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EVALUATION OF DIFFERENT PRE AND POST EMERGENCE HERBICIDES IN PEARL MILLET AND ITS RESIDUAL EFFECT ON SUCCEEDING BLACKGRAM

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ABSTRACT

A field investigation was conducted at the Dryland farm of S. V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University, Andhra Pradesh, during *Rainy season,* 2023 in a randomized block design. Eleven treatments were undertaken and each replicated thrice. The lowest weed density and biomass, higher weed control efficiency and pearl millet growth parameters, yield attributes, grain and stover yield were recorded with hand weeding (HW) twice at 20 and 40 DAS, but it was equally effective with pre emergence (PE) application of pendimethalin 0.5 kgha^{-1} *fb* 1 HW at 30 DAS and PE application of atrazine 0.5 kg ha^{-1} *fb* 1 HW at 30 DAS. Among the pre followed by post emergence (PoE) herbicides the density and dry weight of total weeds were lower with PE application of pendimethalin 0.5 kg ha^{-1} *fb* PoE application of carfentrazone ethyl 20 gha^{-1} at 25 DAS, which was at par with PE application of pendimethalin 0.5 kg ha^{-1} *fb* PoE application of pyrithiobac sodium 0.05 kg ha^{-1} at 25 DAS. Growth parameters of blackgram were not significantly influenced by weed management practices imposed in pearl millet. Application of atrazine, pendimethalin, pyrithiobac sodium, metsulfuron methyl + chlorimuron methyl, carfentrazone ethyl and tembotrione in pearl millet did not exert any residual/inhibitory effect on succeeding blackgram.

Key words: Blackgram,Herbicides,Pearl millet, Residues, Weed management

INTRODUCTION

Pearl millet [*Pennisetum americanum* (L.)] commonly known as Bajra or Bulrush millet is the most widely grown millet crop in India and it is a drought tolerant, warm weather coarse cereal grown in semi-arid and arid climatic conditions of tropical and sub-tropical regions of our country. India is the largest producer and consumer of pearl millet in the world. India is producing around 9.62 million tonns from an area of 6.70 million hectares and with a productivity of 1.43 tonns ha^{-1} (Directorate of Millets Development, 2021-22). Weed management is one of the main constraints in achieving the desired yield in pearl millet, as weeds have better competing ability than the crop and they can thrive under adverse conditions too. The predominant

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method of weed management in pearl millet is hand weeding, which is generally labour intensive. Sequential application of pre followed by post emergence herbicides helps to suppress wide variety of weeds that are actively growing besides maintaining crop performance at its best throughout the growing season. Ready-mix herbicides are formulated by combining different group of herbicides with different mode of action to target specific weed species for broad spectrum weed control. Herbicides applied at recommended rates may have a positive impact. However, even at recommended doses, some herbicides may not breakdown fast and can persist in soil for weeks, months and sometimes years after treatment and may inhibit the growth of subsequent crops (Rani *et al*., 2021). Field studies on persistence and effect of new generation herbicide molecules in pearl millet and their residual effect on succeeding crop are lacking. Hence, the present study was undertaken to find out the suitable pre and post emergence herbicides for effective weed control and for high net returns in pearl millet and also to study the effect of herbicide residues on succeeding blackgram.

MATERIAL AND METHODS

An experiment was conducted during Rainy season of, 2023 at S.V. Agricultural college, Tirupati campus of Acharya N.G. Ranga Agricultural University, Andhra Pradesh which is geographically situated at 13.5°N latitude and 79.5°E longitude with an altitude of 182.9 m above the mean sea level in the Southern Agro-Climatic Zone of Andhra Pradesh. The soil was sandy loam in texture, neutral in soil reaction, low in organic carbon (0.26%) and available nitrogen (212 kg ha^{-1}), medium in available phosphorus (26.6 $kgha^{-1}$) and potassium (234 kg ha^{-1}).The total rainfall received during the crop growth period was 753.0 mm in 29 rainy days. The experiment was laid out using randomized block design with eleven treatments and three replications. Treatments include pre emergence (PE) application of atrazine 0.5 kg ha^{-1}*fb* 1 HW at 30 days after sowing (DAS), PE application of pendimethalin 0.5 kg ha^{-1}*fb* 1 HW at 30 DAS, PE application of atrazine 0.5 kg ha^{-1}*fb* post emergence (PoE) application of pyrithiobac sodium 0.05 kg ha^{-1}at 25 DAS, PE application of pendimethalin 0.5 kg ha^{-1}*fb* PoE application of pyrithiobac sodium 0.05 kg ha^{-1}at 25 DAS, PE application of atrazine 0.5 kg ha^{-1}*fb*PoEapplication of metsulfuron methyl + chlorimuron ethyl 4 g/ha at 25 DAS, PE application of pendimethalin 0.5 kg ha^{-1}*fb* PoE application of metsulfuron methyl + chlorimuron ethyl 4 g/ha at 25 DAS, PE application of atrazine 0.5 kg ha^{-1}*fb* PoE application of carfentrazone ethyl 20 g ha^{-1}at 25 DAS, PE application of pendimethalin 0.5 kg ha^{-1}*fb* PoE application of carfentrazone ethyl 20 g/ha at 25 DAS, PoE application of tembotrione 60 g/ha at 25 DAS, HW twice at 20 and 40 DAS and weedy check.

Pearl millet variety *'ABV-04'* was sown at a spacing of 45 cm x 15 cm, on 2nd July 2023. After harvest of pearl millet, blackgram variety *'TBG-104'* was sown in undisturbed layout of pearl millet experimental field as a succeeding crop after ploughing the pearl millet field, at a spacing of 30 cm x 10 cm to study the residual effect of pre and post emergence herbicides applied to pearl millet on the weeds and on blackgram. Pearl millet was fertilized with 80 kg N, 40 kg P and 30 kg Kha^{-1}. Nitrogen was applied in the form of urea in two equal splits, *viz*. half as basal and the remaining half at 25 DAS and entire dose of phosphorus as single super phosphate and potassium as muriate of potash was applied basally at the time of sowing. All the herbicides alone or in combination were applied uniformly in the experimental plots with the help of knapsack

sprayer fitted with flat fan nozzle using a spray volume of 500 L ha^{-1}. Pre emergence herbicide was applied within 24 hours after sowing and post emergence herbicides application was done at 25 DAS of pearl millet. The data on weed density and dry weight were recorded at different growth stages of pearl millet. The number of weeds associated with pearl millet was recorded by placing a quadrat of 0.5 m x 0.5 m inside the net plot area and expressed as weed density (number m^{-2}). While recording weed density, weeds were harvested from each quadrat for estimating weed dry weight. The weeds collected from the sampling area were dried under shade for 24 hours followed by oven drying at 60°C, till a constant weight was obtained and expressed as weed biomass (gm^{-2}). At every stage of sampling, weeds were categorized into grasses, sedges and broadleaved weeds for both density and dry weight of weeds. These were subjected to square root transformation to normalize their distribution and the corresponding transformed values were used for statistical analysis as suggested by Gomez and Gomez (1984). Five randomly selected plants were tagged in each treatment, from each replication in the net plot area and used for making observations on yield parameters of pearl millet.

RESULTS AND DISCUSSION

Weed flora

Weed flora of experimental plots were comprised of *Dactyloctenium aegyptium* and *Digitaria sanguinalis* among grasses; *Cyperus rotundus,* a sedge; *Boerhavia erecta, Cleome gynandra, Commelina benghalensis* and *Euphorbia hirta* among the broadleaved weeds. Similar type of weed flora were reported by Mishra *et al*.(2014). However, narrow leaved weeds were dominated over broadleaved weeds.

Weed density and dry weight

At harvest of pearl millet, significantly lower density and biomass of grasses was recorded with HW twice at 20 and 40 DAS(Table 1), but it was significantly lower than PE application of atrazine 0.5 kg ha^{-1} *fb* 1 HW at 30 DAS (T_1), which was at par with the post emergence application of tembotrione 60 g ha^{-1}at 25 DAS (T_9). Grasses count was not recorded in treatments with pendimethalin due to the greater efficacy of pre emergence application of pendimethalin 0.5 kg ha^{-1} in controlling the grasses by inhibiting cell division, causes mitotic aberrations which inturn inhibits the root growth of the germinating grasses. Significantly higher density and biomass of grasses were recorded with weedy check (T_{11}).

Lower density and dry weight of sedges was recorded with hand weeding twice at 20 and 40 DAS, which was significantly lower than pre emergence application of pendimethalin 0.5 kg ha^{-1} *fb* 1 HW at 30 DAS, pre emergence application of atrazine 0.5 kg ha^{-1} *fb* 1 HW at 30 DAS and post emergence application of tembotrione 60 gha^{-1}at 25 DAS, while the later three were at par with one another. As mentioned in the above treatments hand weeding performed twice might effectively reduced the weed density or PoE application of tembotrione may have a considerable effect in reducing grasses and sedge count as also reported by Yadav *et al*.(2018). Broadleaved weeds were not observed in treatments with PE application of atrazine as it controlled the weeds by blocking the hill reaction and produces reactive singlet oxygen species in photosystem II leading to inhibition of ATP formation during photosynthesis thereby reduces the density of broadleaved weeds. This was in accordance with Gupta, 2012.Significantly higher total weed density and biomass was reported in weedy check.

Among the sequential application of pre and post emergence herbicides, density and biomass of total weeds were lower with PE application of pendimethalin 0.5 kg ha^{-1} *fb* PoE application of carfentrazone ethyl 20 g ha^{-1}at 25 DAS.Carfentrazone ethyl was found to be effective to control broadleaved weeds by inhibiting activity of protoporphyrinogen oxidase (PPO) in chlorophyll biosynthetic pathway thereby reduced the density of weeds and it was at par with PE application of pendimethalin 0.5 kg ha^{-1}*fb* post emergence application of pyrithiobac sodium 0.05 kg ha^{-1}at 25 DAS.Pyrithiobac sodium was effective in reducing the density of broadleaved weeds as it is readily absorbed by plant foliage and inhibits aceto-lactate synthase (ALS), a key enzyme responsible for biosynthesis of branched chain amino acids leading to reduced amino acids production in susceptible plants. The results are in conformity with the findings of Paswan *et al.*(2017) and Nandagavi and Halikatti (2021).

Weed control efficiency and weed index

Higher weed control efficiency and lower weed index were recorded with HW twice at 20 and 40 DAS (Table1). The next best treatments were PE application of pendimethalin 0.5 kg ha^{-1} *fb* 1 HW at 30 DAS and PE application of atrazine 0.5 kg ha^{-1}*fb* 1 HW at 30 DAS. Among pre followed by post emergence herbicides, higher weed control efficiency and lower weed index were recorded with PE application of pendimethalin 0.5 kg ha^{-1} *fb* PoE application of carfentrazone ethyl 20 g ha^{-1}at 25 DAS, which was on par with PE application of pendimethalin 0.5 kg ha^{-1} *fb* PoE application of pyrithiobac sodium 0.05 kg ha^{-1} at 25 DAS. Reduced density and dry weight of weeds from the initial stages of crop growth due to the absence of weeds might have resulted in higher weed control efficiency as also observed by Girase *et al*.(2017).

Effect on crop gowth

Among the weed control treatments, higher values of growth parameters *viz*., plant height, leaf area index, dry matter production and number of tillers m^{-2} were recorded with HW twice at 20 and 40 DAS, which was at par with PE application of pendimethalin 0.5 kg ha-1 *fb* 1 HW at 30 DAS and PE application of atrazine 0.5 kg ha^{-1}*fb* 1 HW at 30 DAS due to the tremendous growth and development of the crop in a weed free environment during the vital stage of crop growth leading to efficient utilization of light, space, moisture and nutrients leading to increased plant height and leaf area index, which in turn increased the biomass and number of tillers m^{-2}. The next best treatment was PE application of pendimethalin 0.5 kg ha^{-1}*fb*PoE application of carfentrazone ethyl 20 g ha^{-1}at 25 DAS, which was on par with PE application of pendimethalin 0.5 kg ha^{-1}*fb*PoE application of pyrithiobac sodium 0.05 kg ha^{-1}at 25 DAS (Table 2). Weedy check registered lowest values of all the growth parameters due to high degree of crop weed competition.

Effect on yield attributes and yield

Yield attributes and yield of pearl millet differs significantly under different weed control treatments. Significantly higher yield attributes *viz*., number of paniclesm^{-2}, length and diameter of panicle, number of grains/ panicle, test weight, grain and stover yield were recorded with HW twice at 20 and 40 DAS, which was on par with PE application of pendimethalin 0.5 kg ha^{-1}*fb* 1 HW at 30 DAS and PE application of atrazine 0.5 kg ha^{-1}*fb* 1 HW at 30 DAS (Table 2).This might be due to timely and effective weed control that increased the nutrient availability which inturn accelerated the photosynthates production as well as their translocation to sink leading to the production of higher yield attributes coupled with higher grain and stover yield as reported by

Chaudhary *et al*.(2022) and Kumar *et al*. (2012). Among the sequential application of herbicides, higher yield attributes and yield were recorded with PE application of pendimethalin 0.5 kg ha^{-1}*fb*PoE application of carfentrazone ethyl 20 g ha^{-1}at 25 DAS, which was on par with PE application of pendimethalin 0.5 kg ha^{-1}*fb*PoE application of pyrithiobac sodium 0.05 kg ha^{-1}at 25 DAS. Significantly lower values of yield attributes and yield were reported with weedy check due to greater competition for the growth resources among the crop and weeds as evident by the lowest crop stature, yield attributes and yield of pearl millet.

Effect on nutrient uptake by crop and weeds

Among the different weed management practices investigated, highest nutrient uptake *viz*., nitrogen, phosphorus and potassium by pearl millet and lowest nutrient uptake by weeds were reported with hand weeding twice at 20 and 40 DAS, which was at par with PE application of pendimethalin 0.5 kg ha^{-1}*fb* 1 HW at 30 DAS and PE application of atrazine 0.5 kg ha^{-1}*fb* 1 HW at 30 DAS and the above treatments were significantly higher than PE application of pendimethalin 0.5 kg ha^{-1}*fb*PoE application of carfentrazone ethyl 20 g ha^{-1}at 25 DAS and PE application of pendimethalin 0.5 kg ha^{-1}*fb*PoE application of pyrithiobac sodium 0.05 kg ha^{-1}at 25 DAS due to decreased weed competition which concurrently increased the nutrient availability and produced higher biomass production coupled with more nutrient content (Table 3).These results are in conformity with Kiroriwal *et al*. (2012).The lowest nutrient uptake by pearl millet and highest nutrient uptake by weeds was obtained with weedy check.

Economics

Higher gross returns were realized with HW twice at 20 and 40 DAS, which was on par with, PE application of pendimethalin 0.5 kg ha^{-1}*fb* 1 HW at 30 DAS and PE application of atrazine 0.5 kg ha^{-1}*fb* 1 HW at 30 DAS (T_1), whereas, higher net returns were realized with PE application of pendimethalin 0.5 kg ha^{-1}*fb* 1 HW at 30 DAS (T_2), which was on par with pre emergence application of atrazine 0.5 kg ha^{-1} *fb* 1 HW at 30 DAS and HW twice at 20 and 40 DAS (Table 3). Higher gross returns were mainly due to minimal crop weed competition promoted higher grain yield which in turn increased the gross returns. The higher net returns might be due to increased yields and reduced cost of cultivation as reported by Aruna *et al*.(2018). Benefit-cost ratio was higher with PE application of pendimethalin 0.5 kg ha^{-1}*fb* 1 HW at 30 DAS, PE application of atrazine 0.5 kg ha^{-1}*fb* 1 HW at 30 DAS and PE application of pendimethalin 0.5 kg ha^{-1} *fb* PoE application of carfentrazone ethyl 20 g ha^{-1} at 25 DAS. Significantly lower gross and net returns and benefit cost ratio were realized with weedy check.

Effect of weed management practices imposed in pearl millet on succeeding blackgram

Germination percentage of succeeding blackgram was found to be unaffected and exhibited its normal growth and development. This might be due to the degradation of phytotoxic form of herbicides by several ways and resulted in less persistence rate of herbicides. The residual effect of weed management practices imposed in pearl millet on total weed density and biomass of succeeding blackgram was found to be significant at 20 DAS **(**Table 4). The results showed that total weed density and dry weight were significantly lower with HW twice at 20 and 40 DAS. The next best treatments with lower density and biomass of total weeds were PE application of pendimethalin 0.5 kg ha^{-1}*fb* 1 HW at 30 DAS, which was at par with PE application

Table 1. Weed dynamics at harvest of pearl millet as influenced by different weed management practices

Treatments	Weed density (Nom^{-2})				Weed biomass (gm^{-2})				WCE(%)	WI(%)
	Grasses	Sedges	BLW	Total	Grasses	Sedges	BLW	Total		
PE application of atrazine 0.5 kg ha^{-1} *fb* hand weeding at 30 DAS	4.94 (24.33)	7.36 (54.33)	0.71 (0.00)	8.89 (78.67)	2.74 (7.13)	4.43 (19.23)	0.71 (0.00)	5.19 (26.69)	76.0	7.99
PE application of pendimethalin 0.5 kg ha^{-1} *fb* hand weeding at 30 DAS	0.71 (0.00)	7.29 (52.67)	5.05 (25.33)	8.86 (78.00)	0.71 (0.00)	4.28 (18.05)	3.06 (8.96)	5.11 (25.68)	76.9	6.51
PE application of atrazine 0.5 kg ha^{-1} *fb* PoE application of pyrithiobac sodium 0.05 kg ha^{-1} at 25 DAS	7.25 (52.67)	8.89 (79.00)	0.71 (0.00)	11.49 (131.67)	4.16 (16.89)	5.49 (29.67)	0.71 (0.00)	6.85 (46.56)	58.2	47.95
PE application of pendimethalin 0.5 kg ha^{-1} *fb* PoE application of pyrithiobac sodium 0.05 kg ha^{-1} at 25 DAS	0.71 (0.00)	9.15 (83.33)	5.04 (25.00)	10.46 (108.33)	0.71 (0.00)	5.31 (27.80)	3.30 (10.59)	6.14 (37.33)	66.5	25.39
PE application of atrazine 0.5 kg ha^{-1} *fb* PoE application of metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1} at 25 DAS	7.57 (57.00)	9.24 (85.00)	0.71 (0.00)	11.93 (142.00)	4.19 (17.10)	5.54 (30.27)	0.71 (0.00)	6.92 (47.37)	57.5	52.08
PE application of pendime thalin 0.5 kg ha^{-1} *fb* PoE application of metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1} at 25 DAS	0.71 (0.00)	9.77 (95.00)	5.56 (30.67)	11.23 (125.67)	0.71 (0.00)	5.83 (33.48)	3.56 (12.37)	6.81 (45.85)	59.0	44.37
PE application of atrazine 0.5 kg ha^{-1} *fb* PoE application of carfentrazone ethyl 20 g ha^{-1} at 25 DAS	7.54 (56.67)	9.21 (84.33)	0.71 (0.00)	11.89 (141.00)	4.16 (16.80)	5.53 (30.10)	0.71 (0.00)	6.89 (47.03)	57.9	51.34
PE application of pendimethalin 0.5 kg ha^{-1} *fb* PoE application of carfentrazone ethyl 20 g ha^{-1} at 25 DAS	0.71 (0.00)	9.19 (84.00)	5.07 (25.33)	10.43 (109.33)	0.71 (0.00)	5.32 (27.92)	3.08 (9.00)	6.11 (36.92)	66.9	20.50
PoE application of tembotrione 60 g ha^{-1} at 25 DAS	5.22 27.79	7.42 (54.67)	5.27 (27.33)	10.47 (109.00)	3.06 (8.87)	4.36 (18.65)	3.22 (9.93)	6.15 (37.45)	66.3	27.79
Hand weeding twice at 20 and 40 DAS	2.67 (6.67)	4.14 (16.67)	3.38 (11.00)	5.90 (34.33)	1.23 (1.03)	1.36 (1.40)	1.63 (2.20)	2.26 (4.63)	95.9	0.0
Weedy check (Control)	9.91 (97.67)	10.81 (116.67)	8.26 (67.66)	16.80 (282.00)	6.22 (38.22)	6.98 (48.19)	5.06 (25.23)	10.59 (111.64)	0.0	65.04
LSD (P=0.05)	0.73	0.92	0.62	0.73	0.39	0.66	0.56	0.65	-	-

*Data in parentheses are original values, which were transformed to $\sqrt{X + 0.5}$ and analysed statistically.

WCE: Weed control efficiency; WI: Weed Index; DAS: Days after sowing

Table 2. Growth parameters, yield attributes and yield of pearl millet as influenced by weed management practices

Treatments	Plant height (cm)	Leaf area index	Dry matter production (kgha^{-1})	No. of tillers m^{-2}	No. of panicles m^{-2}	Panicle length (cm)	Test weight (g)	Grain yield (kgha^{-1})	Stover yield (kgha^{-1})
PE application of atrazine 0.5 kg ha^{-1}*fb* hand weeding at 30 DAS	189	3.16	9107	35.0	33.0	28.1	9.70	3180	6973
PE application of pendimethalin 0.5 kg ha^{-1}*fb* hand weeding at 30 DAS	195	3.18	9184	35.7	33.7	28.5	9.87	3332	6982
PE application of atrazine 0.5 kg ha^{-1}*fb* PoE application of pyrithiobac sodium 0.05 kg/haat 25 DAS	161	1.92	7341	26.0	24.3	22.8	7.24	1796	5788
PE application of pendimethalin 0.5 kg ha^{-1}*fb* PoE application of pyrithiobac sodium 0.05 kg ha^{-1}at 25 DAS	176	2.56	8270	30.3	28.7	25.7	8.57	2579	6399
PE application of atrazine 0.5 kg ha^{-1}*fb*PoE application of metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1}at 25 DAS	154	1.82	7147	25.0	23.7	22.2	7.16	1658	5718
PE application of pendimethalin 0.5 kg ha^{-1}*fb* PoE application of metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1}at 25 DAS	162	2.00	7418	26.3	24.7	23.0	7.33	1923	5817
PE application of atrazine 0.5 kg ha^{-1}*fb*PoE									
application of carfentrazone ethyl 20 g ha^{-1}at 25 DAS	156	1.88	7261	25.3	24.0	22.7	7.19	1682	5758
PE application of pendimethalin 0.5 kg ha^{-1}*fb*									
PoE application of carfentrazone ethyl 20 g ha^{-1}at 25 DAS	177	2.60	8327	30.7	29.0	25.8	8.60	2745	6433
PoE application of tembotrione 60 g ha^{-1}at 25 DAS	174	2.52	8148	29.7	28.3	25.1	8.44	2495	6371
Hand weeding twice at 20 and 40 DAS	198	3.21	9296	37.0	35.3	28.6	10.37	3457	7004
Weedy check (Control)	138	1.29	6532	19.0	17.0	19.0	6.03	1210	5149
LSD (P=0.05)	10	0.50	601	3.0	3.3	1.9	1.09	280	508

Table 3. Nutrient uptake by crop and weeds and economics of pearl millet as influenced by weed management practices

Treatments	Nutrient uptake by pearl millet(kgha^{-1})			Nutrient uptake by weeds(kgha^{-1})			Economics (₹ ha^{-1})		
	Nitrogen	Phosp-horus	Potas-sium	Nitrogen	Phosp-horus	Potas-sium	Gross returns	Net returns	B:C ratio
PE application of atrazine 0.5 kg ha^{-1}*fb* hand weeding at 30 DAS	86.6	17.2	83.6	16.6	6.0	12.1	104951	72343	3.2
PE application of pendimethalin 0.5 kg ha^{-1}*fb* hand weeding at 30 DAS	88.3	17.8	85.4	15.4	5.5	11.3	109966	76733	3.3
PE application of atrazine 0.5 kg ha^{-1}*fb* PoE application of pyrithiobac sodium 0.05 kg ha^{-1}at 25 DAS	57.3	11.9	63.5	27.4	11.4	23.6	59272	28814	1.9
PE application of pendimethalin 0.5 kg ha^{-1}*fb* PoE application of pyrithiobac sodium 0.05 kg ha^{-1}at 25 DAS	73.0	14.4	74.1	21.0	8.2	18.1	85118	54035	2.7
PE application of atrazine 0.5 kg ha^{-1}*fb* PoE application of metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1}at 25 DAS	53.6	10.7	62.3	28.3	12.1	25.0	54714	25438	1.9
PE application of pendimethalin 0.5 kg ha^{-1} *fb*PoE application of metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1}at 25 DAS	60.3	12.0	65.2	26.2	10.9	23.1	63443	33542	2.1
PE application of atrazine 0.5 kg ha^{-1}*fb* PoE application of carfentrazone ethyl 20 g ha^{-1}at 25 DAS	55.6	11.1	62.1	27.8	11.8	24.5	55494	25994	1.9
PE application of pendimethalin 0.5 kg a^{-1}*fb* PoE application of carfentrazone ethyl 20 g ha^{-1}at 25 DAS	74.2	14.6	76.5	19.9	7.8	16.7	90597	60472	3.0
PoE application of tembotrione 60 g ha^{-1}at 25 DAS	72.7	14.2	73.3	22.2	8.9	18.7	82328	52641	2.8
Hand weeding twice at 20 and 40 DAS	89.2	18.8	87.4	14.6	4.6	10.3	110787	72249	2.9
Weedy check (Control)	41.1	8.0	44.3	33.0	16.7	21.6	39923	13085	1.5
LSD (P=0.05)	11.3	1.9	4.0	2.9	1.5	2.2	9501	9501	0.3

Table 4. Weed density (Nom^{-2}), biomass (gm^{-2}) and growth parameters of blackgram at 20 DAS as influenced by weed management practices imposed in preceding pearl millet

Treatments	Weed density (No m^{-2})				Weed biomass (g m^{-2})				Germination percentage (%)	Root length (cm)	Shoot length (cm)	SPAD chlorophyll reading	Dry matter production (kgha^{-1})
	Grasses	Sedges	BLW	Total	Grasses	Sedges	BLW	Total					
PE application of atrazine 0.5 kg ha^{-1} *fb* hand weeding at 30 DAS	5.82 (33.33)	5.87 (34.33)	4.60 (21.33)	9.44 (89.00)	3.71 (13.26)	3.95 (15.18)	3.06 (8.88)	6.15 (37.32)	91	6.60	25.8	33.3	144
PE application of pendimethalin 0.5 kg ha^{-1} *fb* hand weeding at 30 DAS	5.43 (29.00)	5.76 (32.67)	4.74 (22.00)	9.17 (83.67)	3.58 (12.41)	3.91 (14.93)	3.17 (9.56)	6.06 (36.27)	90	6.53	25.3	32.7	134
PE application of atrazine 0.5 kg ha^{-1} *fb* PoE application of pyrithiobac sodium 0.05 kg ha^{-1} at 25 DAS	6.84 (46.33)	7.70 (59.00)	5.72 (32.33)	11.74 (137.67)	4.44 (19.22)	4.77 (22.26)	3.74 (13.52)	7.45 (55.00)	89	5.93	24.5	31.0	133
PE application of pendimethalin 0.5 kg ha^{-1} *fb* PoE application of pyrithiobac sodium 0.05 kg ha^{-1} at 25 DAS	6.72 (44.67)	6.67 (44.00)	5.87 (34.00)	11.10 (122.67)	4.43 (19.12)	4.45 (19.30)	3.78 (13.81)	7.26 (52.23)	90	6.40	24.8	32.0	139
PE application of atrazine 0.5 kg ha^{-1} *fb*PoE application of metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1} at 25 DAS	8.13 (65.67)	8.76 (76.33)	6.04 (36.00)	13.36 (178.00)	4.83 (22.95)	5.29 (27.58)	3.81 (14.04)	8.06 (64.57)	88	6.47	24.9	30.7	141
PE application of pendimethalin 0.5 kg ha^{-1} *fb*PoE application of metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1} at 25 DAS	6.63 (43.67)	7.80 (60.33)	5.79 (33.00)	11.72 (137.00)	4.38 (18.72)	4.78 (22.41)	3.75 (13.60)	7.43 (54.72)	89	5.97	24.6	31.3	142
PE application of atrazine 0.5 kg ha^{-1} *fb*PoE application of carfentrazone ethyl 20 g ha^{-1} at 25 DAS	6.74 (45.00)	7.95 (63.00)	5.61 (31.00)	11.80 (139.00)	4.45 (19.35)	4.75 (22.06)	3.68 (13.08)	7.41 (54.48)	91	6.55	25.6	33.0	135
PE application of pendimethalin 0.5 kg ha^{-1} *fb*PoE application of carfentrazone ethyl 20 g ha^{-1} at 25 DAS	5.87 (34.00)	6.69 (44.33)	4.37 (18.67)	9.87 (97.00)	3.77 (13.75)	4.38 (18.71)	2.85 (7.62)	6.37 (40.08)	91	6.23	24.6	32.3	143
PoE application of tembotrione 60 g ha^{-1} at 25 DAS	6.79 (45.67)	6.92 (47.33)	5.46 (29.33)	11.08 (122.33)	4.39 (18.82)	4.40 (18.92)	3.73 (13.44)	7.18 (51.19)	89	6.50	25.0	30.3	136
Hand weeding twice at 20 and 40 DAS	4.63 (21.00)	5.21 (26.67)	4.30 (18.00)	8.13 (65.67)	3.00 (8.53)	3.30 (10.40)	2.84 (7.62)	5.20 (26.55)	92	6.80	28.0	33.7	146
Weedy check	8.21 (67.00)	8.80 (77.00)	6.87 (46.67)	13.82 (190.67)	4.86 (23.12)	5.31 (27.74)	4.37 (18.74)	8.37 (69.59)	87	5.80	23.6	30.0	126
LSD (P=0.05)	0.49	0.67	0.60	0.75	0.37	0.42	0.35	0.37	NS	NS	NS	NS	NS

of atrazine 0.5 kg ha^{-1}*fb* 1 HW at 30 DAS and PE application of pendimethalin 0.5 kg ha^{-1}*fb*PoE application of carfentrazone ethyl 20 g ha^{-1}at 25 DAS. These results revealed that hand weeding twice or pre emergence application of atrazine or pendimethalin followed by one hand weeding in pearl millet reduced the density and dry weight of weeds till harvest which inturn lowered the density of weeds in blackgram(Table 4).Significantly higher weed count and biomass was recorded with weedy check (T_{11}). These results are in line with Singh *et al.*(2012).

Growth parameters of blackgram *viz*., root length, shoot length, SPAD chlorophyll meter readings and dry matter production were not significantly influenced by weed management practices imposed in pearl millet (Table 4). However, higher values of root length, shoot length, SPAD chlorophyll meter readings and dry matter production were recorded with hand weeding twice at 20 and 40 DAS, which was statistically comparable with rest of the weed management practices. These results are in line with Nazreen *et al.* (2018).

CONCLUSION

The study revealed that pre emergence application of pendimethalin 0.5 kg ha^{-1}or atrazine 0.5 kg ha^{-1} *fb* 1 HW at 30 DAS was considered as best weed management practice to increase the productivity and to maximize the net returns, but at times of labour scarcity pre emergence application of pendimethalin 0.5 kg ha^{-1}*fb* post emergence application of carfentrazone ethyl 20 g ha^{-1}at 25 DAS or pre emergence application of pendimethalin 0.5 kg ha^{-1}*fb* post emergence application of pyrithiobac sodium 0.05 kg ha^{-1}at 25 DAS were found to be the most effective and economical weed management practices to control mixed weed flora and to maximize the net returns in pearl millet cultivation Pre and Post emergence herbicides applied in pearl millet did not exert any residual/inhibitory effect on weed density and dry weight as well as growth parameters of succeeding blackgram.

REFERENCES

Aruna, K.J, Rao, P.C, Madhavi, M and Padmaja, G. 2018. Effect of herbicides on the activity of soil enzyme urease in maize crop. Indian Journal of Agricultural Research,52 (3): 300-304.

Chaudhary, C., Hooda, V.S., Isha, K.S., Nagora, M., Kumar, S and Nandal, D.P. 2022. Impact of Integrated weed management practices on growth parameters, yield attributes and yield of pearl millet (*Pennisetum glaucum)*. The Pharma Innovation Journal, 11(4): 687-692.

Directorate of Millets Development, 2021-22. Girase, P.P., Suryawanshi, R.T., Pawar, P.P and Wadile, S.C. 2017. Integrated weed management in pearl millet.Indian Journal of Weed Science, 49 (1): 41-43.

Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedure for Agricultural Research. International Rice Research Institute, Manila, Philippines. 304-305.

Gupta, V., Singh, B.N.,Kumar, J., Singh, M and Jamwal, B.S. 2012. Effect of Imazathypr on weed control and yield in chickpea under Kandi belt of low altitude sub-tropical zone of Jammu. Madras Agricultural Journal, 99(1): 81-86.

Kiroriwal, A., Yadav, R.S. and Kumawat, A. 2012. Weed management in pearl millet based cropping system. Indian Journal of Weed Science, 44(3): 200-203.

Kumar, V., Tyagi, S. and Singh, D. 2012. Yield, N uptake and economics of fodder sorghum and associated weeds as affected by different weed management

practices. Progressive Agriculture, 2(1): 96-102.

Mishra, J.S., Rao, S.S and Patil, J.V. 2014. Influence of sorghum cultivars and weed management practices on nutrient uptake by crop and weeds in semi-arid tropical India. Indian Journal of Plant Physiology, 19(4): 351-355.

Nandagavi, R.A. and Halikatti, S.I. 2021. Bioefficacy of the sequential application of herbicides in cotton. Journal of Pharmacognosy and Phytochemistry, 10(1): 2078-2083.

Nazreen, S., Subramanyam, D., Sunitha, N and Umamahesh, V. 2018. Seedling vigour index and productivity of greengram as influenced by pre and post emergence herbicicdes applied to maize. Journal of Pharmacognosy and Phytochemistry, 7(3): 584-587.

Paswan, A.K., Mandal, D., Kumawat, N., Kumar, J., Kumar, R., Singh, A.K and Kumar, A. 2017. Efficacy of separate and premix formulation of metsulfuron-methyl and carfentrazone-ethyl on weeds in wheat: a review. International Journal of Current Microbiology Applied Sciences. 6(7): 2439-2453.

Rani, B.S., Chandrika, V., Reddy, G.P., Sudhakar, P and Sagar, G.K. 2021. Weed management with pre and post emergence herbicides in maize under maize - greengram cropping system. Indian Journal of Weed Science. 53(4): 405-410.

Singh, V.P., Guru, S.K, Kumar, A., Banga, A and Tripathi, N. 2012. Bioefficacy of tembotrione against mixed weed complex in maize. Indian Journal of Weed Science, 44(1): 1-5.

Yadhav, D.B., Yadhav, A., Punia, S.S., Duhan, A. 2018. Temobotrione for post emergence control of complex weed flora in maize. Indian Journal of Weed Science, 50(2): 133-136.

Harini, V., Rani B.S.,Reddy, P.M., Prasanthi, A. and Chandrika, V. 2025. Evaluation of different Pre and Post emergence Herbicides in Pearl Millet and its Residual Effect on Succeeding Blackgram.The Journal of Research, ANGRAU,53(3):1-11.

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EVALUATION OF MAIZE HYBRIDS FOR MORPHO-QUANTITATIVE TRAITS UNDER PRAYAGRAJ AGRO-CLIMATIC CONDITIONS USING MAHALANOBIS D^2 ANALYSIS

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ABSTRACT

The development and cultivation of hybrids is the key to improving the productivity of Maize crop. The present study evaluated 26 maize (*Zea mays* L.) hybrids under the agro-climatic conditions of Prayagraj, Uttar Pradesh, during the Kharif season of 2024-2025 for genetic parameters and genetic variability in relation to yield and its morpho-quantitative traits. Analysis of variance (ANOVA) revealed significant differences among the hybrids, indicating substantial genetic variability. The traits field weight and biological weight recorded the high GCV (50.52 and 30.02) and PCV (50.96 and 30.25) values, respectively. The traits field weight, biological weight and plant height recorded the high heritability (>60%) along with high genetic advance expressed as a percentage of mean (>20%), suggesting predominant additive gene action and high potential for genetic improvement through selection.The assessment of genetic diversity grouped the 26 hybrids into 5 distinct clusters, with the majority (9 hybrids) falling into Cluster V. Among the clusters, the maximum intra-cluster distance was observed in Cluster V (3.6). The greatest inter-cluster distance (9.08) was observed between Cluster IV and Cluster I, suggesting that interbreeding among members in these two clusters could facilitate the production of highly desirable transgressive segregants. The pronounced inter-cluster distances, especially between Cluster IV and others, highlight its potential as a parent in heterotic cross combinations.Based on a genetic divergence study VH171310, ZH22698, ZH20379 and VH183007. These findings offer crucial direction for selecting diverse and high-performing hybrids to enhance maize productivity and adaptability in Eastern Uttar Pradesh.

Keywords: Cluster Analysis, Diversity, Genetic Variability, Heritability, Maize (*Zea mays* L.), Morpho-Quantitative Traits.

INTRODUCTION

Maize (*Zea mays* L.) occupies a significant position in global food, feed and industrial systems. In India, maize ranks third after rice and wheat in terms of area and production and plays a vital role in ensuring food security, economic development and agro-industrial advancement (Nadar *et al.,* 2024). The crop's productivity and adaptation are highly influenced by genetic makeup and

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prevailing agro-climatic conditions. Therefore, the identification and selection of superior hybrids suited to specific environments is essential to maximize yield and quality traits (Long, 2025). It is the most widely grown cereal crop in the world, cultivated for food, feed and industrial uses. Globally, the crop covers an estimated 193.7 million hectares, with a production of approximately 1,147.7 million metric tonnes as of 2023–2024, yielding an average of 5.83 tonnes per hectare (USDA, 2024). India ranks among the top ten maize producers globally. During the 2023–2024 agricultural year, India cultivated maize in 11.24 million hectares, producing about 37.67 million metric tonnes, with an average yield of 3.35 tonnes per hectare (Directorate of Economics and Statistics, 2024). Maize is grown extensively in states like Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh, both in the *kharif* and *rabi* seasons. In Uttar Pradesh, maize is a significant cereal crop due to its adaptability and rising demand in the poultry and starch industries. As per recent estimates, the state recorded an area of around 0.83 million hectares and production of 2.12 million tonnes in 2023–2024 (Mohanty *et al.,* 2025). The Prayagraj region, located in the eastern part of Uttar Pradesh, represents a unique agro-ecological zone with its own soil, climate and cropping system characteristics. Limited systematic studies have been conducted to assess the genetic variability of maize hybrids under local conditions (Singh *et al.,*2021). A survey of genetic variability determinants *viz.* genotypic and phenotypic coefficient of variations (GCV and PCV) indicates the degree of variation exists among sunflower genotypes with respect to particular character and also detail about role of the environment in expression of the character. Broad sense heritability (h^2) and genetic advance as percent of mean (GAM) defines selection effectiveness and also nature of gene action in inheritance of particular character. Evaluating this diversity under specific agro-climatic conditions allows breeders to exploit favorable traits through hybridization and selection (Kachapur *et al.,* 2023). Among the various multivariate techniques available, Mahalanobis' D^2 statistic is a powerful tool for assessing genetic divergence among genotypes. It allows for the classification of genotypes into distinct clusters based on multiple traits simultaneously, thus helping in the identification of genetically diverse parents for hybrid development. Hence, the present investigation was undertaken to evaluate the genetic diversity among maize hybrids for various morpho-qualitative traits under Prayagraj agro-climatic conditions using D^2 analysis. The key to future improvement lies in exploiting a wider range of inbred lines to create even better hybrids. Hence, this study was conducted to assess the variability and genetic diversity in newly developed maize hybrids in this specific agro-ecological zone.

MATERIAL AND METHODS

The experiment was carried out at the Department of Genetics and Plant Breeding field experiment centre, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, during *Kharif* 2024-2025. The experiment material comprised 26 maize hybrids, which were obtained from the maize germplasm pool maintained at the CIMMYT Asia office, Hyderabad, Telangana. The details of the experimental materials are listed in Table 1. It included 22 CIMMYT hybrids along with 4 checks.

The gross field area of 178.2 m^2 was divided into two subplots. An irrigation channel of dimension 0.5 meters ran between adjacent subplots. These subplots were used to replicate the hybrids twice.A total of 26 maize

hybrids have been sown in a Randomized block design. Each entry was sown in a double row of 1 metre in length in each replication. All of these hybrids were sown on one seed per hill. The spacing between the rows and between the plants is 60cm and 30cm, respectively. The crop was raised per the recommended package of practices.

The data were recorded for the following characters: Days to Maturity, Plant Height (cm), Ear Height (cm), Ear Length (cm), Number of Ears, Number of Kernel Rows, Number of Kernels per Row, Field Weight (gm), Ear Aspect, Grain Moisture %, Test Weight (gm), Biological Weight (gm), Grain Weight Per Plant (gm), Grain Weight Per Plot (gm) and Seed Yield Per Hectare (kg). To check the significance among genotypes, Analysis of variance was carried out as per methodology suggested by Panse and Sukhatme (1967). Phenotypic coefficient of variation and genotypic coefficient of variation were calculated by the formula given by Burton and Devane,1953. Heritability in broad sense (h^2) was worked out by using formula suggested by Burton and Devane,1953 and genetic advance i.e. the expected genetic advance was calculated by using the procedure given by Johnson *et al*.(1955).

RESULTS AND DISCUSSION

ANOVA Test for Different Quantitative Traits

The ANOVA results indicated that the mean sum of squares (MSS) due to genotypes was highly significant for all the traits studied, confirming the presence of substantial genetic differences among the hybrids. This significant variation reflects a broad range of diversity in the morpho-quantitative characteristics of the evaluated hybrids, which is crucial for effective selection in breeding programs. These findings align with previous studies that have also reported considerable genetic variability in maize for similar traits by Usman *et al.,* 2024. Such variability offers ample opportunities for identifying superior genotypes and advancing genetic gain through targeted selection and hybridization.

Coefficient of Variation (GCV and PCV), Heritability (h2), Genetic Advance (GA), and Genetic Advance as Percent of Mean (GAPM)

The objective of this study was to assess key genetic parameters, including heritability, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) and

Table 1. List of 22 CIMMYT hybrids along with 4 checks

S.No.	Hybrids	S.No.	Hybrids	S.No.	Hybrids	S.No.	Hybrids	S.No.	Hybrids
1	Internal Check: 1	7	KH151871	13	VH181219	19	ZH22741	25	VH19601
2	Commercial Check: 2	8	VH171310	14	VH19227	20	ZH22742	26	VH18614
3	VH182239	9	ZH221149	15	VH19490	21	ZH20265		
4	ZH22698	10	VH183007	16	ZH22744	22	VH152761		
5	Commercial Check: 1	11	ZH20379	17	ZH22740	23	VH18580		
6	ZH221145	12	Commercial Check: 3	18	ZH22731	24	ZH20154		

Emergence of Silk and Tassel Plant Height Ear Height

Number of Kernels per row Number of Kernel rows

Quantitative traits in Maize

genetic advance as a percentage of the mean (GAPM). This comprehensive evaluation aimed to understand the extent of genetic variability and the potential for genetic improvement in the studied maize hybrids.The detailed findings for each trait, including estimates of genetic variability and potential for improvement,are presented in Table 2.

Genotypic (GCV) and Phenotypic (PCV) Coefficients of Variation

The summary statistics such as mean, range, GCV, PCV, GAM and heritability values of the studied traits were shown in Table 2. Field weight trait ranges from 272.86 to 1878.72 with mean value of 842.25. Whereas, the trait biological weight ranges from 103.6 to 311.58 with mean value of 208.34. The findings showed that the PCV estimates exceeded the GCV estimates for all traits, suggesting a significant environmental influence on their expression. Notably, field weight and biological weight traits recorded the higher estimates of PCV and GCV values. The high GCV values enable the rewarding of direct selection for these traits. Moderate PCV and GCV values observed for plant height (cm), ear length (cm) and number of ears traits. The lower estimates of PCV and GCV was observed for the trait number of days to maturity and ear height (cm). Further, the low GCV value implies that the direct selection is not rewarding for such traits. Similar results were observed by Antony *et al.,* 2024.

Heritability (h^2) and Genetic Advance as Percent of Mean (GAPM)

A wide range of heritability was observed across the fifteen traits evaluated (Table 3). Traits such as plant height (97.67%), number of kernels per row (93.97%), field weight (98.28%), biological weight (98.46%), grain

Table 2. Analysis of variance for different characters in maize hybrids

Summary of ANOVA				
	Source of variance	Mean sum of squares (MSS)		
S.No.	Degrees of freedom	Genotype	Replication	Error
		25	1	25
1	Days to Maturity	15.259*	290.942	6.742
2	Plant Height(cm)	2314.142**	7.948	27.239
3	Ear Height(cm)	93.459**	1.062	18.196
4	Ear Length(cm)	8.394**	0.156	1.707
5	Number of Ears	0.240**	0.396	0.025
6	Number of Kernel Rows	2.677**	3.481	0.550
7	Number of Kernels per Row	34.313**	0.073	1.066
8	Field Weight (gm)	365406.294**	1369.094	3166.429
9	Ear Aspect	1.139**	0.019	0.107
10	Grain Moisture %	3.688**	0.103	0.243
11	Test Weight(gm)	29.862**	1.167	1.906
12	Biological Weight (gm)	7885.209**	271.275	61.041
13	Grain Weight Per Plant (gm)	810.200**	27.857	9.347
14	Grain Weight Per Plot (gm)	182294.893**	6267.823	2103.016
15	Seed Yield Per Hectare (kg)	506374.703**	17410.620	5841.710

Significant at 1% level of significance (**) Significant at 5% level of significance (*)

weight per plant (97.71%), grain weight per plot (97.71%) and seed yield per hectare (97.71%) exhibited very high heritability, indicating that these are largely governed by genetic factors and can be effectively improved through selection. Correspondingly, these traits also showed high GAPM values field weight (103.19%), seed yield per hectare (78.23%), grain weight per plant and plot (78.23%), and Test weight (38.48%) further supporting their strong genetic control and potential responsiveness to selection.

According to GAPM classifications, values below 10% are considered low, 10–20% as moderate and above 20% as high. Traits such as days to maturity (2.93%) showed low GAPM along with low heritability (38.71%), suggesting limited genetic gain and greater environmental influence. Ear height (10.02%) and number of kernel rows (12.93%) showed moderate GAPM, while ear length (22.70%), grain moisture (24.44%) and ear aspect (68.78%) demonstrated high genetic advance as percent of the mean. The combination of high heritability and high GAPM for key traits such as seed yield, grain and biological weight, field weight and kernel number per row suggests that these characters are primarily controlled by additive gene action and can be efficiently improved through simple selection.

These findings are by earlier studies conducted by Hasan *et al.*(2025), who also reported moderate GA values for traits like days to 50% silking and tasseling. Similarly,

Table 3. Estimation of genetic parameters for 26 maize hybrids.

Traits	Range			Coefficient of Variation		Herita-bility (%)	Genetic Advance	GA% Mean
	Mean	Min	Max	PCV (%)	GCV(%)			
Days to Maturity	89.98	86	95.5	3.68	2.29	38.71	2.64	2.93
Plant Height(cm)	224.51	162.64	261.17	15.24	15.06	97.67	68.84	30.66
Ear Height(cm)	103.47	87.24	113.66	7.22	5.92	67.40	10.37	10.02
Ear Length(cm)	13.43	9.06	17.01	16.68	13.56	66.04	3.05	22.70
Number of Ears	1.77	1.2	2.33	20.47	18.42	80.98	0.60	34.16
Number of Kernel Rows	13.33	11.07	14.9	9.52	7.73	65.89	1.72	12.93
Number of Kernels Per Row	26.76	19.88	34.01	15.712	15.23	93.97	8.14	30.41
Field Weight (gm)	842.25	272.86	1878.72	50.96	50.52	98.28	869.13	103.19
Ear Aspect	1.95	1	3.7	40.33	36.69	82.79	1.34	68.78
Grain Moisture %	10.35	7.5	12.37	13.53	12.67	87.64	2.53	24.44
Test Weight (gm)	18.77	13.17	29.77	21.23	19.91	88.00	7.22	38.48
Biological Weight (gm)	208.34	103.6	311.58	30.25	30.02	98.46	127.85	61.36
Grain Weight Per Plant (gm)	52.06	16.85	88.74	38.86	38.41	97.71	40.74	78.23
Grain Weight Per Plot (gm)	781.27	252.75	1331.1	38.86	38.41	97.71	611.23	78.23
Seed Yield Per Hectare(kg)	1302.12	421.25	2218.5	38.86	38.41	97.71	1018.72	78.23

high GAPM values for traits such as grain yield per plant, Test weight and number of kernels per row were also supported by the findings of Hasan *et al.,* 2025. Moreover, reports by Banjara *et al.,* 2025, reinforce the conclusion that traits under high heritable influence and high genetic advance offer the best prospects for genetic improvement through direct selection in maize breeding programs.

Genetic Divergence

Genetic divergence analysis is a powerful tool in plant breeding for identifying genetically diverse genotypes, which can be effectively used in hybridization programs to obtain maximum heterosis. In the present study, Mahalanobis' D^2 statistics was employed to evaluate the extent of genetic variability among 26 maize hybrids based on multiple morpho-quantitative traits under Prayagraj agro-climatic conditions, which were grouped into five distinct clusters (Table 4). This clustering also included four check varieties: Internal Check:1, Commercial Check:1, Commercial Check:2 and Commercial Check:3. The distribution of check varieties across clusters allowed for direct comparisons with test hybrids and provided a benchmark to assess their relative performance.

The intra and inter-cluster distances (Table 5,Fig.1) provide important information regarding the degree of genetic similarity or dissimilarity among genotypes. The intra-cluster distances ranged from 0 (Cluster IV) to 3.604 (Cluster V), suggesting that the hybrids within Cluster IV were highly similar, while moderate variability existed within Cluster V. The inter-cluster distances were highest between Cluster I and Cluster IV (9.08), followed by Cluster III and Cluster IV (8.32), and Cluster II and Cluster IV (6.10). These wide genetic distances indicate that the genotypes grouped in these clusters are highly divergent and could serve as ideal candidates for hybridization to exploit maximum heterosis. Conversely, the lowest inter-cluster distance was observed between Cluster I and Cluster III (4.62), implying relatively lower genetic divergence between these groups.

Internal Check : 1 and Commercial Check:1 was both grouped in Cluster I along with genotypes VH171310, VH182239, and ZH22698. Commercial Check : 2 also fell under Cluster I, indicating genetic similarity among these entries. Commercial Check : 3, on the other hand, was placed in Cluster II, alongside ZH221149, ZH20379 and VH183007.

Table 4. Distribution of 26 maize hybrids in different clusters using D^2 statistics

Cluster Group	No. of hybrids	Name of hybrid
1	6	VH171310, VH182239, Internal Check:1, Commercial Check:2, ZH22698, Commercial Check:1
2	4	ZH221149, ZH20379, VH183007, Commercial Check:3
3	6	ZH22731, ZH22741, ZH221145, ZH22740, KH151871, VH181219
4	1	VH19227
5	9	ZH22742, VH19490, ZH22744, VH18614, ZH20265, ZH20154, VH18580, VH152761, VH19601

The intra and inter-cluster distances

Table 5. Average Intra and Inter cluster distances of 26 maize hybrids

Cluster	CI	CII	CIII	CIV	C V
C I	2.947346				
C II	4.920047	3.034597			
C III	4.623814	5.055006	3.442944		
C IV	9.083386	6.105321	8.321435	0	
C V	7.14766	4.628081	6.447671	4.892003	3.604004

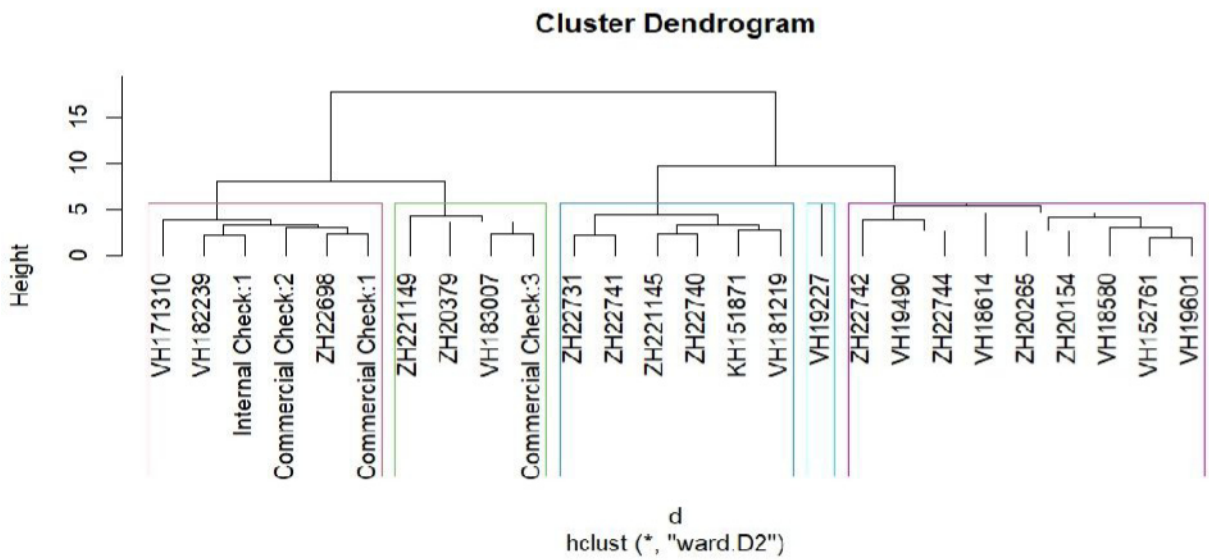


Fig. 1. Cluster Dendogram Showing Grouping of Hybrids

Intra and Inter-Cluster Distances

This grouping suggests that Cluster I contains genotypes genetically similar to the commonly used checks, while genotypes in Clusters III, IV, and V may represent more divergent material.

Cluster Means

The cluster mean values for 15 morpho-quantitative traits (Table 6.) further emphasized the genetic variability across clusters. Cluster IV showed superiority in several traits including plant height (256.42 cm), ear length (16.58 cm), number of ears (2.31), kernels per row (33.37), grain weight per plant (88.74 g) and seed yield per hectare (2218.5 kg). These results suggest that the genotype VH19227, which forms a single-entry cluster (Cluster IV), is a highly promising hybrid possessing multiple desirable traits. This indicates that VH19227 is a significantly superior genotype over all check varieties for most yield-related traits.

Cluster III also recorded high performance in key yield attributes such as ear length (15.8 cm), number of ears (2.139), kernels per row (31.1) and grain weight per plant (73.62 g). In contrast, Cluster V recorded the lowest values for most traits including plant height (188.58 cm), grain weight per plant

Table 6. Cluster Means of different characters in maize hybrids

Trait	C I	C II	C III	C IV	C V
Days to Maturity	86.375	91.5	93.1	89	89.05
Plant Height(cm)	244.24	241.901	253.319	256.42	188.589
Ear Height(cm)	106.498	107.758	108.653	100.59	97.407
Ear Length(cm)	14.808	12.469	15.8	16.58	11.97
Number of Ears	1.5075	1.8033	2.139	2.31	1.6375
Number of Kernel Rows	13.291	13.645	14.112	14.035	12.71
Number of Kernels Per Row	27.149	26.177	31.1	33.37	24.145
Field Weight (gm)	1165.118	743.459	1233.459	1878.725	473.137
Ear Aspect	1.1125	1.875	1.43	1.3	2.675
Grain Moisture %	11.19	11.325	10.894	10.94	9.1135
Test Weight (gm)	25.3425	16.5508	19.468	22.495	16.7565
Biological Weight (gm)	246.989	215.765	278.029	311.58	143.269
Grain Weight Per Plant (gm)	55.23	44.1	73.62	88.74	35.083
Grain Weight Per Plot (gm)	1057.275	661.5	1104.3	1331.1	526.245
Seed Yield Per Hectare(kg)	1762.125	1102.5	1840.5	2218.5	877.075

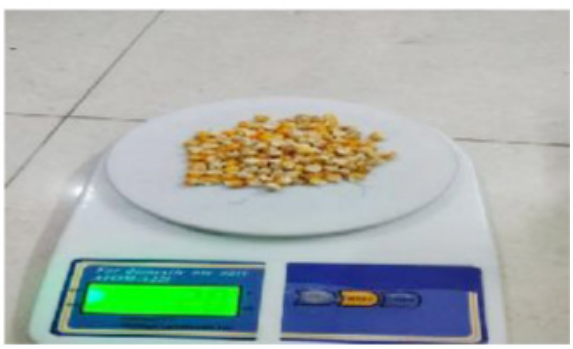
(35.08 g) and seed yield (877.075 kg/ha), indicating the presence of lower-yielding genotypes in this group. Cluster I and Cluster II exhibited moderate values across traits, with Cluster I performing well in Test weight (25.34 g) and field weight (1165.12 g).

Contribution of Traits to Genetic Divergence

The relative contribution of individual traits to total genetic divergence was estimated using D^2 analysis and is presented in Table 7. Among the 15 traits studied, field weight (34.1%) contributed the most to total divergence, followed by biological weight (14.6%), grain weight per plant (12.6%) and grain weight per plot (13.1%). These yield-related traits collectively accounted for more than 70% of the observed genetic variability. In contrast, traits like ear height (0.1%), grain moisture (0.9%) and ear length (1.1%) made minimal contributions.

This suggests that selection based on yield components such as field weight,

Ear Length (cm)



Grain Weight (gm)

Table 7. Percent contribution of 15 characters towards genetic divergence

Characters	Percent contribution
Days to Maturity	1.5%
Plant Height(cm)	8.7%
Ear Height(cm)	0.1%
Ear Length(cm)	1.1%
Number of Ears	3.2%
Number of Kernel Rows	2.1%
Number of Kernels Per Row	2.7%
Field Weight (gm)	34.1%
Ear Aspect	1.3%
Grain Moisture %	0.9%
Test Weight (gm)	1.3%
Biological Weight (gm)	14.6%
Grain Weight Per Plant (gm)	12.6%
Grain Weight Per Plot (gm)	13.1%
Seed Yield Per Hectare(kg)	2.8%

biological weight and grain weight per plant is likely to be more effective in identifying diverse and high-performing genotypes. The greater divergence contributed by yield-related traits also aligns with the primary breeding objective of enhancing productivity under the specific agro-climatic conditions of Prayagraj.

The presence of check varieties in Clusters I and II serves as a benchmark for genetic and agronomic performance. The fact that genotypes in Clusters III and IV outperformed checks across multiple traits indicates the availability of superior genetic material in the experimental hybrids. Notably, VH19227 (Cluster IV) and several Cluster III entries (e.g., ZH22731, ZH22741, ZH221145) can be utilized for future hybrid development due to their high divergence and favorable performance. Similar findings were noted by Singh *et al.*2021.

These findings suggest that crossing genetically divergent and agronomically superior genotypes from Cluster IV or III with stable check-type entries from Cluster I may result in heterotic hybrids with enhanced yield potential and adaptability under Prayagraj agro-climatic conditions.

CONCLUSION

To conclude, the present study established notable genetic variability and divergence among maize hybrids evaluated under the agro-climatic conditions of Prayagraj.

Hybrids like VH19227, VH171310, ZH22698, ZH20379, and VH183007 stood out for their superior performance in multiple morpho - quantitative traits, highlighting their potential for both direct release and use as diverse parental lines in hybrid development.

Special focus should be directed towards traits exhibiting high heritability and genetic advance - most notably field weight, biological weight, and grain weight per plant as they significantly contribute to genetic divergence and hold promise for effective selection. The wide genetic diversity identified in this study offers a strong foundation for improving maize yield, resilience and adaptability, supporting the development of high-performing, region-specific hybrids for eastern Uttar Pradesh.

REFERENCES

Antony, B. J., Kachapur, R. M., Naidu, G. K., Talekar, S. C., Zerka, M. and Harlapur, S. I. 2024. Genetic variability and character association among maize (*Zea mays* L.) Inbred lines. Bangladesh Journal of Botany, 53(1): 57-65.

Banjara, S., Lamichhane, S., Dhakal, K. H., Kunwar, C. B. and Gautam, S. 2025. Agro-morphological and Quality Trait Analysis in Popcorn (*Zea mays* var.

everta): Unveiling Genotypic Potential. Cogent Food & Agriculture, 11(1),: 2516184.

Burton, G.W. and DeVane, E.H. 1953. Estimating heritability in tall fescue (*Festuca arundinacea*) from replicated clonal material. Agronomy Journal, 45: 478-481.

Directorate of Economics and Statistics. 2024. Agricultural statistics at a glance (2024). Ministry of Agriculture & Farmers Welfare, Government of India.

Hasan, N., Jone, M. J. H., Das, B., Siddique, M. N. A., Islam, Y. and Kashem, M. A. 2025. Genetic parameter analysis and evaluation of maize hybrids under local climatic condition of Mymensingh, Bangladesh. Heliyon, 11(1): e41481.

Johnson, R. E., Robison, H. W. and Comstack, H. F. 1955. Estimates of Genetic and environmental variability in rice. Journal of Agronomy, 47, 314-318.

Kachapur, R. M., Patil, N. L., Talekar, S. C., Wali, M. C., Naidu, G., Salakinakop, S. R., Harlapur, S.I., Bhat, J.S. and Kuchanur, P. H. 2023. Importance of mega-environments in evaluation and identification of climate resilient maize hybrids (*Zea mays* L.). Public Library of Science-one, 18(12): e0295518.

Long, S. P. 2025. Needs and opportunities to future-proof crops and the use of crop systems to mitigate atmospheric change. Philosophical Transactions B, 380(1927): 20240229.

Mohanty, K. J., Singh, P. K. and Verma, P. 2025. Evaluating temporal trends and growth dynamics of mustard (*Brassica nigra*) cultivation in Lucknow division of Uttar Pradesh: A two-decade analysis. Proceedings of the Indian National Science Academy, 1-10.

Nadar, C. G., Fletcher, A., Moreira, B. R. D. A., Hine, D., and Yadav, S. 2024. Waste to protein: a systematic review of a century of advancement in microbial fermentation of agro-industrial by products. Comprehensive Reviews in Food Science and Food Safety, 23(4): e13375.

Panse, V.G. and Sukhatme, P.V. 1967. Statistical methods for agricultural workers (2nd Ed.). Indian Council of Agricultural Research, New Delhi, pp. 259.

Singh, K., Singh, V. and Tiwari, D. 2021. Response on growth and yield of maize (*Zea mays* L.) hybrids under agro climatic conditions of Prayagraj (UP). Journal of Pharmaceutical Innovation,10: 1179-1181.

USDA. 2024. World Agricultural Supply and Demand Estimates (WASDE). United States Department of Agriculture.http://www.usda.gov/oce/commodity/wasde/latest.pdf

Usman, S. M., Khan, R. S., Shikari, A. B., Yousuf, N., Waza, S. A., Wani, S. H., Bhat, M.A., Shazia, F., Sheikh, F.A. and Majid, A. 2024. Unveiling the sweetness: evaluating yield and quality attributes of early generation sweet corn (*Zea mays* sub. sp. *sachharata*) inbred lines through morphological, biochemical and marker-based approaches. Molecular Biology Reports, 51(1), 307.

Kiran, E., Neha, T., Abhinav, D. and D. Purvaja. 2025. Evaluation of Maize Hybrids for Morpho-QuantitativeTraits under Prayagraj Agro-climatic Conditions using Mahalanobis D^2 Analysis. The Journal of Research, ANGRAU, 53(3):12-22.

DoI: https://doi.org/10.58537/jorangrau.2025.53.3.03

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EFFECT OF DIFFERENT PACKAGING MATERIALS ON STORAGE QUALITY AND SENSORY EVALUATION OF PIGEON PEA DHAL

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ABSTRACT

Post-harvest losses of pulses primarily result from improper handling and storage conditions. A study was conducted during August 2023 to March 2024 aimed to identify suitable packaging material for storing pigeon pea dhal by evaluating quality attributes and sensory characteristics. Fresh pigeon pea dhal (cv. LRG 52) was stored for 8 months in five different packaging materials: High Density Polyethylene (HDPE), Jute bags, Low Density Polyethylene (LDPE), Biaxially Oriented Polypropylene (BoPP) and Polyethylene Terephthalate (PET) containers, under ambient temperature of 21-37°C and relative humidity (RH) of 26-90 %. Quality parameters such as insect infestation, grain damage, weight loss, moisture content, and cooking time were recorded for every two months. The moisture content (%w.b.) of stored pigeon pea in different packaging materials ranged from 9.13-10.86% in Jute bags, 9.13-9.27% in HDPE, 9.13-9.66% in LDPE, 9.13-8.87% in PET and 9.13-8.94% in BoPP. In HDPE, LDPE and Jute bag, the final moisture content was higher than the initial levels indicating net loss in moisture content, while PET and BoPP showed the opposite trend. The protein content decreased in all packaging materials over the storage period. Further, the grain damage of stored pigeon pea in different packaging material ranged from 0.14-0.33% in HDPE, 0.23-1.05 % in LDPE and 0.34-1.15 % in Jute bags. Grain damage by insects was not detected in pigeon pea samples stored in PET and BoPP material throughout the storage period of 240 days. But infestation was observed after 180 days of storage in HDPE and after 60 days in pigeon pea stored in LDPE and jute bags. The cooking time was less than 16 min for all the pigeon pea samples. Sensory analysis was conducted for non-infested samples and the data was evaluated using fuzzy logic. BoPP proved to be superior packaging material for maintaining the sensory quality of pigeon pea dhal, especially up to 60 days of storage. Taste emerged as the most influential factor in consumer preference, highlighting the importance of preserving flavour during storage. BoPP, with its laminated layers and high barrier properties, retained flavour effectively.

Keywords: BoPP, Fuzzy logic, HDPE, LDPE, Pigeon pea, PET.

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INTRODUCTION

India is the world's largest producer and consumer of pulses, accounting for 36 % of the global area and 26 % of total production. In India, more than 75 % of pulses are marketed and consumed as dehulled splits. The area under pigeon pea cultivation in India covers 5.05 million ha, yielding 4.34 million tonnes with a productivity rate of 859 kg/ha (DES, 2022). Pigeon pea (*Cajanus cajan L.*) is a resilient, shelf-stable, non-perishable crop, but still requires proper handling to minimize post-harvest losses. It is a valuable source of carbohydrates (56 %), protein (24 %), fat (1.2 %) and dietary fibre (20-22 %), along with essential vitamins. Additionally, pigeon pea has a low glycaemic index, lowered amount of fat, cholesterol and is gluten-free, which can be served as a functional food. Pulses, including pigeon pea, play a crucial role in soil and water conservation, food security, malnutrition reduction and poverty alleviation, while also enhancing human health.

Grain storage is a crucial phase aimed at maintaining high-quality standards and ensures grains in good condition from harvest to consumption. Once kernels reach to functional maturity, they should be mowed, dried to optimum level of moisture content, cleaned and stored under optimal conditions to protect them from infestations, microorganisms, rodents, birds and other environmental factors. The storability of grains depends on several key factors, including the type of seed crop, maturity level of seeds, optimum moisture content level, storage environments i.e., (temperature and relative humidity) and harmful insects, birds and rodents. Supplying quality food grains is essential for manufacturing consumer products and supporting farmers in growing healthy crops, which in turn ensures a consistent supply of agricultural outputs and contributes to economic stability. Traditional grain storage and preservation methods have been passed down through generations in many communities. Proper packaging and storage techniques are essential for maintaining the quality and stability (nutritional, physical, pest and fungal resistance, shelf life extension and economic stability) of stored food grains, especially pulses, as poor methods can lead to infestations by pests like *Callosobruchus chinensis*, causing both quantitative and qualitative losses. In India, jute has traditionally been used for bulk packaging of food grains and pulses during transportation from the field to warehouses.

Sensory evaluation, which reflects consumer perceptions, plays a key role in assessing the acceptability of food products. These perceptions are habitually expressed in semantic terms, but they typically lack information about the degree to which various quality attributes influence acceptance or rejection. Fuzzy logic is an appreciated decision-making tool that processes semantic data using a set of approaches to provide more detailed insights. This method has been applied in sensory evaluation for a range of food products, including dragon fruit leather (Raj and Dash, 2022), cookies incorporated with pineapple peel and black rice enriched with anthocyanins. The objective of this study was to assess the effect of different packaging materials viz., high-density polyethylene (HDPE), jute bags, low-density polyethylene (LDPE), biaxially oriented polypropylene (BoPP) bags and polyethylene terephthalate (PET) containers on the quality of pigeon pea dhal during storage. The best packaging material was identified based on key quality parameters such as moisture content, protein content, insect load, grain damage, weight loss, cooking time and sensory data. Fuzzy logic was employed to analyse the sensory data of the stored pigeon pea dhal in different packaging material.

MATERIAL AND METHODS

Procurement of raw material and sample preparation

Fresh pigeon pea (cv. LRG 52) was sourced from e-NAM (electronic National Agriculture Market), and was cleaned to remove foreign material, as well as immature and damaged grains. After cleaning, the grains were dried at room temperature until they reached a milling moisture content of 10±0.5 %. The dried grains were then milled using a PKV mini dhal mill (India) and sorted manually to remove un-hulled and damaged grains. Five different packaging materials namely high-density polyethylene (HDPE), jute bags, low-density polyethylene (LDPE), biaxially oriented polypropylene (BoPP) bags and polyethylene terephthalate (PET) were purchased from the local markets of Bapatla, Andhra Pradesh.

Packing of the samples

Approximately 1 kg of the milled and decorticated pigeon pea splits were packed into five different packaging materials: jute (gunny) bags, LDPE, HDPE, BoPP and PET containers shown in Fig.1. The jute bags and BoPP were sealed using a portable stitching machine, while LDPE and HDPE were thermo-sealed with a hand sealing machine (Sepack, India). The quality parameters such as moisture content, protein content, weight loss, cooking time, insect infestation and grain damage of the packed pigeon pea dhal samples were evaluated for every two months over a period of 8-month (240 days). Environmental factors like temperature and relative humidity were recorded daily in the laboratory throughout the storage period.

Moisture content

Moisture content is a vital factor in ensuring the quality and shelf life of cereals and pulses. Moisture content of the pigeon pea was determined by hot air oven method (Yewle *et al.,* 2020). Approximately five grams of pigeon pea were placed in a pre-weighed aluminum moisture box and dried in a hot air oven (Model: AI-7981, Make: Bio Scientific India, India) at 105°C for 24 hours. After drying, the box containing the sample was removed from the oven, placed in a desiccator for 5 minutes to cool, and then weighed to record the final weight.The moisture content of the samples was calculated by using Eq. (1) below and represented on wet basis.

$$\text{Moisture content, m, \% w.b.} = \frac{W_m}{W_m+W_d} \times 100 \quad (1)$$

where, W_m is the weight of moisture, g,

W_d is the weight of bone-dry material, g

Insect load

Most post-harvest losses of cereals and pulses are caused by insects, which can inflict significant damage during storage by feeding on grains, contaminating them and accelerating deterioration. Therefore, assessing insect load during the storage of pigeon pea is essential. In this study, insect load was calculated by dividing the number of adults that emerged by the number of eggs laid (Eq. 2). To observe the total number of adult insects, a 500 g sample was taken and sieved using standard 2.00 mm sieves (Prajapati *et al.,* 2022)

$$\text{Insect load (\%)} = \frac{\text{No.of adults emerged}}{\text{Number of eggs laid}} \times 100 \quad (2)$$

Grain damage

Grain damage was assessed by randomly selecting 500 grains using a digital seed counter (Model: 6736709-SCP, Make: Osaw Industrial Products Pvt. Ltd, Haryana, India). The number of damaged grains in the sample was counted manually. The extent of

grain damage was then calculated using Eq. 3 (Patel *et al.,* 2018).

$$\text{Grain damage (\%)} \frac{\text{Number of damaged graing}}{\text{Number of graine in sample}} +(3)$$

Loss of weight due to infestation

Weight loss of pigeon pea during storage was evaluated by selecting 100 grains randomly. Then the weight loss due to infested grains (B) and the weight of healthy grains (A) were recorded from the composite sample. The percentage of weight loss was then calculated using Eq. 4 (Revathi *et al.,* 2015).

$$\text{Weight loss (\%)} \frac{A-B}{A} \times 100 \quad (4)$$

Protein Content

Protein content of pigeon pea was quantified using the procedure described by (Rizvi *et al.,* 2022). Briefly, 0.1 mL of the sample was mixed with 0.1 mL of 2 N NaOH, then hydrolyzed at 100 °C for 10 min in a boiling water bath. After cooling the hydrolysate to room temperature, 1 mL of freshly prepared complex-forming reagent was added. The solution was left to stand at room temperature for 10 min and then added with 0.1 mL of Folin-Ciocalteu reagent, mixed with a vortex mixer. The mixture was then allowed to stand at room temperature for 30–60 min (not exceeding 60 min). The absorbance was measured at 650 nm using spectrophotometer (Rayleigh UV-9200, Beijing) and protein content was calculated using Eq. 5

$$\text{Concentration of Test} = \frac{\text{OD of Test}}{\text{OD of standard}} \times \frac{\text{Concentration of standard}}{\text{Volume of Test}} \times 100 \quad (5)$$

Cooking time

Cooking time was measured as the time when 90 % of the sample became soft enough to chew. 150 ml of distilled water was heated in a water bath to 95°C and then 15 g of pigeon pea was added to the beaker. Samples were drawn from the beaker at 1 min interval for the determination of cooking time. Cooking time was recorded when the sample core was soft enough to press in between the thumb and forefinger.

Sensory assessment of cooked pigeon pea by using fuzzy logic

Twenty samples of pigeon pea were obtained by combining different packaging materials with varying storage periods. Samples that are safe for consumption were selected for the sensory evaluation based on the insect load and grain damage during storage. Sensory evaluation and fuzzy logic analysis were performed based on the method described by (Raj and Dash, 2022). A panel of judges were selected from the faculty and research scholars of Dr. NTR College of Agricultural Engineering, ANGRAU, Bapatla to perform the sensory evaluation of pigeon pea stored in different packaging material and the selected panellist age group was 23 to 45 years. All selected panellists were non-smokers and reported to be in good physical and mental health, ensuring suitability for sensory evaluation.The quality attributes evaluated in the present investigation included color (Co), odor (Od), taste (Ta) and overall acceptability (Oa). Sensory assessment was conducted using a 5-point hedonic scale.Food of any kind was prohibited for panellists to consume one hour before the sensory evaluation.The panel members were made to comprehend the selected quality factors for sensory evaluation such as taste, colour, odour and overall acceptability. Sensory analysis was done for stored produce by keeping dhal to hot water in the ratio of 5:10 in a beaker at a temperature of 90°C for 2 min. The panellists also clarified the scoring pattern that was to be used, which involved using a template for the results of a

sensory assessment. The samples were evaluated independently by the chosen panel members based on how well they satisfied particular sensory attributes. Panellists were apprised to put their preference in the form of tick against the fuzzy scale template for each quality parameter sample according to their perception.

After completing the sensory evaluation by thepanellists, the recorded linguistic data was used for fuzzy logic evaluation performed with MATLAB R2017b (The Math Works Inc). These phases involved in the fuzzy logic assessment were: Estimating the overall sensory scores of stored pigeon pea in the form of triplets, estimating similarity values and ranking the stored pigeon pea and estimating similarity values and ranking the quality attributes generally for stored pigeon pea.

Statistical analysis

All the quality parameters data were replicated thrice and represented as mean ± standard deviation. Using IBM SPSS software, an analysis of variance (ANOVA) and Duncan multiple range test at ($p<0.05$) were used to determine whether there was a significant difference between the mean samples.

RESULTS AND DISCUSSION

The results obtained from the evaluation of various quality parameters of pigeon pea, along with the findings from the experiment investigating the impact of various packaging materials on the duration of storage, are discussed below:

Moisture Content

The initial moisture content of fresh pigeon pea was found to be 9.13±0.04 (% w.b). The moisture content (% w.b.) of pigeon pea in different packaging material varied throughout the storage period as follows: PET (8.87-9.13 %), BoPP (8.94-9.13 %), HDPE (9.13-9.27 %), LDPE (9.13-9.66 %) and Jute (9.13-10.86 %) shown in Fig. 2. For the samples stored in BoPP, HDPE and LDPE, moisture content significantly increased up to 180 days. However, in PET and Jute bags, moisture content initially increased up to 120 days and then decreased after 120 days of storage. The final moisture content in PET and BoPP was lower than the initial levels, which may be due to the barrier properties of the packaging material that restricted the sample exposure to the environment conditions like humidity and temperature. This might have created a low respiration rate and limited the migration of moisture from environment to the sample and vice versa. Pigeon pea stored for 240 days in HDPE, LDPE and Jute has moisture content higher than the initial moisture content. The reason for higher moisture than the initial may be due to high thermal expansion, high gas permeability and poor barrier properties of the packaging material.

Similarly, Sethi (2014) reported a moisture increase in HDPE - packed samples from 6.04% to 6.39 %.A similar result was observed in HDPE bags (8.56 %) for pigeon pea splits (Harika *et al.* 2024). There was no significant change in moisture content for samples stored in PET and LDPE (60 and 120 days), BoPP (180 and 240 days), and HDPE (120 and 180 days), as presented in Fig. 1. From Fig.1, it can be observed that there is significant difference in moisture content between the packaging materials at a particular storage day ($p<0.05$).

Insect load

Favourable environmental factors including relative humidity, temperature and wetness have an impact on the evolution of insects. Fig. 3 illustrates the insect load of stored pigeon pea with respect to different packaging material. The adult insect population in the Jute bag and LDPE increased significantly with increase of storage period.

More number of insect population in Jute bags and LDPE could be attributed to their poor barrier properties. Yewle *et al.*(2020) observed in green gram that infestation was higher in jute bags (83 insects/500g) compared to hermetic bags and plastic containers during 180 days of storage. Satasiya *et al.,*(2021) also reported highest insect populationin chickpea grain stored in jute bags (268 insects/500g) at the end of twelve months. At the end of four months, insect load with 46 insects/500g in in chickpea stored in jute bags over twelve months of storage period (Patel *et al.*, 2018). A higher population of insects in wheat grain was observed after 150 days in cloth bag by Atta *et al.*,(2020). The highest number of adult insects was recorded in the Jute bag (197 insects/500g), followed by LDPE (16 insects/ 500g) after 8 months of storage period. No adult insects were observed in samples stored in PET and BoPP throughout the storage period, in contrast, insect pest infestation in split pulses stored was negligible in HDPE after 180 days (6 insects/500g). However, insects were drawn to processed pulse grains kept in woven polymer bags and jute lined with polythene, causing damage and product loss and demonstrating the grains vunerability to both insect activity and deterioration, HDPE bags showed zero infestation throughout the year (Patel *et al*., 2018). Transparent polyethylene bags have been shown to reduce pest infestation in pigeon peas (Vishwakarma *et al.,*2019). Insect load in pigeon pea samples stored in HDPE, LDPE, and jute bags was found to be significant over time. However, no significant difference was observed between LDPE and Jute bags with respect to the storage period ($p<0.05$).

Loss of weight due to infestation

Weight loss in HDPE, LDPE and Jute bag ranged from 2.85% to 19.06% (Table 1). The weight loss by insects due to infestation was found to be increased in jute bag and LDPE during entire storage period i.e., 240 days. Jute bags rapidly absorb moisture and provide minimal protection against insect infestation. Jute bag also easily absorbs humidity and offers little resistance to the attacks of insects. These results are in agreement with Satasiya *et al.*,(2021) for chickpea grain in which higher weight loss of 16.91% was recorded. Contradictory results were conveyed by Nehra *et al.,*(2021) that the maximum weight loss per cent of black gram was recorded in polythene bag (73.42 %) followed by jute bag (19.76 %). LDPE grows wide, soft, weak in high temperature and is permeable to gases like carbon dioxide. Insect eating is the primary source of weight loss. When insect populations are high, grains may develop weevil infestations that damage the grain's outer layer and obstruct its edible interior, which lowers the grain's weight.Weight loss is caused by the feeding of insects and in some situations, insect load was more due to which the grains may form weevil causing pulses to degrade by damaging the outer layer and obstructing the inside edible sections of the grain and lowered the weight. However, during the initial 120 days of storage period, weight loss in HDPE was not observed. HDPE is sensitive to stress cracking in suboptimal environments and has poor weathering resistance. No weight loss was observed in PET and BoPP during entire storage period because PET has high tensile strength and is shatterproof. BoPP films are resistant to moisture, temperature and relative humidity by which insects find it difficult to survive (Kumar Vinayak *et al.*, 2022). Samples stored in jute bag resulted the highest weight loss of 19.06 % followed by LDPE 16.42 % and HDPE 9.16 % after 240 days of storage period. The order of the packing components to minimize the weight loss of the seeds was: HDPE> LDPE >Jute bags. Weight loss in the pigeon pea samples stored in HDPE, LDPE and jute bag

was significantly different with respect to time and no significant results were observed in LDPE and jute bag with respect to storage period ($p<0.05$).

Grain Damage

It was observed that the grain damage in Jute bag, LDPE increased with increase of storage period (Fig.4). Dhal stored in jute bag recorded the highest grain damage (1.15 %) at the end of storage period. Adult insects have emerged that are capable of damaging the grain.These findings are consistent with those of Nehra *et al.,* (2021), who reported that seed damage in black gram decreased in the order: polythene bags > gunny bags > cloth bags > jute bags. Maximum grain damage was found only in jute bag (26.30 %) at the end of twelve months of storage period (Patel *et al.*, 2018).

In HDPE, after 6 months of storage period damaged grains were observed.The probable reason for grain damage was due to high respiration and metabolic changes that occurred in seeds, which may have led to an increase in insect attacks. PET and BoPP were free from grain damage during entire storage period. Grain damage in the pigeon pea samples stored in HDPE, LDPE and jute bags was found to be significant over time. During the storage period, significant differences were observed among the packaging materials-HDPE, LDPE and jute bags ($p < 0.05$)

Protein content

The initial protein content of pigeon pea was found to be 22.60 % and it decreased in all the samples stored in different packaging materials with advancement of storage period (Fig.5 and Table 2). At the end of storage period of 240 days, higher amount of protein content retained in the samples stored in PET (21.91 %) whereas samples stored in jute bag resulted significantly lowest protein content at 21.19 %. Satasiya *et al*., (2021) reported that chickpea grains stored in jute bags exhibited a significantly lower protein content (13.78%) after a twelve-month storage period. This reduction in protein can be attributed to weevil infestation, as these insects primarily feed on the grain's endosperm. However, they may also target the embryo, which contains a substantial portion of the grain's protein and vitamins, thereby exacerbating nutrient losses.Protein content in BoPP after 8 months of storage was marginally lower than the PET. It could be explained by the oxidation of amino acids, a rise in respiratory activity and moisture content brought on by the grains' deterioration during storage. Protein content of pigeon pea stored in HDPE after eight months was 21.66 % which is lower than the initial level. Protein content obtained in samples stored in LDPE was 21.41 % which is slightly higher than the samples stored in Jute bag over 240 days of storage period.

Protein content in the pigeon pea samples stored in PET (120,180 and 240 days), BoPP (120 and 180 days) and HDPE (60 and 120 days) was found to be non-significant. The effect of packaging material during storage period in PET (180 days), BoPP (60, 120 and 180 days), HDPE (60, 120 and 240 days), LDPE (60 and 240 days) and jute bag (60 days) were non- significant ($p<0.05$). As the level of infestation increases, there was decrease in the true protein content of pigeon pea. The decrease in true protein content might have been due to the reason that more non protein nitrogenous substances are produced by insects. Proteins are also utilized by insects for their growth. The results for protein content align with those reported by Satasiya *et al*., (2021), who found the lowest protein content (13.78%) in chickpea grains stored in jute bags, while the highest average protein content (18.80%) was recorded in grains stored in HDPE with vacuum packaging (HDPEV) at the end of storage period.

Cooking time

Cooking time of pigeon pea stored in different packaging materials ranged from 14.44-15.58 min (Table 3). As the levels of infestation increased, increase in the cooking time was observed over 240 days of storage period. The final cooking time in all the packaging materials was higher than the control sample cooking time. The jute bag resulted in a significantly higher cooking time (15.58 min) over the 8-month storage period. This may be attributed to the formation of a hardened surface of the dhal due to direct exposure of environmental factors such as moisture and air permeability through the jute material. Such conditions can lead to physiological hardening of the grains, thereby increasing cooking time. In contrast, Satasiya *et al*., (2021) reported that jute bags resulted in significantly lower cooking time for chickpea grains during a 12-month storage period. This discrepancy could be due to differences in crop type, environmental conditions, or storage management practices. Notably, the lowest cooking time in the present study was observed in PET containers (14.58 min), which may be due to their zero infestation level and reduced respiration rate, resulting in minimal changes to seed structure and internal moisture content. The cooking time for the pigeon pea dhal stored in BoPP after 240 days of storage period was observed to be 15.04 min. It is because of pre-fabricated multilayer laminated pouch protecting them from moisture and oxygen. Cooking time of the samples stored in LDPE after 240 days of storage was 15.56 min which is slightly lower than the jute bag. Because of having poor UV resistance and exposure to sunlight the gum layer was hardened. The maximum cooking time for the stored pigeon pea after completing of storage time was recorded in jute bag (15.58 min) followed by LDPE (15.56 min), HDPE (15.43 min), BoPP (15.04 min) and PET (14.58 min), presented in Table 2. Cooking time for stored pigeon pea samples in PET after 180 and 240 days was found to be non-significant at $p<0.05$. The effect of packaging material during storage period in PET (60 days) and BoPP (60 days), LDPE (240 days) and jute bag (240 days) was found to be non- significant ($p<0.05$), as shown in Table 2.

Similarity values of pigeon pea stored in different packaging material and their ranking by fuzzy logic analysis

The infested pulses were unfit for the consumption as they produce uric acid which may contribute to health problems, such as gout and kidney stones that can harm the health of human beings. Therefore, out of 20 samples a total of 10 samples which were fit for consumption were selected for sensory analysis. For better understanding, the selected pigeon samples were represented with notation (Table 4). Similarity values of pigeon pea stored in different packaging material were presented in Table 5 along with their ranking. All the nine samples except pigeon pea stored in BoPP for 240 days (B_{240}) were selected under the category of 'very good' based on the similarity values. The sample was least preferred by the panellists under the category of good with similarity value (0.722) and was most preferred by the judges under the category of very good with similarity value (0.823). The ranking of the ten samples is as follows:>H_{60}> P_{60}> B_{120}> P_{120}> P_{180}> H_{120}>P_{240}>. The higher liking of dhal stored in BoPP over a 60-day storage period could be attributed to its ability to retain key quality attributes essential for human consumption. BoPP packaging effectively prevents changes in odour, colour, and overall acceptability, thereby preserving the sensory qualities of the product.Taste was found to be affected as the storage period increased probably due to lipolytic changes; hastened by increase in moisture content in stored pigeon pea sample.

Table 1. Weight Loss due to infestation in different packaging material during storage period

Days	PET	BOPP	HDPE	LDPE	JUTE
60	-	-	-	2.85±0.02^{bQ}	4.87±0.01^{aP}
120	-	-	-	6.98±0.01^{bQ}	11.64±0.01^{aP}
180	-	-	5.91±0.01^{cR}	10.30±0.00^{bQ}	14.53±0.02^{aP}
240	-	-	9.16±0.01^{cR}	16.42±0.01^{bQ}	19.06±0.00^{aP}

Table 2. Protein content of dhal stored in different packaging material during storage period

Days	PET	BOPP	HDPE	LDPE	JUTE
0	22.60±0.00^{aP}	22.60±0.00^{aP}	22.60±0.00^{aQ}	22.60±0.00^{aR}	22.60±0.00^{aS}
60	22.35±0.25^{bP}	22.01±0.02^{bQR}	21.93±0.02^{bQR}	21.91±0.02^{bQR}	21.75±0.03^{bQR}
120	22.01±0.02^{cP}	21.93±0.02^{cQ}	21.91±0.02^{bQ}	21.75±0.03^{cR}	21.66±0.04^{cS}
180	21.93±0.02^{cP}	21.91±0.02^{cP}	21.75±0.03^{cQ}	21.66±0.04^{dR}	21.41±0.02^{dS}
240	21.91±0.02^{cP}	21.75±0.03^{dQ}	21.66±0.04^{dR}	21.41±0.02^{eR}	21.20±0.01^{eS}

Table 3. Effect of different packaging material on cooking time of pigeon pea during storage period

Days	PET	BOPP	HDPE	LDPE	JUTE
0	14.44±0.01^{cP}	14.44±0.01^{eP}	14.44±0.01^{eP}	14.44±0.01^{eP}	14.44±0.01^{dP}
60	14.46±0.01^{cS}	14.47±0.01^{dS}	15.00±0.01^{dR}	15.32±0.01^{dQ}	15.38±0.01^{cP}
120	14.53±0.02^{bT}	14.56±0.01^{cS}	15.32±0.01^{cR}	15.38±0.01^{cQ}	15.43±0.02^{bP}
180	14.57±0.01^{aT}	15.02±0.01^{bS}	15.38±0.01^{bR}	15.43±0.02^{bQ}	15.56±0.02^{aP}
240	14.58±0.01^{aS}	15.04±0.01^{aR}	15.43±0.02^{aQ}	15.56±0.02^{aP}	15.58±0.01^{aP}

Table 4. Selected pigeon samples along with the notation

Sl.No	Sample	Notation	Sl.No	Sample	Notation
1	PET stored for 60 days	P_{60}	**6**	BoPP stored for 120 days	B_{120}
2	PET stored for 120 days	P_{120}	**7**	BoPP stored for 180 days	B_{180}
3	PET stored for 180 days	P_{180}	**8**	BoPP stored for 240 days	B_{240}
4	PET stored for 240 days	P_{240}	**9**	HDPE stored for 60 days	H_{60}
5	BoPP stored for 60 days	B_{60}	**10**	HDPE stored for 120 days	H_{120}

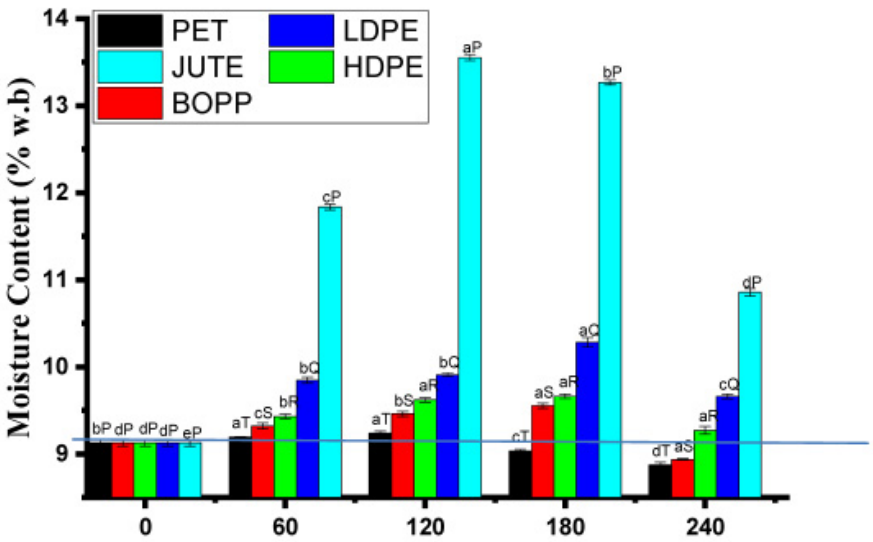
Table 5. Similarity values and ranking of pigeon pea stored in different packaging materials by fuzzy logic

Sensory scale	P_{60}	P_{120}	P_{180}	P_{240}	H_{60}	H_{120}	B_{60}	B_{120}	B_{180}	B_{240}
Not satisfactory	0	0	0	0	0	0	0	0	0	0
Fair	0.013	0.018	0.023	0.041	0.009	0.026	0.004	0.015	0.048	0.073
Satisfactory	0.195	0.216	0.237	0.306	0.172	0.257	0.146	0.202	0.323	0.369
good	0.561	0.579	0.597	0.674	0.533	0.622	0.501	0.564	0.693	**0.722**
very good	**0.817**	**0.798**	**0.775**	**0.732**	**0.821**	**0.767**	**0.823**	**0.806**	**0.722**	0.656
excellent	0.384	0.348	0.314	0.257	0.417	0.300	0.448	0.372	0.237	0.180
Rank	III	V	VI	VIII	II	VII	I	IV	IX	X

Table 6. Similarity values of quality attributes for stored pigeon pea and their ranking

Sensory scale	Color	Odour	Taste	Overall acceptability
not satisfactory	0.000	0.000	0.000	0.000
fair	0.000	0.000	0.000	0.000
satisfactory	0.000	0.000	0.000	0.000
good	0.296	0.152	0.080	0.248
very good	**0.919**	**0.800**	0.680	**0.895**
excellent	0.548	0.685	**0.778**	0.597
Rank	II	IV	I	III

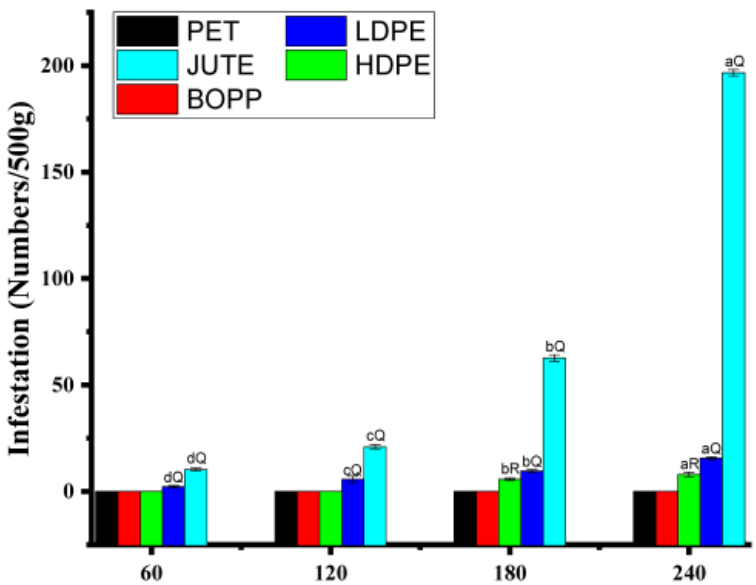
Fig.1. Pigeon pea dhal stored in different packaging materials (a) BoPP; (b) HDPE; (c) LDPE; (d) PET; and (e) Jute bag



* PQRST indicates significant difference between different packaging materials at a particular storage period ($p<0.05$)

* abcde indicates significant difference between different storage days for a particular packaging material ($p<0.05$)

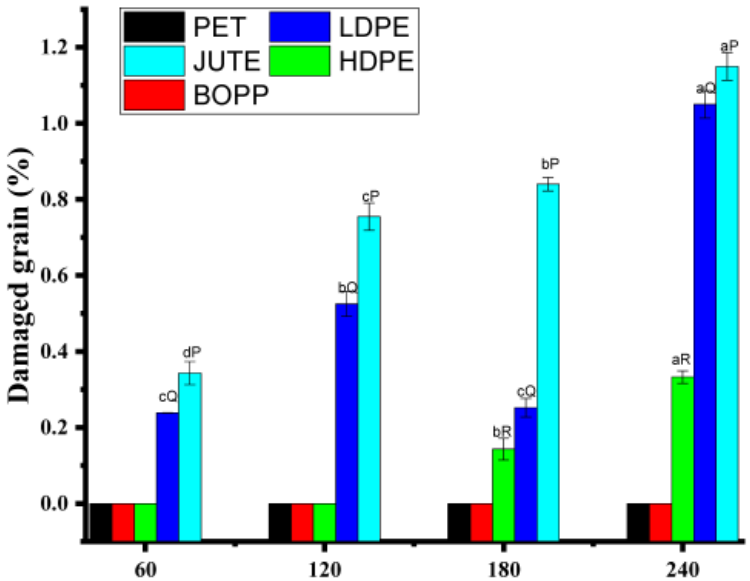
Fig.2. Effect of different packaging materials on moisture content of pigeon pea dhal during storage period



* PQRST indicates significant difference between different packaging materials at a particular storage period ($p<0.05$)

* abcd indicates significant difference between different storage days for a particular packaging material ($p<0.05$)

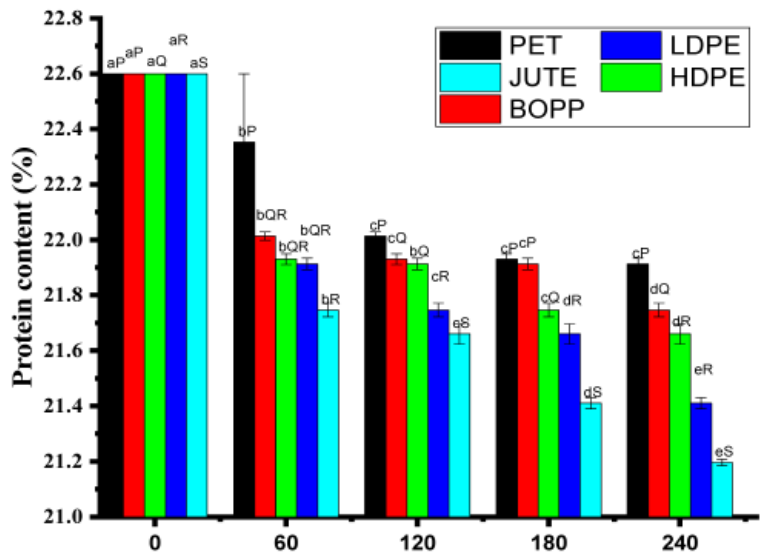
Fig.3. Effect of different packaging materials on insect population (number/500g) of pigeon pea during storage period



* PQRST indicates significant difference between different packaging materials at a particular storage period ($p<0.05$)

* abcd indicates significant difference between different storage days for a particular packaging material ($p<0.05$)

Fig.4. Effect of different packaging materials on damaged pulses of pigeon pea dhal during storage period



* PQRST indicates significant difference between different packaging materials at a particular storage period ($p<0.05$)

* abcde indicates significant difference between different storage days for a particular packaging material ($p<0.05$)

Fig.5. Effect of different packaging materials on protein content of pigeon pea dhal during storage period

Similarity values of quality attributes selected for the stored pigeon pea and their ranking by fuzzy logic analysis

The quality parameters preferred for stored pigeon pea were taste (T), colour (C), odour (*Od)*, and overall acceptability (*Oa*). By using standard fuzzy scale, ranking of selected quality parameters of stored pigeon pea in general was accomplished. Based on the sensory score given by the selected panel members the similarity values for quality attributes provided by Fuzzy logic analysis (Table 6). From the Table 6, it was seen that the taste had the highest similarity value (0.778) in the excellent category and the lowest value (0.800) in the very good category. On the other hand, the similarity values for the other two quality attributes - color (0.919) and overall acceptability (0.895) - fall into the very good category. This indicates that taste is the primary quality characteristic and is regarded as the most important quality criteria for pigeon pea dhal, followed in order by color, overall acceptability and odour.

CONCLUSION

After 240 days of storage, grains stored in jute bags recorded the highest losses due to infestation (19.06%), the largest insect population (197 insects/500 g), and the greatest proportion of damaged grains (1.15%). In contrast, no infestation or grain damage was observed in PET and BOPP packaging during the entire storage period. Moisture content varied notably among packaging materials. Jute bag samples reached the highest moisture content (13.55%) after 120 days, whereas PET maintained the lowest moisture content (8.87%) after 240 days. PET consistently recorded the minimum moisture content throughout the storage period. Protein content was best preserved in PET containers, with an average maximum value of 21.91% after 240 days. The lowest protein level (21.19%) was observed in jute bag storage at the end of the storage period, though variations among other packaging materials were minimal. Cooking time tests after eight months revealed that pigeon pea grains stored in PET required the least cooking time (14.58 minutes). The longest cooking time was recorded in jute bag storage (15.58 minutes), followed by LDPE (15.56 minutes), HDPE (15.43 minutes), and BOPP (15.04 minutes).

Considering the quality parameters, it may be concluded that pigeon pea dhal stored in PET containers and BoPP retained quality for up to 240 days of storage, due to the hermetic conditions provided by these packaging materials. In sensory analysis, panellists preferred the sample stored for 60 days in BoPP and PET for quality attributes such as taste, odour, colour, and overall acceptability. Since both PET and BoPP offer similar barrier properties that help maintain hermetic conditions, PET containers are recommended over BoPP for long-term storage. Thus, PET packaging emerges as a practical solution for preserving quality and reducing post-harvest losses in pigeon pea storage.

REFERENCES

Atta, B., Rizwan, M., Sabir, A. M., Gogi, M. D. and Ali, K. 2020. Damage potential of *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) on wheat grains stored in hermetic and non-hermetic storage bags. International Journal of Tropical Insect Science, 40(1), 27–37.

Directorate of Economics and statistics, Ministry of Agriculture and Farmers welfare.2022

Harika, P., Swamy, S. V. S. G., Kumar, G. V. S. and Rao, C. V. 2024. Storage quality of dehulled split pulses as influenced by

packaging material. Journal of Stored Products Research, 107, 102322.

Kumar Vinayak, A., Kumar, V. and Venkatachalam, S. 2022. Moisture Barrier Behavior of Polymer Films On Food Packaging Plastic Materials. International Journal For Technological Research In Engineering,9(5), 2347–4718. https://doi.org/10.5281/zenodo.6348202

Nehra, S., Swami, H. and Chhangani, G. 2021. Assessment of various packaging materials for pulse storage against pulse beetle *(Callasobruchus chinensis L .)*. 10(9), 554–558.

Patel, J. V, Antala, D. K. and Dalsaniya, A. N. 2018.Influence of Different Packaging Materials on the Seed Quality Parameters of Chickpea.7(12), 2458–2467.

Prajapati, A. R., Panickar, B. K., Chandaragi, M. K., Padhiyar, B. M. and Dave, G. S. 2022. Biochemical basis of resistance in different pulses against pulse beetle (*Callosobruchus maculatus Fabricius*). Journal of Experimental Zoology India, 26(1), 423–430. https://doi.org/10.51470/jez.2023.26.1.423

Raj, G. B. and Dash, K. K. 2022. Development of Hydrocolloids Incorporated Dragon Fruit Leather by conductive hydro drying: Characterization and Sensory Evaluation. Food Hydrocolloids for Health, 2(March), 100086. https://doi.org/10.1016/j.fhfh.2022.100086

Revathi, K., Sreekanth, M., Krishnayya, P. V, and Rao, V. S. 2015. Incidence of pod fly, *Melanagromyza obtusa* (Malloch) and its influence on weight loss in different pigeonpea genotypes. International Journal of Innovative Science, Engineering & Technology, *2*(5), 460–464.

Rizvi, N. B., Aleem, S., Khan, M. R., Ashraf, S., and Busquets, R. 2022. Quantitative Estimation of Protein in Sprouts of *Vigna radiate* (Mung Beans), *Lens culinaris* (Lentils), and *Cicer arietinum* (Chickpea) by Kjeldahl and Lowry Methods. Molecules, *27*(3). https://doi.org/10.3390/molecules27030814

Satasiya, R. Me., Antala, D. K., Sojitra, M. A., Kothiya, A. V. and Chauhan, P. M. 2021. Effect of packaging on storage behaviour of chickpea grain. Journal of Pharmacognosy and Phytochemistry, 10(1), 1575–1584.

Sethi, S. 2014. Development and quality evaluation of quick cooking dhal-A convenience product.51(March), 595–600. https://doi.org/10.1007/s13197-011-0534-6

Vishwakarma, R. K., Jha, S. N., Dixit, A. K., Kaur, A., Rai, A. and Ahmed, T.2019. Assessment of harvest and post-harvest losses of major pulses in India. Agricultural Economics Research Review,32(2), 247–258.

Yewle, N., Charpe, A. M., Gupta, S., Patil, B., Tushir, S. and Mann, S. 2020. Impact of hermetic packaging on green gram (*Vigna radiata*) insect and microbial damage under environmental storage condition. Journal of Entomology and Zoology Studies, *8*(5), 1883–1887. https://doi.org/10.22271/j.ento.2020.v8.i5z.7766

Mohammod Jeelani, S, Vasudeva Rao, V., Sandeep Raja, D., Gopalaswamy, S.V.S. and Edukondalu, L. 2025. Effect of Different Packaging Materials on Storage Quality and Sensory Evaluation of Pigeon Pea Dhal. The Journal of Research ANGRAU, 53(3): 23-36.

DoI: https://doi.org/10.58537/jorangrau.2025.53.3.04

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PERFORMANCE EVALUATION OF TRACTOR OPERATED SIX ROW PLANTER-CUM-FERTILIZER DRILL FOR MILLETS and OTHER CROPS

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ABSTRACT

Millets are the most useful grain crops as they are nutritious and can withstand climate changes.Performance evaluation of tractor operated 6 row planter with fertilizer drill for millet – multi crops (CIAE design) were carried out to determine the field efficiency, effective field capacity and time required to plant during years, 2022-23 and 2023-24. The field capacity of the planter was 0.32 hah^{-1} with field efficiency 53.87 percent. The average depth of sowing was 55 mm. The cost of operation of tractor operated millet planter on finger millet crop was found Rs.2084 ha^{-1} whereas in traditional method it was Rs.8283 ha^{-1}. Thus, there was a saving of amount Rs.6199 ha^{-1}. The performance of the tractor operated 6 row planter with fertilizer drill for millet –multi crops (CIAE design) was found satisfactory and economical and can be adopted for millet and other crops (small grains) planting by small land holding farmers.

Keywords: Finger millet, Field capacity, Field efficiency, Millet planter

INTRODUCTION

Millets are a nutritious, climate change-ready crops with highpotential for yielding higher economic returns in marginal conditions in comparison with other cereals even in case of climate change such asharsh temperature conditions (Sadhukhan and Debangshi, 2023). Millets are important but underutilized crops in tropical and semiarid regions of the world due to their greater resistance to pests and diseases, good adaption to a wide range of environments and good yield of production, can withstand significant levels of salinity, short growing season, resistance to water logging, drought tolerance, requires little inputs during growth and with increasing world population and decreasing water supplies represents important crop for future.(Chandra *et al.*, 2016).

Millet is a collective term referring to several small seeded annual grasses, belonging to the botanical family Poaceae, which are cultivated as grain crops, primarily on marginal lands in dry areas in temperate, subtropical and tropical regions. Millets are known as “Nutrition powerhouses” (Paliwal *et al.,* 2023). Despite having various advantages, total area harvested is declining since a few decades. It may be due to the lower cost of the produce, less area under cultivation and

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lower level of mechanization in all production operations. Millets are mostly cultivated during Kharif season in India. According to data from the Agriculture Ministry, three millet crops namelybajra (3.67%), jowar (2.13%), and ragi (0.48%) accounted for nearly 7.00% of the nation's gross cultivated area about 15.48 mllion hectare in 2018 to 2019.

In India, millets are sown by broadcasting and drilling method by traditional implements. The use of such devices results in non-uniform distribution of seeds which results in excess plant population and uneven spacing. Non-uniformity in seed spacing and plant population results in reduced crop yield. Uniformity of seed spacing is an important factor in designing the seed metering device. Besides the design of metering device, there are other operational parameters that affect the precision distribution of seeds. The seed metering device may not singulate seeds and sometimes results in more spacing between plants and overcrowded plants. Broadcasting and drilling methods hinder in intercultural operations and effective weed control. Harvesting operations become more effective if sowing is done in line rather than broadcasting.

The main reasons for reduction in millet production area are more sowing and transplanting time, high labour requirement, small size plots and low level of mechanization. Research targeting mechanized crop production is greatly inclined to highpowered equipment, not easily affordable by small marginal farmers and mostly suited for large grains crops. Mechanized seeders currently available are used for large-seeded crops and cannot be used for finger millet as their metering mechanisms release large quantities of seed in a furrow, necessitating another tedious exercise of thinning.

Since the manual, hand push and animal driven methods of grain planting result in low seed placement, low spacing efficiencies and severe drudgery for the farmers which limit the size of field that can be planted. The design and production of tractor operated planters have eliminated most of the limitations attached to the manual and animal driven methods.

Since millet grains are small in size, it is very difficult to singulate seeds and obtain uniform spacing in rows without much scattering with commonly used fluted roller metering in seed drills. The fluted roller type device is not suitable for metering small seed like millets in general, kodo and little millet in particular due to smaller size and subjected to mechanical damages. Similarly, commonly used metering devices in the planters such as vertical plate, inclined plate and horizontal plate with cells/cups/slots over the periphery also causes the non-uniformity and seed damage (Nandede *et al.,* 2018).

Nandede *et al.* (2018) developed a manually operated single row millet planter-cum-fertilizer drill and reported that for kodo millet average seed spacing, seed rate and coefficient of uniformity of the planter were 5.90 cm, 4.50 kg ha^{-1} and 0.90, respectively. Nandede *et al.* (2018) and Kumar *et al.* (2018),conducted research on performance testing of planters in major crops.However, the above developed machines have their own advantages and limitations for small and marginal farmers. Therefore, considering the above facts, a study was carried out to evaluate the performance of the multi-crop tractor operated planter for small sized seeds like finger millet.

MATERIAL AND METHODS

Specifications of Tractor operated 6 row planter with fertilizer drill for millet and other crops.

Tractor operated 6 row planter with fertilizer drill for millet (CIAE design) consists

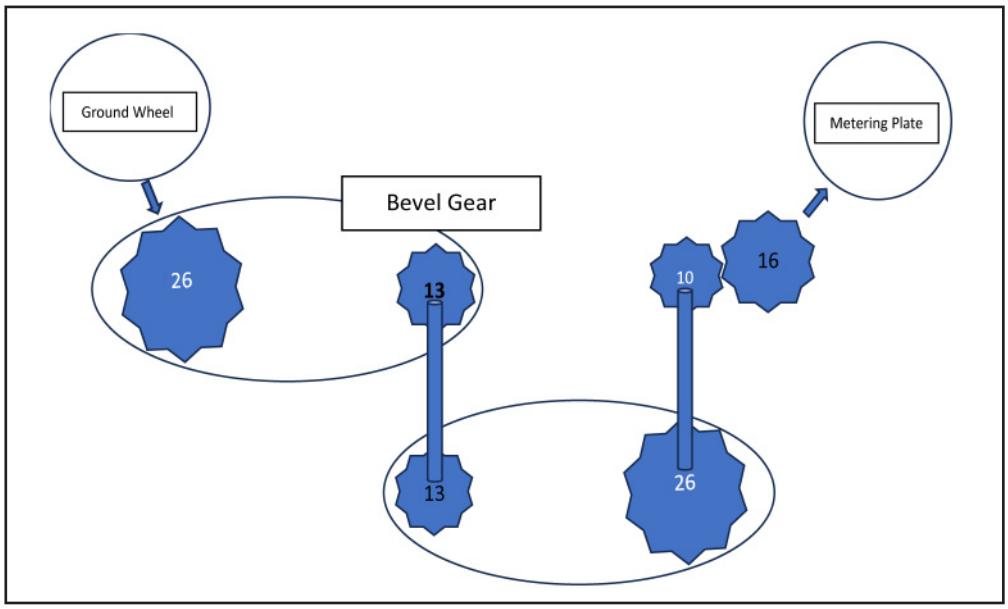


Fig.1. Sprocket setting of Tractor operated 6 row planter with fertilizer drill for millet - multi crops (CIAE design)

of main frame, inclined plate seed metering device, seed hopper, seed tube, fertilizer box, furrow openers and ground drive wheel. Hopper is a storage structure for holding seeds and fertilizers during sowing. Hopper consists of 6 compartments for seeds and fertilizer with 5 kg capacity each. Seed plate has number of holes or cells around its periphery and is exposed to the seed for picking up the seed. Transmission system consists of gear or combination of gear to transmit power from ground wheel to metering disc. It is also used for proper selection of gear ratio for sowing with correct seed rate. It has two ground wheels to provide power through the transmission system to the seed metering plate.Sprocket settings of the planter is as shown in Fig.1.Furrow opener facilitates opening of the furrow in the soil for proper placing of seed. There are six furrow opener of shoe type. Seed tubes are provided at the lower end of the feed cups. They conduct seeds from feed cups to the furrow lines through suitable boots and furrow openers. Main frame is the main supporting structure of seed box, furrow openers and other parts. The specification of tractor operated 6 row planter with fertilizer drill for millet and other crops (CIAE design) is shown in Table 1.

Performance evaluation of the tractor operated 6 row planter with fertilizer drill for millet and other crops.

The planter was tested for its performance in laboratory as well as in the field condition.Before testing the planter in the field, the laboratory testing was carried out. Performance evaluation test of millet planter involved laboratory test to check seed rate and frequency distribution of seed spacing and field performance to evaluate various parameters.

The testing of tractor operated 6 row planter with fertilizer drill for millet and other crops (CIAE design) was carried out for about 2 ha. area at the Research Farm of Birsa Agricultural University, Ranchi (Jharkhand) for 2 years (2022-23 & 2023-24). The experimental field was prepared by using mould board plough followed by secondary

Table 1. Specification of Tractor operated 6 row planter with fertilizer drill for millet and other crops

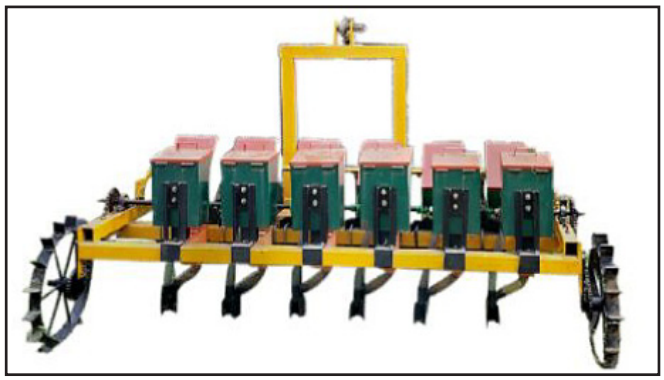
S.No.	Parameter	Specification
1	Power source	33.57kW tractor
2	Overall dimensions	
i	Length (mm)	765
ii	Width (mm)	1800
iii	Height (mm)	1260
iv	Weight (kg)	150
v	Suitability for Crops	Kodo millet, little millet, porso millet, foxtail millet, barnyard millet, finger millet, mustard and jute
3	Furrow openers	Shoetype
(i)	Driver system	Chain and sprocket
(ii)	Transmission ratio (drivewheel axle to metering shaft)	1:2
(iii)	Type of seed and Fertilizer box	inclination angle adjustment system
4	Ground drive wheel	
(i)	Number	One
(ii)	Type	Spiked type
(iii)	Overall diameter (mm)	480
(iv)	Effective diameter (mm)	445
5	Type of hitch	Three point linkage
6	Row to row spacing (mm)	Adjustable
7	Number of rows	6

tillage implements. Field was ploughed twice to obtain a good tilth, destroy weeds, insects and pests; also to mix the crop residues with top soil of the field. The cross ploughing was done by the rotavator. During field operations, different parameters were measured. Systematic view in standing position and during operation of the tractor operated 6 row planter with fertilizer drill for millet crops (CIAE design) is shown in Fig. 2.

During the field study,parameters (seed rate, seed spacing, determination of seed breakage or damage, speed of operation, fuel consumption, actual field capacity, theoretical field capacity, field efficiency, wheel slippage, actual seed to seed spacing, measurement of depth and spacing of seed etc.) were calculated following the Bureau of Indian Standard test code (BIS, 1993).

Economic Analysis

The cost of planter was calculated based on the amount of materials used and the calculated cost incurred in the fabrication. The total cost of the developed power operated rice transplanter was determined by standard procedure guided by Bureau of Indian Standards (BIS, 1979). The cost, time and labour required for the planter were computed.



(a) Tractor operated 6 row planter with fertilizer drill

(b) Sowing and Fertilizer application with Tractor operated 6 row planter with fertilizer drill

Fig.2. Tractor operated 6 row planter with fertilizer drill for millet–multi crops

The life of planter and its use per year were assumed as 10 years and 250 hours, respectively. The fixed cost was calculated by assuming the rates prevailing in the market for mild steels and other materials. The variable cost was worked out by taking the hiring charges prevailing in Jharkhand state for labourers. Cost economics of the planter was compared with traditional method of sowing.

Statistical Analysis

Each experiment was replicated five times. The data sets were processed for analysis of variance as applicable to randomised block design using least significant difference as described by Gomez and Gomez (1984). Treatment means were compared at 5% level of significance. Correlation studies were carried out among the different physical and chemical parameters of soil using Microsoft Excel.

RESULTS AND DISCUSSION

Performance evaluation of Tractor operated 6 row planter with fertilizer drill for milletand other crops

Calibration of planter

For laboratory test, the calibration of planter was done with finger millet seed. The number of holes on metering plate was 42, having a hole diameter of 4 mm, the diameter of ground wheel was 5 cm, spacing between furrow opener were kept 30 cm, it was done manually by adjusting the furrow openers on the main frame. The power transmission to metering mechanism flows according to the sprocket setting as shown in Fig.1 and the transmission ratio was found to be 1.62. Therefore, for the one revolution of ground wheel, metering plate will rotate 1.625 times. The calibration of Tractor operated 6 row planter with fertilizer drill for millet and other crops under laboratory condition is shown in Table 2.

The data obtained from laboratory testing of planter was reported in Table 2. The ground wheel was rotated at constant speed of 1.4 km h^{-1} for 20 revolutions. Seed dropped from each furrow openers were collected and average value was reported. From the Table it was observed that the average seed rate was 16.34 $kgha^{-1}$. The minimum seed rate was 11.01 kg/ha whereas maximum seed rate was 17.76 $kgha^{-1}$. However, the recommended seed rate for manual transplanting is 8kg ha^{-1}. The variation in seed rate could be due to manual error in rotating the ground wheel, non-uniform

Table 2. Laboratory Calibration of Tractor operated 6 row planter with fertilizer drill for millet and other crops

No. of rev	Repli-cation	Time recorded (Minute)	Weight of seed collected from each furrow opener,(g.)						Total seed dropped (g.)	Average seed rate (kg ha$^{-1)}$
			1	2	3	4	5	6		
20	R_1	1.53	10.538	2.500	9.058	12.473	14.038	14.817	63.424	11.01
20	R_2	1:33	14.195	8.432	12.487	30.495	17.044	17.045	99.698	17.31
20	R_3	1:38	13.219	8.047	10.788	30.249	16.556	15.931	94.791	16.46
20	R_4	1:25	13.210	7.501	10.112	30.207	16.223	15.321	92.574	16.07
20	R_5	1:45	12.902	8.082	10.357	28.870	15.909	17.138	93.258	16.19
20	R_6	1:10	12.98	6.243	11.876	28.976	17.594	16.257	93.926	16.31
20	R_7	1:13	13.186	7.358	12.164	31.125	19.024	18.158	101.015	17.54
20	R_8	1:15	11.135	7.053	15.433	30.909	17.151	20.628	102.309	17.76
20	R_9	1:05	9.182	6.254	15.345	30.872	17.553	19.121	98.327	17.07
20	R_{10}	1:09	10.110	8.451	15.168	31.022	18.026	19.145	101.922	17.70
									Average	**16.34**
									Standard Deviation	**0.604**
									CV%	**3.69**

ANOVA

Source	df	Sum of squares	Mean square	F-value	p-value
Replications	9.00	195.025	21.669	3.942	0.00093303*
Treatments.-rows	5.00	2692.977	538.595	97.975	4.9739E-23*
Error(Residual)	45.00	247.377	5.497		
Total sum of squares			3135.379		
Correction factor			14765.640		
T value			2.014		
Standard error difference			1.049		
C.D.			2.112		
Std. dev.(SD)			2.345		
Mean			15.687		
C.V. %			14.946		

Note: SS: Sum of Square; df: degree of freedom; *p<0.05: significant. NS: non-significant

seed size, mechanical components error and two or more number of seed picked by inclined plate metering unit. It was also observed that the variation in seed obtained from each seed delivery tube.

The analysis of variance (ANOVA) shows that both replications and treatments had a significant effect on the average seed rate. The effect of replications was statistically significant ($F = 3.942$, $p = 0.00093$), indicating notable variability across different runs. More importantly, the treatment effect was highly significant ($F = 97.975$, $p < 0.00001$), suggesting that different furrow opener rows had a substantial influence on seed distribution. The mean seed rate recorded was 15.687 kg/ha, with a standard deviation of 2.345 and a coefficient of variation (CV) of 14.95%, indicating moderate variability among treatments. The critical difference (CD) at a 5% significance level was calculated as 2.112, suggesting that differences in seed rate greater than this value between treatments are statistically significant. These results confirm that the choice of furrow opener significantly impacts seed delivery uniformity.

Field trial

Testing of planter was conducted in an area of 2 ha.on finger millet crop during years 2022-23 and 2023-24 at the research farm of Birsa Agricultural University, Ranchi, Jharkhand. The seed bed of the field was prepared before hand using cultivator and rotavator prior to experiment date. The speed of operation is affected by the soil condition, draft and the slip produced during operation. The speed of operation was calculated with five replications as discussed above and average speed of operation was found to be 3.30 kmh^{-1}.

The wheel slip is affected by the working depth, soil moisture and tractor speed of operation. The tractive wheel slip and ground wheel slip is shown in Table 3 and Table 4, respectively. The maximum and minimum value of tractive slip was 18.65% and 15.62 %, respectively. Similarly, maximum and minimum value ground wheel slip were reported 3.86% and 1.00 %, respectively. Whereas the average tractive wheel slip and ground wheel slip were found 16.95% and 2.658 %, respectively.

Table 3. Determination of tractive wheel slip of tractor wheel

Repli-cations	No.of rotation	$V_a$km h^{-1}	Time (S)	Tractive wheel radius (m)	Revolution per minute	V_t, km h^{-1}	Slip,%
i	18	3.5	62	0.634	17.41	4.16	15.94
ii	18.5	3.1	70	0.634	15.85	3.7	18.65
iii	18	3.3	66	0.634	16.36	3.91	15.62
iv	18.5	3.0	72	0.634	15.41	3.68	18.60
v	18	3.5	62	0.634	17.41	4.16	15.94
Average	**18.2**	**3.30**	**66.4**	**0.634**	**16.48**	**3.922**	**16.95**
Std. dev.(SD)	0.27386	0.22803	4.56070	0.00	0.90632	0.23520	1.53473
CV %	1.50473	6.95228	6.86852	0	5.49686	5.99699	9.05446

The statistical analysis of tractive wheel slip across five replications showed an average slip of 16.95%, with a standard deviation of 1.53 and a Coefficient of Variation (CV) of 9.05%, indicating moderate consistency in the slip values. The actual forward speed (Va) averaged 3.28 km/h, while the theoretical speed (Vt) was 3.92 km/h, confirming a consistent slip trend across trials. The constant tractive wheel radius of 0.634 m ensured no structural variation. Low CV values for rotational speed (5.50%) and time (6.87%) further support the stability of operating conditions. The calculated slip values fall within acceptable agronomic limits, validating the reliability of the setup and consistency of traction under field conditions.

The analysis of ground wheel slip for the planter revealed an average slip of 2.66%, with a standard deviation of 1.21 and a high Coefficient of Variation (CV) of 45.55%, indicating notable inconsistency in slip values

Table 4. Determination of ground wheel slip of planter

Repli-cations	No.of rotation	$V_a$km h^{-1}	Time S	Ground wheel Diameter, m	Revolution per minute	V_t, km h^{-1}	Slip,%
I	38.5	3.5	62	0.51	37.25	3.58	2.23
Ii	38	3.1	70	0.51	32.57	3.13	1.0
Iii	39	3.3	66	0.51	35.27	3.38	2.36
Iv	39	3.0	72	0.51	32.5	3.12	3.84
V	38.2	3.5	62	0.51	37.96	3.64	3.86
Average	38.54	3.30	66.4	0.51	35.11	3.37	2.658
Std. dev.(SD)	0.45607	0.22803	4.56070	0	2.54908	0.24351	1.21067
CV %	1.18337	6.95229	6.86853	0	7.26029	7.22599	45.5481

Table 5. Summarized data of the performance of Tractor operated 6 row planter with fertilizer drill for millet and other crops (CIAE design)

S.No.	Parameter	Tractor operated millet planter (CIAE design)	Traditional method
i	Location	BAU Farm	BAU Farm
ii	Area(ha)	2	-
iii	Crop	Finger Millet	Finger Millet
iv	Average depth of sowing (mm)	45	-
v	Average row spacing (mm)	300	211
vi	Width of coverage (mm)	1800	One row
vii	Average seed rate ($kgha^{-1}$)	16.34	19.12
viii	Average speed of operation (kmh^{-1})	3.30	-
ix	Fuel consumption (lh^{-1})	4.5	-
x	Field efficiency (%)	53.87	
xi	Actual field capacity (hah^{-1})	0.32	-
xii	Wages of labour per day of 8h (Rs day^{-1})	350	350
xiii	Wages of operator per day of 8h (Rs day^{-1})	500	-
xiv	No. of labourers	1	-
xv	No. of operators	1	-
xvi	Man-hour per hectare(hha^{-1})	6.25	200
xvii	Total cost of operation (Rs h^{-1})	629.09	87.50
xviii	Total cost of operation (Rs ha^{-1})	3,883.27	7,050

across replications. The mean actual forward speed (Va) was 3.28 km/h, while the calculated theoretical speed (Vt) was 3.37 km/h, confirming a small but variable slippage. The ground wheel diameter remained constant at 0.51 m, ensuring no dimensional variability (CV = 0%). Other parameters such as revolutions per minute and speed showed moderate variability (CV = 7%). Despite the relatively low average slip percentage, the high CV suggests irregular slip behavior possibly influenced by minor variations in groundwheel interaction. These results imply that while the average performance is within acceptable operational limits, consistency in field traction needs further optimization.

The summarized data of the performance of tractor operated 6 row planter with fertilizer drill for millet crops is shown in Table 5. The planter was tested under field condition in 2 ha area in research farm of Birsa Agricultural University Ranchi, Jharkhand on millet crop. The average depth and width of operation was 45 mm and 300 mm, respectively. The average actual field capacity, average field efficiency and average fuel consumption was 0.32 ha h^{-1}, 53.87 %, and 4.50 l h^{-1}, respectively. It depends on the soil condition, live load on tractor, draft and the experience of tractor driver.

The fixed and variable costs had been considered for the calculation of cost economics of the sowing of millets by the tractor operated 6 row planter with fertilizer drill for millets and other crops. The average labour requirement for planting of millet crop by

planter was found 6.25 manh ha^{-1} whereas by traditional method it was 200 man-h ha^{-1}. The cost of operation of tractor operated planter was Rs. 3,883 ha^{-1} whereas by traditional method was Rs. 7,050 ha^{-1}. It shows the tractor operated planter was more efficient, economical and precise than the traditional conventional method as it saves Rs.3,167 ha^{-1}.

CONCLUSION

Field capacity of the tractor operated 6 row planter with fertilizer drill was 0.594 ha/h with field efficiency 53.87% at an average speed of operation 3.30 kmh^{-1}.The average seed rate of the planter on finger millet seeds was 16.34 kg ha^{-1} when compared to traditional manual sowing of 19.12kg ha^{-1}.The average seed to seed distance and average depth of sowing of finger millet seeds were 8.5 cm and 4.5 cm, respectively. The average tractive wheel slippage of the tractor wheel and the average ground wheel of the planter were 16.95 % and 2.65 %, respectively. The cost of operation of tractor operated planter was Rs. 3,883 ha^{-1} whereas by traditional method was Rs. 7,050 ha^{-1}. Thus, there was a saving of amount Rs.3167 ha^{-1}.Based on the experimental studies, it can be concluded that the planter is intended to minimize seed damage during planting while improving metering efficiency and field capacity.

REFERENCES

APEDA. 2021. Country Wise Production Data: Last Five Year. Agricultural and Processed Food Products Export Development Authority (APEDA*)*.https://apeda.gov.in/milletportal/Production.html

APEDA.2022. Agricultural and Processed Food Products Export Development Authority (APEDA*). h*ttps://apeda.gov.in/milletportal/assets/img/pro2.jpg

Bureau of Indian Standards. 1979. Guide for Estimating Cost of Farm Machinery Operation. IS: 9164-1979: 1-12.

Bureau of Indian Standards. 1993. Sowing equipment seed-cum-fertilizer drillspecification. IS: 6316:1993. https://archive.org/details/gov.in.is.6136.1971.

Chandra, D., Chandra, S., Pallavi and Sharma, A. K. 2016. Review of Finger millet (*Eleusine coracana* (L.) Gaertn): A power house of health benefiting nutrients; Food Science and Human Wellness, 5(3): 149-155.

Gomez, K.A., Gomez, A. A. 1984. Statistical Procedures for Agricultural Research. International Paddy Research Institute Book, John Wiley and Sons, New York, 2nd Ed., 83-4556, pp: 680.

Kumar, A., Mani, I and Singh, J. K. 2018. Performance Evaluation of IARI Wheat Seed-Cum-Fertilizer Plot Drill for Pearl Millet-Wheat Cropping System on Permanent Raised Bed System. Journal of Agricultural Engineering, 55(4): 7-9.

Nandede, B., Sethilkumar, T., Chandel, N and Dhimate, A. 2018. Development of Manually Operated Single Row Millet Planter cum Fertilizer Drill. Indian Journal of Dryland Agricultural Research and Development, 33(1): 1-4.

Paliwal, H., Mishra, I and Warshini, A. 2023. Importance and Benefits of Millets Cultivation in India. Just Agriculture,3 (7): 146-147.

Sadhukhan, A and Debangshi, U. 2023. Millets in Meeting the Nutrition Security - A Review; Just Agriculture: multidisciplinary e- Newsletter, 3(5): 226-227.

Uttam Kumar, Gouarv Sahu, Sushma Kumari, Suman Kumari and Suman Kumar Pandit. 2025. Performance Evaluation of Tractor Operated Six Row Planter-cum-Fertilizer Drill for Millet and other Crops. The Journal of Research, ANGRAU, 53(3): 37-46.

DoI: https://doi.org/10.58537/jorangrau.2025.53.3.05

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MANJISTHA (*RUBIA CORDIFOLIA*) NATURAL DYE EXTRACTION METHODS FOR SUSTAINABLE TEXTILE APPLICATIONS

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ABSTRACT

The study conducted in 2024 provides acomparative evaluation of four extraction techniques Traditional Fermentation Extraction (TFE), Enzyme Assisted Extraction (EAE), Microwave Assisted Extraction (MAE) and Enzyme Assisted Microwave Extraction (EAME) for efficient recovery of natural dyes from Manjistha (*Rubia cordifolia*) roots. The objective was to enhance colour strength, dye yield and environmental sustainability in cotton dyeing. Cotton fabrics were dyed with extracts from each method, using both guava leaf powder (bio-mordant) and alum (chemical mordant), with process optimization for pH (optimal at 9), temperature (90°C), dyeing time (60 minutes) and a material-to-liquor ratio of 1:10. Among the methods, EAME achieved the highest dye yield (28.4%) and colour strength (K/S value: 12.3 with alum, 10.9 with guava leaf powder), surpassing traditional fermentation (yield: 12.1%, K/S: 6.2 with alum), EAE (yield: 21.7%, K/S: 9.3 with alum), and MAE (yield: 23.6%, K/S: 10.2 with alum). Additionally, EAME reduced extraction time by 60 percent compared to TFE, demonstrating sustainability advantages. Recycling of dye sludge for re-dyeing achieved up to 68 percent colour strength retention, highlighting an innovative strategy for waste minimization and circular resource use. The synergistic effect of enzyme and microwave treatments not only maximized dye recovery and colour fastness but also reduced environmental impact, positioning EAME as a green and scalable method for natural dye extraction.

Keywords: Bio-mordants, Dye bath reuse, Enzymatic extraction, Manjistha, *Rubia cordifolia*

INTRODUCTION

Natural dyes are biodegradable, renewable and less harmful to the human body than synthetic dyes. Their eco-friendly, non-toxic nature has led to widespread use in the textile industry. Manjistha (*Rubia cordifolia*) is a notable natural red dye source valued both in Ayurvedic medicine and textiles. Its primary pigments—alizarin, purpurin, and manjistha—produce rich red to brown hues. The method used to extract these dyes greatly influences the color yield, intensity, and fastness. Concerns about chemical dye pollution and health risks have increased interest in natural alternatives. Plant-based dyes are increasingly favoured for their environmental compatibility and potential health benefits. Traditional extraction techniques like fermentation and soaking are well-established. Recent advances, such as enzymatic hydrolysis and microwave-assisted extraction, offer better efficiency and sustainability. This study

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analyses and compares various extraction approaches, focusing on their effects on colour yield and dye fastness.

Traditional extraction of Manjistha involves soaking dried root powder in water or organic solvents such as ethanol, methanol, or aqueous alkali for 24–48 hours, followed by heating or boiling (Gokhale, 2020). Microwave-Assisted Extraction (MAE) uses microwave radiation to enhance solvent penetration and pigment release, significantly reducing extraction time and improving dye yield (Chandran *et al*., 2021). Enzyme Assisted Extraction (EAE) utilizes enzymes like cellulase and pectinase to break down plant cell walls, promoting dye release under mild and eco-friendly conditions (Mandal,2023). Enzyme Assisted Microwave Extraction (EAME) combines enzymes such as cellulase, amylase, and pectinase to break down plant tissues for colorant release, and the addition of microwave extraction accelerates dye extraction at lower temperatures, enhancing both yield and speed (Muruganandham, *et al.,* 2023; Kasiri, M. B.and Helmy *et al.,* 2020). Regarding mordants, plants rich in tannin and chlorophyll have proven effective as bio-mordants for natural dyeing of textiles (Singh *et al.,* 2021). For example, guava leaf powder and neem bark, both high in tannic acid and carotenoids, have been used as mordants for dyeing wool with cocoa fibers (Jabar *et al.,* 2023). In traditional dyeing, certain metal salts, especially alum, have been commonly used to enhance dye affinity, with alum having a long history in Europe for centuries (ISmal and Yildrim, 2019).Cotton specifically requires mordanting because, unlike wool or silk, it lacks amino and carboxyl groups necessary for dye molecule binding, making it more challenging to dye.Alongside advances in extraction methods, reusing dye baths for multiple dyeing cycles is increasingly recognized for enhancing sustainability in the textile industry. This practice lowers water and chemical use, reduces waste and effluents, and supports circular economy objectives, thereby strengthening the environmental advantages of natural dyeing over synthetic alternatives.

MATERIAL AND METHODS

Selection and preparation of mordant

Alum (Potassium aluminium sulphate) was chosen as the chemical mordant for its effectiveness in enhancing dye fixation and colour fastness, prepared at a concentration of 3-5% on the weight of fabric (o.w.f.) with a material-to-liquor (M:L) ratio of 1:10. Guava leaf powder (*Psidium guajava* Linn) served as the bio-mordant, leveraging its high flavonoid and tannin content for sustainable and eco-friendly textile dyeing (Zayed *et al*., 2022). The simultaneous mordanting method was used, where both alum and guava leaf powder were introduced directly into the dye bath with cotton fabric and Manjistha dye extracted via traditional, enzymatic, microwave or enzyme-assisted microwave methods. Dyeing was conducted at 70°C for 60 minutes with an M:L ratio of 1:20, followed by thorough rinsing and shade drying to preserve dye quality, allowing comparative evaluation of both mordant types.

Optimization of dyeing parameters

Optimization of dyeing parameters was achieved by systematically varying key conditions: the material-to-liquor ratio (testing ratios such as 1:10), dye bath pH (adjusted to 8, 9, and 10 using NaOH), dyeing time (including durations up to 60 minutes) and temperature (up to 90°C). After each trial, the fabrics were rinsed, soaped, dried, and assessed for colour strength to determine the settings that produced optimal dye uptake and colour quality. The best-performing combination of ratio, pH, dyeing time, and temperature was selected for all subsequent

dyeing experiments using both chemical (alum) and natural (guava leaf) mordants.

The optimized dyeing parameters for each extraction method were determined by varying key factors including material-to-liquor (M:L) ratio, dye bath pH, temperature and time, with microwave power incorporated for microwave-assisted methods. The M : L ratio affects dye concentration relative to fabric weight, while pH influences dye solubility and fiber affinity. Temperature and time govern dye fixation and color development. Microwave power was applied during Microwave-Assisted Extraction (MAE) and Enzyme-Assisted Microwave Extraction (EAME) to enhance dye release and efficiency. Table 1 summarizes these optimized parameters for Traditional Fermentation Extraction (TFE), Enzymatic Aqueous Extraction (EAE), MAE, and EAME, providing a clear reference for the dyeing conditions used with both chemical and bio-mordants.

Cotton fabrics were dyed with Manjistha extracts obtained by different extraction methods, using previously optimized parameters for material-to-liquor ratio, pH, temperature and dyeing time. After dyeing, fabrics were rinsed and shade-dried before evaluating colour strength.

The residual dye sludge from the initial dye effluent was dried, ground, and reused as a recycled dye source for re-dyeing. This process followed the same optimized conditions as the initial dyeing, except the material-to-liquor ratio was set at 1:10 to accommodate the solid sludge. Simultaneous mordanting with 3% guava leaf powder was applied. Colour intensity and strength were compared between fabrics dyed with original

Table 1. Optimized Dyeing Parameters and Mordanting Conditions of Cotton Fabrics Using Manjistha Extracts from Different Extraction Methods

Extraction Method	M: L Ratio	pH	Temp (A°C)	Time (min)	Microwave power(W)	Mordant Type	Mordant Conc.	Mechanism/ Remarks
Traditional Fermentation Extraction (TFE)	01:20	9	80	60	-	Alum / Guava leaf powder	3% o.w.f.	Alum forms metal-dye -fibre complexes; guava provides bioactive tannins / flavonoids
Enzymatic Aqueous Extraction (EAE)	01:15	8	75	45	-	Alum / Guava	3% o.w.f. leaf powder	Enzymes aid dye-penetration; guava bio-mordant enhances fixation
Microwave Assisted Extraction (MAE)	01:20	9	85	30	100	Alum / Guava	3% o.w.f. leaf powder	Microwave speeds extraction and improves colour yield
Enzyme Assisted Microwave Enzyme (EAME)	01:15	8	80	30	100	Alum / Guava	3% o.w.f. leaf powder	Synergistic effect of enzyme + microwave ensures deeper, more uniform shades

extracts and those re-dyed using recycled sludge.

RESULTS AND DISCUSSION

The colorimetric parameters of cotton fabrics dyed with Manjistha extracts were obtained through different extraction methods—Traditional, Enzyme, Microwave, and a combination of Enzyme and Microwave—without using mordant. The data indicate that the Enzyme + Microwave method consistently yields the highest values across most parameters, including tri-stimulus values (X=8.75, Y=8.05, Z=7), lightness (L* = 24), chroma (c* = 11.25), and colour strength (K/S = 63.25), reflecting a deeper and more intense coloration. The higher a* (9.85) and b* (3.96) values suggest a stronger red and yellow hue, respectively, compared to other methods. In contrast, the traditional extraction method shows the lowest values across these parameters, with a K/S of 38.21, indicating a lighter and less saturated colour. The hue angle (H) varies slightly among methods, with the traditional method exhibiting the highest hue angle (26.24), suggesting subtle differences in shade tone. Overall, the results demonstrate that the combined Enzyme and Microwave extraction technique shows high colour intensity without mordanting.

Enzyme Assisted microwave extraction achieved the highest performance, with a color strength (K/S) of 63.25 and a dye yield of 100%. Enzymatic extraction also showed strong results (K/S = 57.74, dye yield = 91.3%), followed by microwave extraction (K/S = 54.04, dye yield = 85.4%). Traditional extraction had the lowest values (K/S = 38.21, dye yield = 60.4%). These results indicate that combining enzymatic treatment with microwave assistance significantly enhances both dye yield and color strength compared to other methods.

The superiority of the Enzyme Assisted Microwave Extraction (EAME) method can be attributed to its combined chemical and physical effects. Enzymatic hydrolysis using cellulase and pectinase partially breaks down the cotton fibre surface, opening pores and exposing additional hydroxyl groups that serve as new binding sites for dye molecules. At the same time, microwave irradiation generates rapid dipole rotation of water molecules, creating localized heating and enhanced molecular mobility that accelerates dye

Table 2. Colour strength of extracted dye without mordant

Parameter	TFE	EAE	MAE	EAME
X	4.66	6.59	5.49	8.75
Y	4.27	5.72	4.66	8.05
Z	3.5	5	3.94	7
L*	16.5	19.43	17	24
a*	4.32	7.2	7.07	9.85
b*	2.62	2.43	2.45	3.96
c*	5.05	7.6	7.48	11.25
H	26.24	16.19	15.51	16
K/S	38.21	57.74	54.04	63.25

****TFE**-Traditional Fermentation method of Extraction, **EAE** -Enzymatic Assisted Extraction, **MAE**- Microwave Assisted Extraction, **EAME -**Enzyme Assisted Microwave Extraction. **

Table 3.Percentage of dye yield without mordant

Parameter	TFE	EAE	MAE	EAME
K/S	38.21	57.74	54.04	63.25
% Dye Yield	60.4%	91.3%	85.4%	100%

Percentage Dye Yield= (Highest K/S value/S value) ×100

diffusion into the fibre. This synergistic interaction results in deeper dye penetration, stronger dye-fibre interactions and higher colour strength (K/S values) compared to other methods. Moreover, microwave irradiation can cause subtle changes in the dye bath chemistry, such as slight pH shifts and structural modification of anthraquinone compounds present in Manjistha, leading to brighter, more intense shades. Thus, the combination of enzymatic treatment and microwave irradiation provides both improved dye uptake and superior colour vibrancy.

The evaluation of colour strength using both alum and guava leaf powder as mordants revealed that both agents produced comparable and satisfactory colour intensities on the dyed cotton fabrics. Notably, as a natural bio-mordant, guava leaf powder presents several advantages over alum, a conventional metallic mordant. Guava leaf powder is environmentally benign, bio degradable and non-toxic, representing a more sustainable alternative in textile dyeing processes.

The colorimetric analysis of cotton fabrics dyed and re-dyed with Manjistha extracts using guava leaf mordant reveals notable differences across extraction methods and dyeing cycles. Initial dyeing (first dye) consistently shows higher values for colour strength (K/S), lightness (L*), and chromaticity (a*, b*, c*) compared to re-dyeing (reuse), indicating some reduction in colour intensity upon reuse of the dye bath. Among the methods, the combined enzyme and microwave extraction yields the highest colour strength (K/S = 95) and chroma (c* = 15) in the first dyeing,

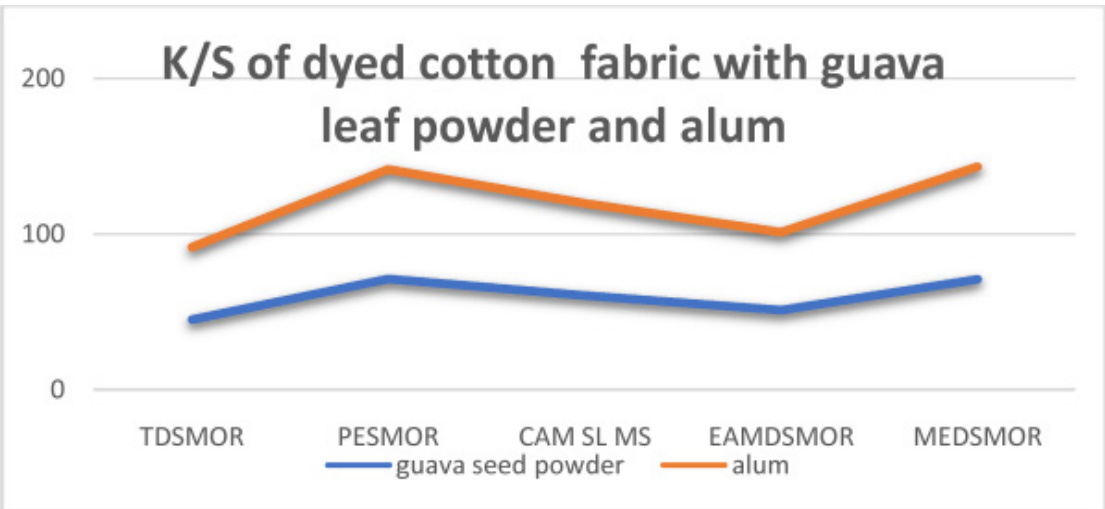

Fig.1 K/S of dyed cotton fabric with guava leaf powder and alum

Note: Based on the experimental results, guava leaf powder was selected for the remainder of the study due to its comparable performance to alum.

Table 4. Colorimetric Analysis of Cotton Fabrics dyed and Re-dyed with Manjistha Extracts using Guava Leaf Mordant.

Para-meter	TFE	Reused TFE	EAE	Reused EAE	MAE	Reused MAE	EAME	Reused EAME
X	6.65	3.89	9.41	8.02	7.86	6.64	12.5	8.97
Y	6.09	3.6	8.17	7.77	6.67	5.62	11.5	8.43
Z	4.98	2.96	7.13	6.42	5.62	4.82	10	7.29
L*	22.62	13.64	26.65	24.91	23.28	19.45	33	24.47
a*	5.92	3.28	9.87	5.74	9.7	8.44	13.5	9.88
b*	3.59	2.12	3.33	3.63	3.36	2.57	5.4	3.87
c*	6.92	3.9	10.42	6.67	10.26	8.72	15	10.79
H	26.24	17	16.19	30.83	15.51	10.57	16	12.76
K/S	79.86	49.12	82.62	80.23	77.2	65	95	72.18

reflecting superior dye uptake and vibrancy. Re-dyeing results in decreased but still substantial colour strength, with enzyme extraction showing the best retention (K/S = 80.23). Variations in hue angle (H) suggest subtle shifts in colour tone between dyeing cycles and extraction techniques. The data demonstrate that advanced extraction methods, particularly enzyme plus microwave, enhance dye fixation and colour intensity. In contrast reuse of dye baths remains effective for sustainable dyeing with moderate colour strength retention.

Among all methods adopted in the study, enzyme-assisted microwave extraction demonstrated the highest efficiency, yielding the greatest color strength (K/S = 95) and dye yield (100%). Enzymatic extraction also performed well, with high K/S (82.62) and dye yield (87.02%), and showed excellent retention of these parameters upon dye bath reuse (K/S = 80.23, dye yield = 84.45%), indicating strong sustainability for multiple dyeing cycles. In contrast, traditional extraction and microwave extraction alone resulted in moderate initial K/S and dye yield values, but both showed significant decreases upon reuse, particularly the traditional method (K/S = 49.12, dye yield = 51.71%). Notably, the reuse of enzyme-assisted microwave extraction baths maintained relatively high color strength (K/S = 72.18) and dye yield (75.98%), outperforming other reused methods. Overall, enzyme-assisted microwave extraction stands out as the most effective and sustainable approach, offering superior dye yield, color strength and reusability.

Table 5. Percentage of dye yield with various extraction methods and mordants.

Para-meter	TFE	Reused TFE	EAE	Reused EAE	MAE	Reused MAE	EAME	Reused EAME
K/S	79.86	49.12	82.62	80.23	77.2	65	95	72.18
% Dye Yield	84.06%	51.71%	87.02%	84.45%	81.26%	68.42%	100%	75.98%

****Percentage Dye Yield= (Highest K/S value/S value) ×100****

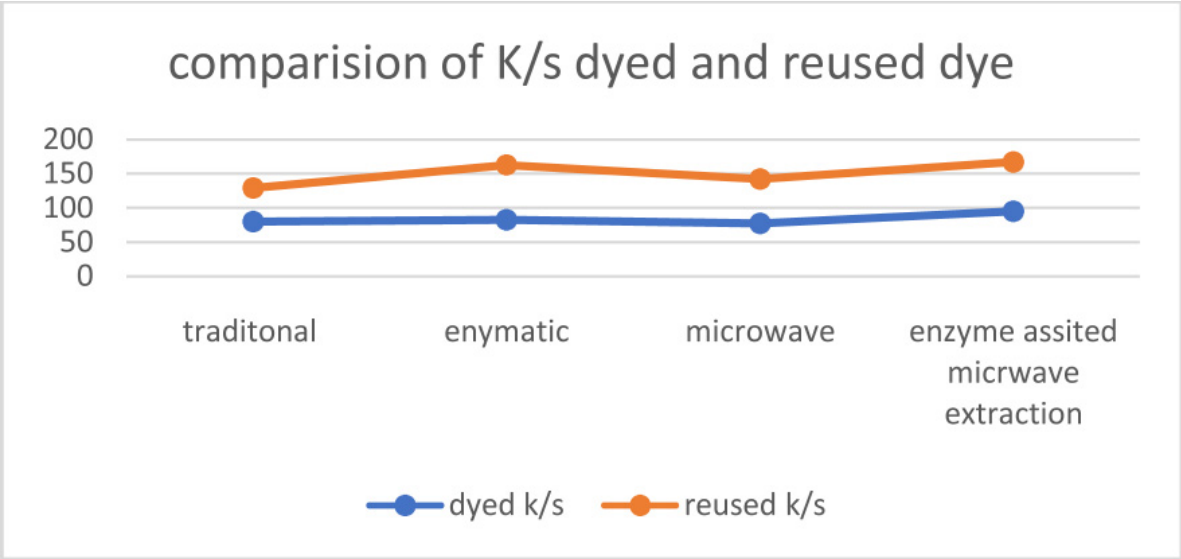

Fig. 2. Dye Fixation and Uptake: Fresh vs Reused Dye

Table 6 compares four extraction methods-Traditional, Microwave-Assisted Extraction (MAE), Enzymatic, and Enzyme-Assisted Microwave Extraction—based on extraction time, dye yield, solvent usage, environmental impact, and resulting color intensity. Traditional extraction requires the longest time (24–48 hours) and uses high solvent volumes, leading to moderate dye yield and ecological impact. Microwave-assisted extraction significantly reduces extraction time (5–10 minutes) and solvent use, resulting in high dye yield and color intensity with low environmental impact. Enzymatic extraction, performed over 4 hours, achieves the highest dye yield and color intensity while minimizing solvent use and environmental footprint. The combined enzyme-assisted microwave extraction further optimizes the process, reducing extraction time to 1–2 hours and maintaining the highest dye yield and color intensity with minimal solvent consumption and environmental impact. Overall, enzyme-assisted microwave extraction emerges as the most efficient and sustainable method for natural dye extraction, balancing rapid processing, superior yield, and eco-friendliness.

Based on the corrected mean and standard deviation values from the table, here is the revised and accurate interpretation of the colour strength data:

Table 6. Comparison of Extraction Methods for Natural Dye Yield, Environmental Impact, and Color Intensity

Method	Extraction Time	Dye Yield	Solvent Use	Environmental Impact	Colour Intensity
TFE	24–48 hrs	Moderate	High	Moderate	Moderate
MAE	5–10 mins	High	Low	Low	High
EAE	4 hrs	Highest	Minimal	Lowest	Highest
EAME	1-2 hrs	Highest	minimal	lowest	Highest

Table 7. Average Colour Strength (Mean ± SD) of Cotton Samples Dyed with Manjistha Using Various Extraction

Sample	Without Mordant	1st Dye	Reuse (2nd Dye)	Mean ± SD
TFE	38.21	79.86	49.12	64.49 ± 21.77
EAE	57.74	82.62	80.23	81.43 ± 1.69
MAE	54.04	77.20	65.00	71.10 ± 8.63
EAME	63.25	95.00	72.18	83.59 ± 16.21

Without Mordant

All samples exhibit relatively lower colour strength without mordanting, highlighting the essential role of mordants in enhancing dye fixation on cotton fabric. Among these, the enzyme -assisted microwave extraction method shows the highest baseline value (63.25), suggesting better dye availability or affinity even without amordant.

1st Dye (Initial Dyeing with Mordant)

Color strength significantly increases for all extraction methods upon mordanting and initial dyeing. The enzyme-assisted microwave extraction method achieves the highest value (95.00), followed by enzyme extraction (82.62), traditional (79.86) and microwave (77.20). This indicates that mordanting advanced extraction techniques enhances dye uptake and color intensity.

Reuse (Second Dyeing):

Reuse of the dye bath results in a decrease in color strength compared to the first dyeing but remains substantially higher than the values without mordant, demonstrating the

Fig. 3.Colour Shades Obtained from Manjistha Dyeing with Different Mordants

potential for sustainable dye bath reuse. The enzyme extraction method retains the highest color strength upon reuse (80.23), followed by enzyme-assisted microwave extraction (72.18), microwave (65.00) and traditional (49.12) methods.

Mean ± SD:

The average color strength across the three conditions (without mordant, 1st dye, reuse) shows that the enzyme-assisted microwave extraction method delivers the highest overall dyeing performance (83.59 ± 16.21), followed by enzyme extraction (81.43 ± 1.69), microwave extraction (71.10 ± 8.63), and traditional extraction (64.49 ± 21.77). The lower standard deviation in enzyme and microwave-assisted methods indicates more consistent dyeing results than conventional extraction.

1. TFE Alum 1a. Reused Alum1b. Guava mordant TFE 1c. Guava mordant reuse TFE
2. MAE with Alum 2a. Reused MAE with Alum 2b. Guava mordant MAE 2c. Guava mordant reuse MAE
3. EAE with Alum 3a. Reused EAE with Alum 3b. Guava mordant EAE 3c. Guava mordant reuse EAE
4. EAME with Alum 4a. Reused with Alum EAME 4b. Guava mordant EAME 4c. Guava mordant reuse EAME

CONCLUSION

The comparative analysis of Manjistha dye extraction methods demonstrated that Enzyme Assisted Microwave Extraction (EAME) was the most efficient, achieving the highest dye yield (100%) and maximum colour strength (K/S = 95), while also reducing extraction time to nearly one-tenth of that required for traditional fermentation. Among the methods, traditional extraction gave the lowest yield (60.4%, K/S = 38.21), while Microwave assistance alone significantly enhanced dye yield to 85.4% (K/S = 54.04), representing an increase of nearly 41% over traditional methods. Enzymatic treatment alone further improved yield to 91.3% (K/S = 57.74) and the synergistic effect of combining enzymes with microwave energy in EAME boosted extraction efficiency by an additional 9% over MAE, producing deeper, more vibrant shades. Use of alum mordant resulted in the highest colour strength, whereas guava leaf powder provided a sustainable bio-mordant alternative with only a modest reduction in intensity. Importantly, dye sludge reuse retained up to 68% of initial colour strength, supporting principles of waste minimization and circular resource use. Overall, the findings confirm that EAME not only enhances dye yield and shade depth but also minimizes processing time, solvent usage, and environmental impact, positioning it as a highly scalable and sustainable method for natural dye applications in the textile industry.

REFERENCES

Chandran, S., Pillai R., Nair P. and Kutty S. 2021. Enhancing natural dye extraction using microwave irradiation. Dyeing Science and Engineering, 15(1): 45–56.

Gokhale, N., Mehta S., Shah P. and Jadhav R. 2020. Influence of heating on anthraquinone dye yield from *Rubia cordifolia*. Indian Textile Research Journal, 28(3): 198–207.

Helmy, H. M. 2020. Extraction approaches of natural dyes for textile coloration. Journal of Textiles, Coloration and Polymer Science, 17(2): 65–76.

Ismal, O. E. and Yildrim, L. 2019. 3-Metal mordants and biomordants. In Shahid-ul-Islam B S and Butola B S (Eds.), The Textile Institute Book Series: The Impact and Prospects of Green Chemistry for

Textile Technology, Woodhead Publishing, pp. 57–82.

Jabar, J. M., Adebayo, M. A., Oloye M. T., Adenrele, A. Y. and Oladeji, A. T. 2023. Catechinrich reddish-brown dye from cocoa (*Theobroma cacao* L.) leaf for functionalizing herbal-anchored wool fabrics. Industrial Crops and Products, 205: 117465.

Kasiri, M. B. and Helmy, H. M. 2020. Extraction approaches of natural dyes for textile coloration. Journal of Textiles, Coloration and Polymer Science, 17(2): 65–76.

Mandal, P., Sharma, N., Bhowmik, S. and Saini, G. 2023. Eco-friendly extraction of Manjistha dye and application on textiles. Sustainable Textile Innovations, 12(2): 89–104.

Muruganandham, K., Rangarajan, R., Vasudevan, S. and Srinivasan, K. 2023. Microwave Assisted Extraction of Natural Dyes: A Review. Biochemical Journal, 9(2): 80–199.

Singh, M., Vajpayee, M. and Ledwani, L. 2021. Eco-friendly surface modification of natural fibres to improve dye uptake using natural dyes and application of natural dyes in fabric finishing: a review. Materials Today: Proceedings, 43(5): 2868–2871.

Zayed, M., Ghazal, H., Othman, H. and Hassabo, A. G. 2022. *Psidium guajava* leaf extract for improving ultraviolet protection and antibacterial properties of cellulosic fabrics. Biointerface Research in Applied Chemistry, 12(3): 3811–3835.

Nivya,N. and Bagyalakshmi,G. 2025, Manjistha (*Rubia Cordifolia*) Natural Dye Extraction Methods for Sustainable Textile Application. The Journal of Research ANGRAU, 53(3): 47-56.

DoI: https://doi.org/10.58537/jorangrau.2025.53.3.06

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ASSESSMENT OF NUTRITIONAL STATUS OF ADULTS WITH CARDIOVASCULAR DISEASES

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ABSTRACT

The study was conducted in 2024 to assess the nutritional status, food habits and management of CVD among adults. A purposive random sampling method was employed to select respondents.Based on the study's objective, a suitable, pre-structured questionnaire was designed to collect information. The questionnaire comprised socio-demographic data, anthropometric data, biochemical parameters, clinical signs and symptoms, dietary data, diagnosis and treatment and management of CVD. Hundred participants residing in Bengaluru, within an age group of 40 to 65 years with cardiovascular complications were included in the research. The data collected was analysed through statistical analysis as a percentage, standard deviation and chi-square test. The majority of the respondents (86%) were of the age group between 40-59 years. The data on the education levels of the respondents revealed that 44 percent of them were graduates and the majority of the respondents (64%) were from the nuclear family. The family history of cardiovascular diseases revealed that 54 percent of respondents were with no family history**.** Most of the respondents (54%) were overweight followed by 22 percent of the respondents who were in the obese class I category indicating a prevalence of obesity among the respondents. Being physically inactive is recognized as one of the most significant risk factors for CVD which strongly supports the results**.** A higher number of the respondents (53%) were non vegetarians and 53 percent and 48 percent of them were with diabetes and hypertension respectively. The elevated levels of triglycerides and LDL with low levels of HDL might be the strong link for the development of CVD**.** Seventy nine percent of the respondents had Coronary Artery Disease (CAD) and heart failure and had undergone angioplasty and Coronary Artery Bypass Grafting (CABG). Non vegetarians (52%) had a maximum occurrence of CAD compared to other types of diet, however, the P value indicated that there was no statistically significant association between the type of diet and occurrence of CVD. The chi-square test indicated that there is no statistically significant association between BMI and CVD (since P is 0.234 > 0.05) even though the obese respondents had a higher percentage of cardiovascular disease.

Keywords: Cardiovascular disease,Lifestyle changes, Management, Nutritional status.

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INTRODUCTION

Non Communicable Diseases (NCD) are one of the main causes of major public health concern. Non Communicable conditions are listed by the World Health Organisation (WHO) as the principal cause of death worldwide. As a result of rapid urbanization and changes in lifestyle; the epidemiological health transition has taken place; which has led to an overall economic rise, but with certain associated flip sides (risk factors) like growing burden of NCDs (WHR, 2023).

Among this, WHO (2024) pointed out that cardiovascular diseases (CVD) accounted for most NCD deaths, or at least 19 million deaths in 2021, followed by cancers (10 million), chronic respiratory diseases (4 million) and diabetes (over 2 million including kidney disease deaths caused by diabetes).

CVD is a class of diseases that affect the heart or blood vessels, which have now become the leading cause of mortality contributing to the global burden of disease among NCDs. The causes of CVD can be attributed to hereditary and acquired risk factors, including the current epidemic pathological risk factors of smoking, diet, physical inactivity and hypertension at both the individual and community level and socio-economic status. Diet, nutrition and physical activity are key modifiable determinants of CVD, potentially influencing the risk of developing the disease by modulating blood pressure, blood levels of lipids, inflammation and fasting glucose as well as functions of the heart (Prabhakaran *et al.,* 2016).

CVDs are the leading cause of mortality and a major contributor to disability. Cardiovascular disease needs a person-centered model of attention that offers primordial and primary prevention in adults older than 40 years and secondary prevention to middle-aged adults. Cardiovascular diseases are now the main causes of death in India, with factors comprising urbanization, lifestyle, diets and improved longevity. The risks to this population are high due to the combined effect of these factors, especially in the middle-aged adult population that ranges from 40 to 65 years. Hence, an attempt had been made with an objective to assess the nutritional status, food habits and management of CVD among adults.

MATERIAL AND METHODS

Based on the objective of the study, a suitable pre-structured questionnaire was designed to collect information. The questionnaire was validated by the experts in the field of Food and Nutrition and by the statistician. The developed questionnaire comprised five different parts, namely, Socio-demographic data, Anthropometric measurements, Biochemical parameters, Food habits, Dietary status and Diagnosis and treatment. The respondents' Socio-demographic information like name, gender, age, education level, employment status, family income and type of family was included. The Anthropometric information included the record of height and weight and BMI was calculated.

The important biochemical markers that assess the absolute status of the heart and cardiovascular risk such as blood pressure, lipid profile (total cholesterol, LDL, HDL, and triglyceride) and blood sugar, were gathered from newly admitted patients from the hospital. Similarly information on dietary habits, consumption frequency of different foods, diet modifications and challenges in maintaining diet were collected. The type of cardiovascular disease faced by the respondents was recorded and questions regarding health-related complaints and challenges faced by the respondents were noted. The information on clinical signs and symptoms, diagnosis and

treatment were also collected using the questionnaire. A purposive random sampling method was used to identify respondents and the data collection was done during the year 2024. The participants who were residing in Bengaluru under an age group of 40 to 65 years with cardiovascular complications were included in the research. The respondents who were younger than 40 years or more than 65 years are excluded from the study as the purpose of the study is to focus on middle-aged individuals. The study was limited to 100 respondents from the hospitals of Bengaluru city. The samples were selected by obtaining prior permission from the respective hospital authorities and respondents' consent. The data was collected through appropriate methods and collected data was compiled and statistically analyzed using frequency, percentage and chi-square methods.

RESULTS AND DISCUSSION

Table 1 depicted the demographic data of the respondents, the majority of the respondents (86%) belonged to the age group between 40-59 years, with female respondents as 54 percent and male respondents as 46 percent. Regarding education levels of the respondents, 44 percent of them were graduates, 25 percent were Intermediate and

Table1.Socio-demographic profile of the respondents

n=100

Socio-demographic parameters		No.of respondents(n)	Percentage(%)
Age	40-49 years	41	41.0
	50-59 years	45	45.0
	60-64 years	14	14.0
Gender	Male	46	46.0
	Female	54	54.0
Education level	Illiterate	4	4.0
	Up to 10^{th}	14	14.0
	12^{th}	25	25.0
	Graduate	44	44.0
	Post-graduate & above	13	13.0
Employment status	Employed	50	50.0
	Homemaker	39	39.0
	Retired	4	4.0
	Others	7	7.0
Type of family	Joint family	36	36.0
	Nuclearfamily	64	64.0
Family history of cardiovascular disease	Yes	46	46.0
	No	54	54.0

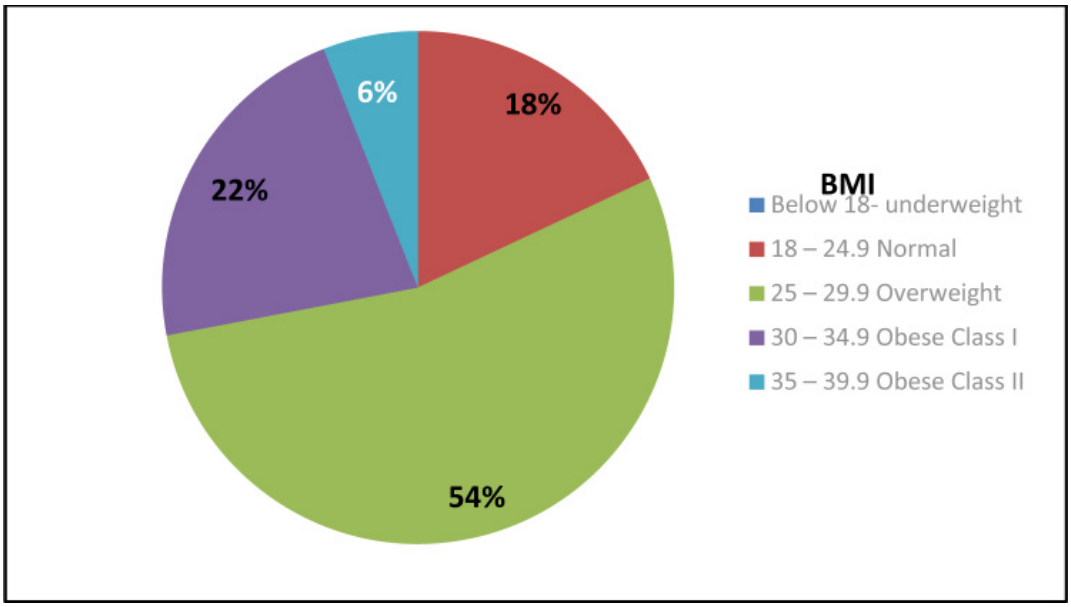

Fig. 1. BMI of the respondents(n=100)

the least percent were illiterates. Fifty percent of the respondents were employed, whereas 39 per cent were homemakers. The majority of the respondents (64%) were from the nuclear family whereas 36 percent of them stayed in a joint family. The family history of cardiovascular diseases revealed that 54 per cent of respondents had no family history and 46 percent of the respondents had a family history. Contradictory to the present study, Kundu and Kundu (2022) revealed that the risk of having CVD was 0.5 times less among individuals without a family history of CVD.

The present study revealed that with aging, there is an incremental acquisition of several CVD risk factors in an individual's lifespan. The results showed that more than half of the subjects didn't have a family history of CVD, which indicated the prevalence of CVD among the subjects was due to changes in lifestyle, which may have led to occurrence of CVD.

Fig. 1 dipicts the BMI data of the respondents. The mean height of the respondents was found to be 160.48 cm and the mean body weight of the respondents was 72.370 kg, with a relatively higher variability, reflected by an SD of 12.491 kg. Most of the respondents (54%) were overweight followed by 22 percent of the respondents who were in the obese class I category indicating a prevalence of obesity among the respondents. It showed 82 percent of the respondents were having higher BMI than normal. Among the respondents, no one belonged to the category of underweight. Highest prevalence risk factor for CVD was reported as central obesity (78.2%), followed by 23.9% of overweight and obesity (Behera *et al.,* 2024). prevalence of obesity and overweight was 60% and 20%, respectively among 30-45 years aged CVD patients (Prasad *et al.,* 2024).

Being physically inactive is recognized as one of the most significant modifiable risk factors for cardiovascular morbidity and mortality. Loss of weight by the obese results in a considerable reduction in the work of the heart because the basal metabolism is at a lower level. Slowing down of the heart rate, a drop in blood pressure and thereby improving cardiac efficiency leads to lower incidence of CVD.

Table 2. Medical history of the respondents

n=100

Medical history		Number of respondents(n)	Percentage(%)
Diabetes	Yes	53	53.0
	No	47	47.0
Hypertension	Yes	48	48.0
	No	52	52.0

Table 2 provides the medical history of the respondents; 53% of the respondents were diabetic and 48% of the respondents had a history of hypertension. Most of the studies indicated that the individuals with a medical history of hypertension and diabetes were more likely to develop CVD themselves.In the present study, only half of the respondents were with medical history of either hypertension or diabetes, showed the presence of other risk factors which compounded for CVD. Kundu and Kundu (2022) found that physical inactivity was a major cause of CVD whereas diabetes and high cholesterol had a stronger association with CVD among older adults. Sverre *et al.,* (2021) concluded that hypertension is one of the strongest risk factors for almost all different cardiovascular diseases including coronary artery disease, stroke, heart diseaseand arrhythmia acquired during life. People with metabolic disorders, such as insulin resistance, diabetes and cardiometabolic syndrome, often exhibit a significant prevalence of hypertension, which is a strong contributor to the risk of CVDs (Zakir *et al.,* 2022).

The biochemical parameters of the respondents depicted in Table 3. The mean value of total cholesterol is 179.38 mg/dL which was within the normal range (less than 200 mg/dL). The mean value of triglycerides and low-density lipoprotein (LDL) were 178.498 mg/dL and 113.974 mg/dL respectively which were higher than the normal ranges (Triglycerides-below 150 mg/dL, LDL- below 100 mg/dL) whereas the mean value for high-density lipoprotein (HDL) is 37.370 mg/dL which was lesser than the normal range.

According to a survey in Punjab, 27% of adults have high levels of cholesterol or TGs. Specifically, 9.8% have high cholesterol levels and 21.6% have high TG levels. (Tripathy *et al.,* 2017). The development of Congenital Heart Disease (CHD) is significantly influenced by lipid dysfunctions such as elevated levels of total cholesterol, LDL, Very LDL (VLDL) cholesterol and triglycerides (TGs), as well as decreased levels of HDL cholesterol (HDL-C). In particular, an increase in LDL cholesterol is

Table 3. Bio chemical parameters of the respondents

n=100

Parameters	Mean± SD
Totalcholesterol (mg/dL)	179.38± 47.4
Triglycerides(mg/dL)	178.498± 152.7
LDL(mg/dL)	113.974± 39.8
HDL(mg/dL)	37.370± 9.3

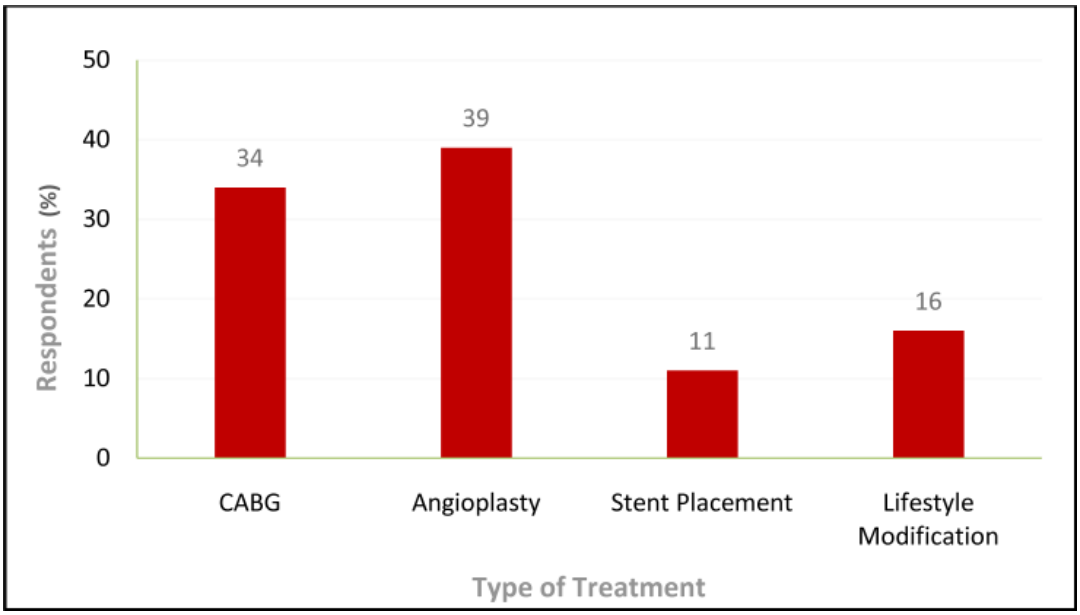

Fig. 2. Diagnosis of cardiovascular disease of the respondents (n=100)

strongly linked to the onset and advancement of CVD (WHO, 2018).

The elevated levels of triglycerides and LDL with low levels of HDL might be the strong link for the development of CVD.

Fig. 2 represented the data on the diagnosis of different types of CVD among respondents, The majority of the respondents (41%) were diagnosed with coronary artery disease followed by 38 percent of the respondents who were with heart failure and 12 percent of the respondents diagnosed with arrhythmia. The least percent of the

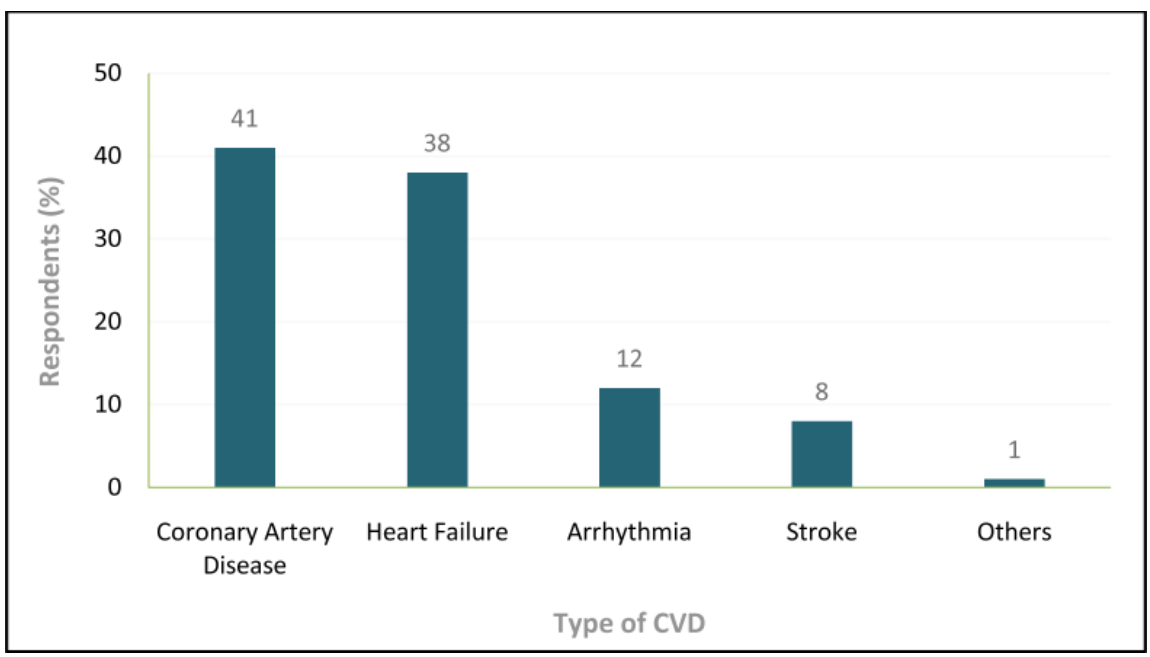

Fig. 3. Treatment for cardiovascular diseases of the respondents (n=100)

respondents (9 %) were diagnosed with stroke.

Fig. 3 described the treatment for cardiovascular disease undergone by the respondents. 39 percent of respondents have been treated with angioplasty, 34 percent of the respondents have done Coronary ArteryBypass Grafting (CABG), whereas 16 percent of the respondents were treated with lifestyle modification and medication. Eleven percent (11%) of the respondents had stent placements.

Table 4 revealed the dietary habits of the respondents. A maximum number of respondents (53%) were non-vegetarians followed by 32 percent vegetarians and ovo-vegetarians were of 15 percent. Forty one percent of non-vegetarian respondents used

Table 4.Dietary habits of the respondents

n=100

Dietaryhabits		No.of respondents(n)	Percentage(%)
Dietary pattern	Vegetarian	32	32.0
	Non-vegetarian	53	53.0
	Ovo-vegetarian	15	15.0
	Lacto-ovovegetarian	0	0
Frequency of Non veg consumption	Never	47	47.0
	Oncea week	8	8.0
	Thriceaweek	41	41.0
	Occasional	4	4.0
Meals consumed/ day	2 meals	15	15.0
	3-4meals	83	83.0
	Morethan 4 meals	2	2.0
Smoking	Yes	42	42.0
	No	58	58.0
Frequency of smoking	1-3sticks/day	24	24.0
	4-7sticks/day	17	17.0
	Morethan8 sticks/day	1	1.0
	Never	58	58.0
Alcohol	Yes	28	28.0
	No	72	72.0
Frequency of alcohol consumption	Daily	2	2.0
	Weekly	9	9.0
	Monthly	12	12.0
	Occasionally	5	5.0
	Never	72	72.0

to consume non veg thrice a week and 8 percent of them had a habit of consuming non veg once a week. Maximum number of respondents (83%) used to have 3 meals a day. The smoking habit was found among 42 percent of the respondents with 3-4 sticks per day as the frequency of smoking. Smoking is one of the leading risk factors for coronary heart disease, heart attack and stroke. Smoking causes a build-up of a fatty substance (plaque) in the arteries, which eventually leads to a hardening of the arteries (Zakir *et al.,* 2022). Alcohol consumption was not a regular habit among the respondents, only 28 percent of them used to drink with a frequency of once in a month (12%). Kaur *et al.,* (2019) found that smoking was one of the main risk factors for CVD among men, which was associated with a 1.6-fold increased risk whereas alcohol consumption was associated with a 1.7-fold increased risk however it was not significant.

Thus, World Health Organization recommends 5 portions of fruits and vegetables a day, whole grains and nuts, less than 10% of total energy intake from free sugars, less than 30% of total energy intake from fats (less saturated and trans-fats) and less than 5 g of iodized salt every day (WHO, 2018) for cardiovascular health along with physical activity of moderate intensity for at least 150 minutes in a week.

Table 5 depicted the association between BMI and the occurrence of CVD. The occurrence of Coronary artery disease (CAD) was found majorly (41.0%) followed by heart failure (38.0%) and arrhythmia (12.0%) irrespective of the range of BMI. The overweight and obese class I category together had the maximum percentage of occurrence of CAD, heart failure, arrhythmia and stroke. However, the P value indicated that there was no statistically significant association between BMI and the occurrence of CVD. Xue *et al.,* (2024) revealed that the coexistence of central obesity and high BMI exhibited a significant correlation with CVD incidence, encompassing both heart disease and stroke, exhibiting a stronger association than either central obesity with normal BMI or normal waist circumference with high BMI.

Table 6 presents the association between Diet and CVD. The occurrence of CAD was found majorly (41.0%) followed by heart failure (38.0%) and arrhythmia (12.0%) irrespective of the type of diet. Non vegetarians had a maximum occurrence of CAD compared to other types of diet and a similar trend was observed concerning the occurrence of heart failure, arrhythmia and stroke. However, the P value indicated that there was no statistically significant association between the type of diet and the occurrence

Table 5. Association between BMI and occurrence of Cardiovascular Disease (CVD)

BMI	CVD				P Value
	CAD n (%)	Heart failure n(%)	Arrhythmia n(%)	Stroken (%)	
18 – 24.9	10(24.4%)	7(18.4%)	0 (0.0%)	1(12.5%)	**0.234**
25 – 29.9	19(46.3%)	20(52.6%)	10 (83.3%)	5(62.5%)	
30–34.9	11(26.8%)	6(15.8%)	2(16.7%)	2(25.0%)	
35–39.9	1(2.4%)	5(13.2%)	0 (0.0%)	1(0.0%)	
Total	41 (41%)	38 (38%)	12(12.0%)	9(9.0%)	

Table 6. Association between Diet and CVD

Diet	CVD				P Value
	CAD n (%)	Heart failure n(%)	Arrhythmia n (%)	Stroke n(%)	
Vegetarian	14(34.1%)	14 (36.8%)	2 (16.70%)	2(22.2%)	**0.949**
Non-vegetarian	21(51.2%)	18 (47.4%)	8 (66.7%)	5(55.5%)	
Ovo-vegetarian	6 (14.6%)	6 (15.8%)	2 (16.7%)	1(11.1%)	
Total	41 (41.0%)	38(38.0%)	12(12.0%)	9(9.0%)	

of CVD. This was supported by Vinay *et al.,* (2020) who concluded that vegetarians found a beneficial association with coronary heart disease risk factors compared to omnivores. Khatun *et al.,* 2021 revealed that consumption of junk foods is associated with a significantly higher risk of coronary artery diseases. On the contrary, the consumption of fish, fruits, fresh vegetables and fat-free yogurt has protective effects on CAD while beef and eggs have a role in increasing the risk of CAD. There is no one-size-fits-all approach to improving cardiovascular health globally. Every population is susceptible to different risk factors based on where they live and their lifestyles (WHR, 2023). Lifestyle changes like smoking cessation, healthy eating, restricted fat intake, exercise and managing diabetes, blood pressure and stress, can greatly reduce the chance of CVD.

Table 7indicates the association between triglyceride levels and the occurrence of CVD. The maximum median value of triglycerides level was found with heart failure (156 mg/dL) with interquartile ranges from 114 mg/dL to 190 mg/dL, whereas the median value of CAD was found to be144 mg/dL with interquartile ranges from 95.25 mg/dL to 178.50 mg/dL. The lowest median value of 122 mg/dL was in stroke with interquartile ranges from 100 mg/dL to 374 mg/dL. However, the P value is 0.155, indicating that there is no statistically significant association between CVD and triglycerides.

Similar results were obtained by Khatun *et al*. (2021) found that cardiovascular risk factors, such as total cholesterol, triglycerides, LDL, HDL and high blood pressure were strongly related to CAD and concluded that Hypertriglyceridemia and high levels of LDL-cholesterol were prevalent in most CHD patients (99%) while half of the control patients showed hypertriglyceridemia and one-fifth had high concentrations of LDL-cholesterol. Another study by Deshmukh and Chavan (2020) concluded that patients with ischemic heart disease are associated with significantly

Table 7. Association between Triglycerides and CVD

Triglycerides (mg/dL)	CVD				P Value
	CAD	Heartfailure	Arrhythmia	Stroke	
Median	144	156	211	122	**0.155**
IQR	95.25-178.50	114 -190	100-374	97.75-207	

higher levels of serum Total Cholesterol, Total Triglycerides and LDL-Cholesterol. Another study conducted by Behera *et al.,* 2024 revealed that the highest prevalent risk factor for cardiovascular diseases was reported to be central obesity followed by overweight/ obesity, oral contraceptive use, raised blood pressure, raised blood sugar and tobacco use.

CONCLUSION

The present study revealed that the majority of the respondents (82%) were overweight to obese, most of the respondents (53%) were non vegetarians and fifty percent of them had diabetes and hypertension. A higher number of the respondents (79%) had CAD and heart failure and had undergone angioplasty and CABG treatment. The obese respondents had a higher percentage of CVD and non- vegetarians had a higher occurrence of CVD, though the associations were non-significant.

A higher prevalence of overweight and obesity added with other non-communicable diseases are the major risk factors among middle-aged and older respondents. This manifests alarming public health concerns and threat to a healthy future. Identifying and managing these risk factors with proper diet and health care can significantly reduce the incidence of CVD and enhance the quality of life, especially for middle-aged and older adults in India. Nutrition education, health promotion activities, early diagnosis and initiatives to manage CVD and related complications can play a key role in controlling and managing Cardiovascular Diseases.

REFERENCES

Behera, S., Sharma, R., Yadav, k., Chhabra, P., Das, M. and Goel, S. 2024. Prevalence and predictors of risk factors for cardiovascular diseases among women aged 15-49 years across urban and rural India: findings from a nation wide survey. BMC Women's Health, 24:77: 1-10

Deshmukh, P. K. and Chavan, M. S. 2020. A comparative study of lipid profile in IHD patients and healthy controls. MedPulse International Journal of Medicine, 14(3): 73-76.

Khatun, T., Maqbool, D., Ara, F., Sarker, M. R, Anwar, K. S and Hoque, A. 2021. Dietary habits of patients with coronary artery disease in a tertiary-care hospital of Bangladesh: a case-controlled study. Journal of Health, Population and Nutrition, 40(3): 1-6

Kaur, P., Rao, S. R, Venkatachalam, R., Kangusamy, B., Radhakrishnan, E., Kaliaperumal, K., Thota V. and Gupte, M. D. 2019. Risk factors for cardiovascular disease in rural South India: cohort study. BMJ Open: e029759. doi:10.1136/bmjopen-2019-029759.

Kundu, J and Kundu, S. 2022. Cardiovascular disease (CVD) and its associated risk factors among older adults in India: Evidence from LASI Wave 1. Clinical Epidemiology and Global Health, Volume 13, 100937.

Prabhakaran, D., Jeemon, P and Roy, A. 2016. Cardiovascular Diseases in India. Current Epidemiology and Future Directions Circulation,133: 1605-1620.

Prasad, D.K.V., Prabhavathi V, Sandhya Metta, and Sasikala T. 2024. Prevalence of Obesity and Overweight and their Association with Hypertension: A Cross-Sectional Study in a Tertiary Care Center of Northern Andhra Pradesh of India. European Journal of Cardiovascular Medicine, 14(3): 623-632.

Sverre, E.,Peersen, K., Perk, J., Husebye, E., Gullestad L, Dammen T,Otterstad J. E. and Munkhaugen J, 2021. Challenges in coronary heart disease prevention–experiences from a long-term follow-up study in Norway. Scandinavian Cardiovascular Journal, 55(2), 73–81.

Tripathy, J. P., Thakur, J. S., Jeet, G. 2017. Burden and risk factors of dyslipidemia-results from a STEPS survey in Punjab India. Diabetes and Metabolic Syndrome: Clinical Research & Reviews, I (11): S21–S27.

Vinay, B.C, Shastrya, C. S, Kodangalab, S., Matetia, U. V. and Bhat, K. 2020. Association of diet and lipid profile among coronary heart disease patients. Clinical Epidemiology and Global Health, 8: 1321–1324

WHO 2018. Healthy diet. Available at http:// www.who.int/news-room/ fact-sheets/ detail/healthy-diet.

WHO 2018.Physical activity recommendations. Available at http:// www.who.int/ dietphysicalactivity / factsheetrec ommendations

World Health Organization, 2024, Fact Sheets on Non communicable diseases.

WHR, 2023. World Heart Report - Confronting the World's Number One Killer. World Heart Federation 32, Rue De Malatrex, 1201 Geneva, Switzerland.

Xue, Y., Yang X and Liu G 2024. Association of combined body mass index and central obesity with cardiovascular disease in middle-aged and older adults: a population-based prospective cohort study. BMC Cardiovascular Disorders, 24:443 pp 1-11

Zakir, F., Mohapatra, S., Farooq U., Mirza, M. A., and Iqbal Z., 2022. Introduction to metabolic disorders in Drug Delivery Systems for Metabolic Disorders. Elsevier, pp. 1–20.

Pattan, N. and Iffath, A. 2025. Assessment of Nutritional Status of Adults with Cardiovascular disease. The Journal of Research ANGRAU, 53(3): 57-67.

DoI: https://doi.org/10.58537/jorangrau.2025.53.3.07

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PHYTOPHARMACOLOGICAL EVALUATION OF *ANACARDIUM OCCIDENTALE* L. TESTA FROM CASHEW PROCESSING BIOWASTE

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ABSTRACT

The present study was performed during the year 2024 to evaluate and explore the phytopharmacological properties of *Anacardium occidentale L*. nut testa – a biowaste obtained after cashew kernel processing. The presence of versatile forms of phytochemicals was confirmed by qualitative analysis, whereas anti-nutritional factor analysis revealed no detectable presence.The total phenolic content was quantified, as phenols can contribute to various biological activities. The pharmacological properties of the testawere assessed using in-vitro alpha amylase inhibition assay and in-vitro protein denaturation assay. The former method was used to estimate the anti-diabetic potential and the resultant IC_{50} value of the standard and extract were 1.77±0.145µg/ml and 2.56 ±0.211µg/ml respectively. The latter method was opted to evaluate the anti-inflammatory potential of the extract. The IC_{50} values of the standard was 3.17 ±0.221 µg/mland the extract were 4.80 ±0.314 µg/ml. The results of the study showed that the sample contains substantial amounts of phenols, potentially contributing to the significant anti-diabetic and anti-inflammatory activity compared to that of the standards used.Thus, the study aids the research in utilizing cashew nut testa for developing value added products with pharmacological potential.

Keywords: *Anacardium occidentale L*. testa, Anti-diabetic activity, Anti-inflammatory activity, Biowaste, IC_{50} values, Phytopharmacology.

INTRODUCTION

Cashew cultivation in India has been spread across the peninsular areas including Kerala, Goa, Karnataka, Maharashtra, Tamil Nadu**,**Andhra Pradesh, West Bengal and Orissa. Cashew is also cultivated in other states of the country to a small extent. (Directorate of cashew and cocoa development, Government of India, 2024). As per the report of Kerala State Agency for the Expansion of Cashew Cultivation (2022), about 8,80,000 numbers of high yielding varieties of cashew were developed by Kerala Agricultural University and the same was distributed by Indian Council of Agricultural Research (ICAR) under Cashew Model Garden, Cashew Model Farm and Muttathoru Kasumavu schemes in the year 2022 -2023. Now, contribution of Kerala towards the cashew processing sector in India has set a standard.

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Unit operations in cashew industry follows the steps including roasting, shelling, peeling and packing of kernels. After these processes, the outer shell and testa are discarded as waste from these industries. The bio wastes obtained after processing are utilised to extract cashew nut shell liquid (CNSL) and tannins. The focus area of the present study is to evaluate the phytopharmacological properties of cashew nut testa and todetermine the reusing potential of testa to obtain products that can manage various non- communicable diseases.

MATERIAL AND METHODS

Sample Collection and preparation

The sample in sealed cover were collected from a Cashew processing unit, located at Cheerankavu, Kollam district, Kerala. The sample was grounded and sieved to obtain evenly sized powder. The sieved powder about 200gms was packed and subjected to soxhlet extraction. The extraction was successfully completed at 50^0C for 48 hours using petroleum ether followed by ethanol as solvents. The extracts thus obtained were concentrated at 40^0C using rotary evaporator after successive collection from the soxhlet apparatus. The extracts were then refrigerated at 4^0C for further analysis.

Percentage yield of the sample extract

The estimation of percentage yield of the sample extract from the raw material is relevant in product manufacturing industry. Many factors including the origin of the sample as well as extraction methods can influence the yield of the sample. The percentage yield of the sample was calculated using the following formula.

$$\text{Percentage yield of the sample} = \frac{\text{Weight of the crude extract}}{\text{Weight of the dry sample used for extraction}} = 100$$

Phytochemical screening of the extracts

The petroleum ether extract and ethanolic extract of the sample were used to qualitatively analyse the presence of major phytochemicals. Standardized methods were used for the analysis.

Analysis of anti-nutritional factors in the crude extract

Antinutritional factors are chemical compounds present in plants that are proven to reduce the biological availability of essential nutrients like proteins. These compounds can also be a major reason for disorders caused due to micronutrient deficiency (Samtiya *et al.,* 2020). Thus, the testa sample was analysed to detect the presence of antinutritional factors including phytates,oxalates and nitrates.

Quantitative estimation of total phenolic content

Phenolic compounds are proved to exhibit anti-diabetic activity and inhibit pro-inflammatory cytokine synthesis, contributing to the regulation of immune response. (de Paulo Farias *et al.,* 2021; Yahfoufi *et al.,* 2018). Thus, the total phenolic content of the crude ethanolic extract was determined using Folin – Ciocalteau assay.

Antidiabetic activity of the crude ethanolic extract

Crude ethanolic extract of the sample was evaluated for its antidiabetic activity performing alpha-amylase inhibition assay using 3,5 – dinitrosalicylic acid (DNSA) described by Wickramaratne *et al.,* (2016) with modification. The buffer was solubilized with alpha-amylase from porcine pancreas. Stock solution of sample with standard value was prepared. Starch solution dissolved in

buffersaline, distilled water and sample were mixed well. The test tubes were incubated at 25°C for three minutes after addition of the enzyme.

After the initiation of the reaction the enzyme was further added at one minute interval. In a test tube,dinitrosalicylic acid colour reagent and the mixture was added and placed in a water bath at 85°C–90°C for fifteen minutes. The dilution of the mixture was completed with addition of distilled water. Acarbose which is aná-amylase inhibitor was the standard drug used for the assay.The experiments were done in triplicates. The formula used to calculate the á-amylase inhibitory activity using the spectrophotometric values at 540nm is as follows.

$$\text{Percentage inhibition} = \frac{\text{Absorbance of control - Absorbance of sample]} \times 100}{\text{Absorbance of control}}$$

Anti-inflammatory activity of the crude ethanolic extract

The crude ethanolic extract of the sample wasevaluated for its anti-inflammatory potential using protein denaturation assay described by Bailey-Shaw *et al.,* (2017) with modification. The total volume of reaction mixture was 5ml which consist of albumin solution, sample and phosphate buffer saline. A mixture of standard was also prepared at varying concentrations. The total volume of the control was also set to 5ml. The reaction mixtures were incubated at 37±2°C for thirty minutes and was kept in a water bath at 70±2°C for fifteen minutes. After cooling, the absorbance was measured at 660 nm by a UV/Visible spectrophotometer.The IC_{50} value was determined by plotting percentage inhibition against concentration gradient. The following equation was used to determine the % inhibition of the standard and the sample.

RESULTS AND DISCUSSION

The results of phytochemical screening and assessment of phytopharmacological properties of the crude ethanolic extract of the sample is discussed under the following headings.

Percentage yield of the sample

The weight of the powdered sample taken for soxhlet extraction was 200gms. The table no: 1 illustrated below shows the percentage yield of the crude extracts obtained after soxhlet extraction using petroleum ether and ethanol as solvents.

Qualitative phytochemical analysis

The qualitative analysis of the phytochemicals in petroleum ether extract and ethanolic extract of the sample was performed. The methods and results of qualitative analysis of phytochemicals in the extracts are depicted in table no.2.

The phytochemical screening of the testa using the petroleum ether extract,showed the presence of terpenoids and steroids whereas the ethanolic extract showed the presence of alkaloids, tannins, flavanoids, glycosides, terpenoidsand sugars. Sruthi *et*

Table 1. Percentage yield of the extracts

Sl.No.	Solvent used for the soxhlet extraction	Weight of the powdered sample (g)	Weight of the crude extract (g)	Percentage Yield (%)
1.	Petroleum ether	200	85.43	42.72
2.	Ethanol	200	118.79	59.40

Table 2. Phytochemical present in the crude extracts

Sl.No.	Tests for secondary metabolites	Petroleum ether extract	Ethanolic extract
1.	Alkaloids		
	a) Mayer's Test	b) Dragendroff's Test	a) Negative
	b) Negative	a) Positive	b) Positive
2.	Tannins		
	a) Ferric Chloride Test	b) Lead acetate Test	a) Negative
	b) Negative	a) Positive	b) Positive
3.	Flavonoid's		
	a) Shibata's Test	a) Negative	b) Negative
	b) Ammonia Vapour Test	a) Positive	b) Positive
4.	Saponins		
	Frothing Test	Negative	Negative
5.	Glycosides		
	Fehling's Test	Negative	Positive
6.	Cyanogenic Glycosides		
	Picrate Test	Negative	Positive
7.	Cardiac glycosides		
	Negative	Negative	
8.	Sugars		
	Molisch's Test	Negative	Positive
9.	Anthraquinone's		
	Borntrager's Test	Negative	Negative
10.	Steroids		
	Liebermann's Test	Positive	Negative
11.	Terpenoids		
	a) 2,4 dinitrophenyl hydrazine Test	Positive	Positive
	b) Salkowski test	Positive	Positive

al.(2023) and Zafeer *et al*. (2023) has reported the presence of flavanols and tannins in cashew nut testa which favours the results of the present study.

Analysis of anti-nutritional factors in the crude extract

The sample was analysed to determine the presence of common antinutritional factors. The analysis confirmed the absence of phytates, oxalates and nitrates. The results suggests that the sample may be suitable for formulation of value-added products as there

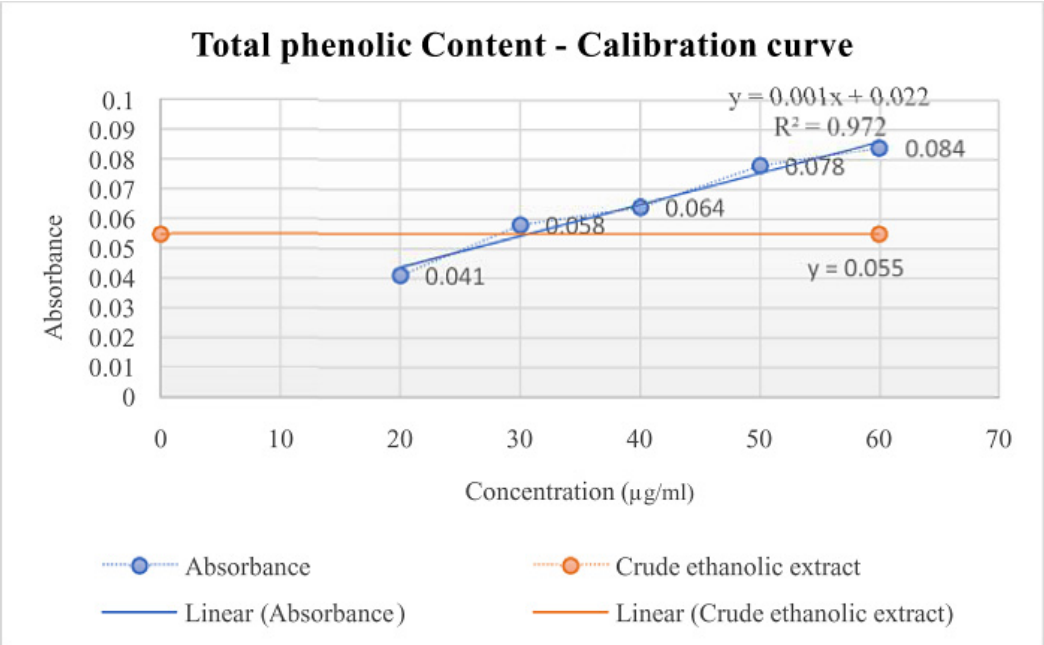

Fig.1. Calibration curve of catechol for determination of total phenolic content

is minimal risk of interference with nutrient metabolism.

Quantitative analysis of total phenolic content of the crude extract

The total phenolic content of the crude extract was determined using Folin- Ciocalteu method. Fig. 1 represents the calibration curve constructed using the standard at different concentration (µg/ml) and corresponding absorbance at 750nm. The estimated value of phenol is represented as mg CE/g of extract.

The concentration vs absorbance graph was plotted to determine the total phenolic content in the ethanolic extract of the sample. A linear regression y = 0.0011x+ 0.0226 with coefficient of determination R^2 = 0.972 was displayed in the above graphical representation. The total phenolic content of the sample was quantified to be29.45+ 0.184µg/mland is expressed as 29.45+ 0.184mg CE/g extract, indicating a substantial amount in the sample and the testa as a comparable source of natural polyphenol.

Table 3. Alpha-amylase inhibitory effects of standard and extract

Concentration (µg/ml)	Average absorbance of standard(nm)	Average % inhibition of standard	Average absorbance of extract (nm)	Average % inhibition of extract
0.2	0.584	41.37	0.674	32.33
0.4	0.471	52.71	0.599	39.86
0.6	0.354	64.46	0.411	58.73
0.8	0.274	72.49	0.324	67.47
1	0.147	85.24	0.221	77.81

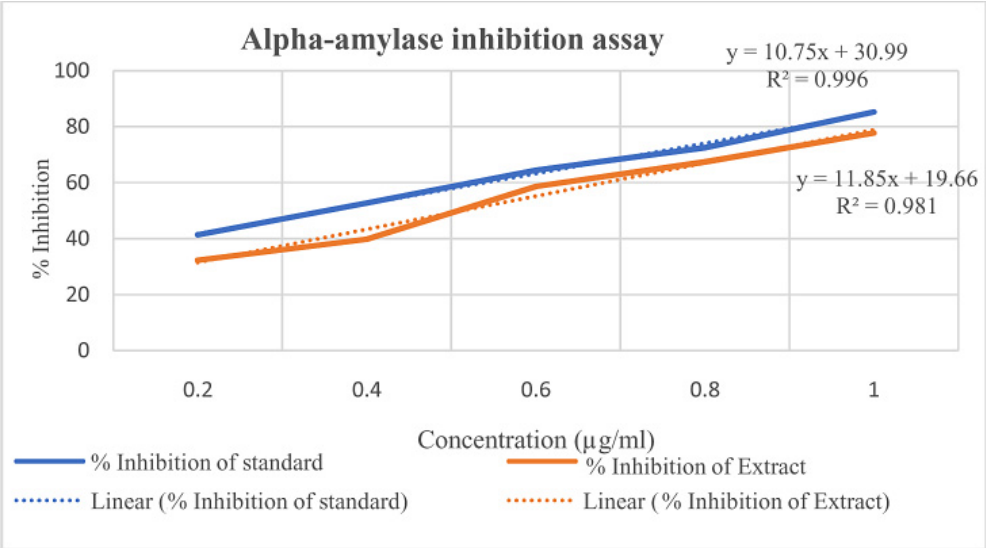

Fig. 2. Alpha - amylase inhibition assay

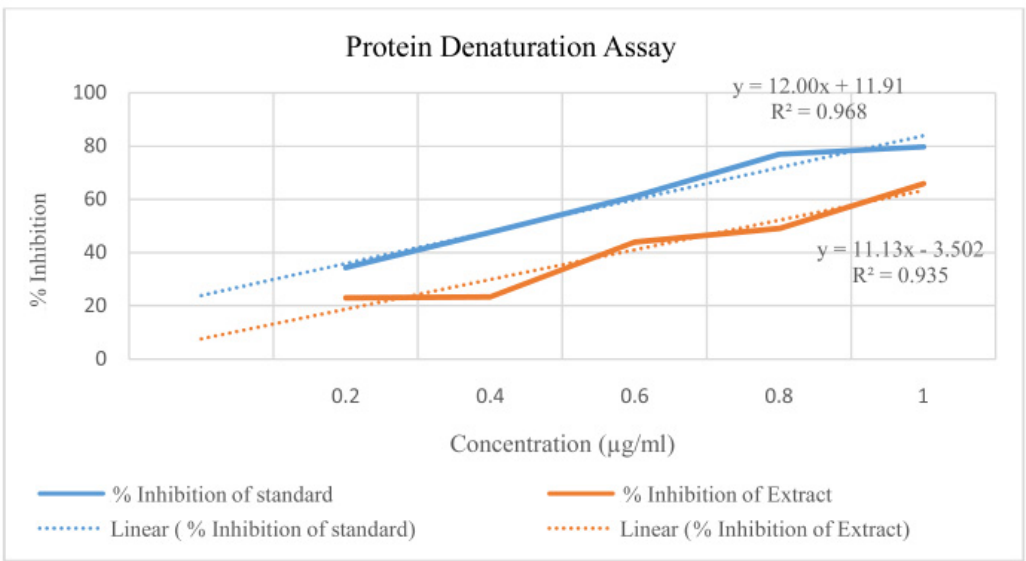

Fig. 3. Protein denaturation assay

Anti- diabetic activity of the crude ethanolic extract of the sample

Anti- diabetic activity of the sample was assessedusing in-vitro alpha amylase inhibition assay. The following tabular column (table no.3) shows the concentration, average absorbance and average percentage inhibition values of the standard and the extract. The graphical representation (fig.2) shows concentration vs average percentage inhibition of the standard and the sample extract. The absorbance of the control was 0.996nm.

It has been reported that the alpha-amylase enzyme is a reason for the rise in post prandial hyperglycemia and blood glucose levels. In order to treat and maintain the blood sugar level, treatments are targeted in inhibiting the activity of this enzyme (Kaur *et al.,* 2021). From the graph, it is evident that there is aconcentration dependent increase in average percentage inhibition proving the antidiabetic potential of the standard and the sample. The regression analysis revealed a strong correlation between both the variables,

Table 4. Effect of standard and extract on protein denaturation

Concentration (µg/ml)	Average absorbance of standard(nm)	Average % inhibition of standard	Average absorbance of extract (nm)	Average % inhibition of extract
0.2	0.599	34.32	0.702	23.02
0.4	0.478	47.59	0.699	23.36
0.6	0.354	61.18	0.511	43.97
0.8	0.211	76.86	0.465	49.01
1	0.185	79.71	0.311	65.90

reflected in the R – squared value of standard (R^2 = 0.9964) and value of sample (R^2 = 0.9814). The concentration dependent inhibition of the standard and sample were determined by calculating the IC_{50} values.The IC_{50} values of the standard and sample were obtained using the prescribed linear regression equation y = mx + c. The resultant IC_{50} of the standard and extract were 1.77±0.145µg/ml and 2.56±0.211µg/ml respectively. From the above results it was evident that the sample possess a very strong alpha-amylase inhibition activity as the IC_{50}value falls below 50µg/ml, supporting the potential of components in the extract as natural anti-diabetic agent.

Anti – inflammatory activity of the crude ethanolic extract of the sample

The protein denaturation assay was used to evaluate the anti – inflammatory activity of the sample. The potential of the components in the ethanolic extract to inhibit the denaturation of bovine serum albumin was determined in comparison to activity expressed by the most potent non – steroidal anti-inflammatory drug, Diclofenac.

The tabular column (table no.4) shows the concentration, average absorbance and average percentage inhibition values of the standard and the extract. The concentration vs average % inhibition graph (fig.3)illustrates the change in absorbance value with respect to the concentration of the standard and the sample. The absorbance of the control was 0.912nm.

From the graph it is evident that there is an increment in average percentage inhibition with respect to the increase in concentration, proving the potential of the standard and the sample to stabilize proteins. The regression analysis revealed a strong correlation between concentration and average percentage inhibition, reflected in the values of R^2 = 0.9688of standard and value of R^2 = 0.935ofsample. The concentration dependent inhibition of the standard and sample were determined by calculating the IC_{50}values.The IC_{50} values of the standard and the extract was3.17 ±0.221 µg/ml and 4.80 ±0.314 µg/ml respectively. Thus, from the results it can be confirmed that the bioactives in the crude ethanolic extract of the sample exhibits significant anti-inflammatory activity in relation to the standard used, supporting its potential use as a natural anti-inflammatory agent.

CONCLUSION

The study systematically evaluated the phytopharmacological profileof cashew nut testa. The qualitative analysis of bioactive compounds was performed both in crude extracts of petroleum ether and ethanol. The results confirmed the presence of key secondary metabolites that possess extensive bioactivity potential. In parallel, analysis of

antinutritional factors resulted in the absence of inhibitory compounds like phytates, oxalates and nitrates,indicating the potential of cashew nut testa for nutritional and therapeutic use. Among the crude extracts,ethanolic extract revealed a broad spectrum of plant derived actives and thus it was used for further analysis.As the presence of phenols is indicative of various physiological effects,the total phenolic content in the crude ethanolic extract was estimated. A significant concentration of phenolics with a value of 29.45+ 0.184mg CE/g extract highlights the pharmacological potential of the sample.The promising phyto-pharmacological properties exhibited by cashew nut testa encourages the efficient recovery, recycling and reuse,to develop cost – effective and sustainable therapeutic as well as value-added products. This approach would also maximize the waste utilisation and ceases unethical use of the testa. In depth clinical studies are suggested to confirm the efficacy of the sample in exhibiting these properties.

REFERENCES

Bailey-Shaw, Y. A., Williams, L. A., Green, C. E., Rodney, S. and Smith, A. M. 2017. In-vitro evaluation of the anti-inflammatory potential of selected Jamaican plant extracts using the bovine serum albumin protein denaturation assay. International Journal of Pharmaceutical Sciences Review and Research, 47(1),145-153.

de Paulo Farias, D., de Araujo, F. F., Neri-Numa, I. A. and Pastore, G. M. 2021. Antidiabetic potential of dietary polyphenols: A mechanistic review. Food Research International, 145, 110383.

Directorate of Cashew and Cocoa development. Crop history, Cashew. Retrieved from Crop history - cashew | Directorate of Cashewnut and Cocoa Development on 13.11.2024.

Kaur, N., Kumar, V., Nayak, S. K., Wadhwa, P., Kaur, P. and Sahu, S. K. 2021. Alpha-amylase as molecular target for treatment of *Diabetes mellitus*: A comprehensive review. Chemical biology and drug design, 98(4), 539-560.

Kerala State Agency for the expansion of Cashew Cultivation 2022. About cashew. Retrieved from KSACC - Kerala State Agency for the expansion of Cashew Cultivation on 12. 11. 2024.

Samtiya, M., Aluko, R. E. and Dhewa, T. 2020. Plant food anti-nutritional factors and their reduction strategies: an overview. Food Production, Processing and Nutrition, 2, 1-14.

Sruthi, P. and Naidu, M. M. 2023. Cashew nut (*Anacardium occidentale L.)* testa as a potential source of bioactive compounds: A review on its functional properties and valorization. Food Chemistry Advances, 3, 100390.

Wickramaratne, M. N., Punchihewa, J. C. and Wickramaratne, D. B. M. 2016. In-vitro alpha amylase inhibitory activity of the leaf extracts of *Adenanthera pavonina*. BMC complementary and alternative medicine, 16: 1-5.

Yahfoufi, N., Alsadi, N., Jambi, M. and Matar, C. 2018. The immunomodulatory and anti-inflammatory role of polyphenols. Nutrient, 10(11): 1618.

Zafeer, M. K., and Bhat, K. S.2023. Valorisation of agro-waste cashew nut husk (Testa) for different value-added products. Sustainable Chemistry for Climate Action, 2, 100014.

Priyanka, P.S. and; Isaac, B. R. 2025. Phytopharmacological Evaluation of *Anacardium Occidentale L.* Testa: Cashew Processing Biowaste. The Journal of Research ANGRAU, 53(3): 68-75.

DoI: https://doi.org/10.58537/jorangrau.2025.53.3.08

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NUTRITIONAL HEALTH CHALLENGES AND LIFESTYLE PATTERNS AMONG NURSES IN THIRUVANANTHAPURAM, KERALA

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ABSTRACT

This research conducted in 2019-20, aimed to assess the lifestyle patterns and nutritional status of nurses using a crosssectional, comparative approach with purposive sampling. The study included 500 registered female nurses, aged 25–45 years, from government and private hospitals in rural and urban regions of Thiruvananthapuram city. Findings revealed unhealthy lifestyle habits among nurses in both sectors, including insufficient physical activity (72% in government hospitals; 78% in private hospitals), inadequate sleep (51% and 56%, respectively), insufficient work breaks and difficulty in managing worklife balance. Underweight conditions were observed in 41% of government and 47% of private hospital nurses, together with poor dietary practices (40% and 70%, respectively). Biochemical analyses revealed high prevalence rates of anemia (50% in both sectors), diabetes (33% and 25%) and hypercholesterolemia (42% in both). These findings underscore critical gaps in nurses' health and lifestyles, calling for urgent staff development initiatives and training programs by hospital authorities and policymakers to improve nurses' well-being and care quality.

Keywords: Dietary habits, Lifestyle patterns, Nutritional status, Work-life balance

INTRODUCTION

Nurses often face challenges in maintaining healthy lifestyles and dietary habits due to their demanding schedules. A key factor affecting health is lifestyle and as frontline health professionals, nurses play a vital role in combating various diseases. However, this also exposes them to a higher risk of developing health issues and related complications. The study seeks to examine lifestyle patterns and contributing factors among nurses working shifts in hospitals across Thiruvananthapuram.

A study by Kumar *et al*., (2023) highlights that lifestylerelated disorders, including irregular sleep patterns, poor eating habits, meal skipping and lack of physical activity are strongly associated with shift work, contributing to deteriorating health. The demanding work environment and unpredictable nature of nursing tasks expose nurses to numerous work related risks, which can have long term health consequences.

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Additionally, healthcare workers, particularly nurses, have played a critical role in managing the COVID-19 pandemic. As frontline workers, nurses are at higher risk of exposure to the virus, with both the illness and its lingering effects posing significant health challenges (Cheng *et al.,* 2024).

The global COVID-19 pandemic has significantly impacted healthcare workers, with nurses facing a higher incidence of illness due to their frontline roles. Despite the growing concerns surrounding the health and wellbeing of nurses, a thorough examination of their lifestyle patterns and nutritional status remains underexplored. Given the critical role nurses play in healthcare systems, this study aims to assess the lifestyle behaviors, dietary habits and overall nutritional status of nurses in Thiruvananthapuram, in light of the ongoing challenges they face in their demanding profession.

MATERIAL AND METHODS

This study employed a cross-sectional, comparative design, utilizing a purposive sampling method. The sample consisted of 500 registered female nurses, aged 25–45 years, working in both government and private hospitals located in rural and urban areas of Thiruvananthapuram city, Kerala, India.

Data collection took place over a span of more than one and a half years which is from February, 2019- August 2020, across government and private hospitals in both rural and urban settings within Thiruvananthapuram, Kerala. After obtaining necessary permissions from relevant authorities, the investigator personally contacted participants, coordinating with the Nursing Superintendent of the respective hospitals to schedule a convenient time for data collection. The study purpose was explained to the nurses and interviews were conducted at their workplaces towards the end of shifts to minimize disruption. A structured interview schedule assessed lifestyle patterns, including physical activity (exercise habits, types and duration), sleep (duration, quality, satisfaction and improvement methods) and social/family relationships.

Physical activity scores were derived based on participants' responses regarding their exercise habits, including the type of exercise and its duration. Since the physical activity parameters could not be converted into a continuous scale, each question was categorized accordingly. Sleep scores were calculated based on the duration of sleep, sleep quality, and the time taken to fall asleep, with individual scores assigned to each variable and the overall score reflecting the individual's sleep pattern. Additionally, thirteen statements, considered significant by experts, were identified concerning social relationships, leisure activities, child upbringing and interactions with family and friends. Participants' responses to these statements were recorded on a 3-point scale (yes/no/sometimes), with scores allotted for each response and a compounded score was then calculated.Nutritional status was evaluated using anthropometric (height, weight, waist/hip circumference, BMI, WHR), biochemical (hemoglobin, total cholesterol, HbA1c), dietary and clinical assessments.

The clinical symptoms experienced by shift workers were compiled from relevant literature (Belczak *et al*., 2018) and validated with input from medical experts. The schedule included a range of measurement parameters, organized as a checklist. To assess the health status of the participants, blood pressure readings were taken using an automated digital blood pressure monitor.

RESULTS AND DISCUSSION

The study encompassed 500 nurses working in government and private hospitals across Thiruvananthapuram. A summary of the

Table 1. Demographic details of the respondents **n=500**

Particulars	Government hospitals (n=250)			Private hospitals (n=250)		
	Rural n=125	Urban n=125	Total	Rural n=125	Urban n=125	Total
Age(yrs)						
25-30	26(10.4)	16(6.4)	42(16.8)	38(15.2)	45(18.0)	83(33.2)
31-35	27(10.8)	58(23.2)	85(34.0)	64(25.6)	61(24.4)	125(50.0)
36-40	20(8.0)	16(6.4)	36(14.4)	17(6.8)	14(5.6)	31(12.4)
41-45	52(20.8)	35(14.0)	87(34.8)	6(2.4)	5(2.0)	11(4.4)
Religion						
Hinduism	79(31.6)	94(37.6)	173(69.2)	97(38.8)	94(37.6)	191(76.4)
Christianity	26(10.4)	17(6.8)	43(17.2)	25(10.0)	31(12.4)	56(22.4)
Islam	20(8.0)	14(5.6)	34(13.6)	3(1.2)	0(0.0)	3(1.2)
Years of Experience						
Up to 5yrs	36(14.4)	47(18.8)	83(33.2)	19(7.6)	24(9.6)	43(17.2)
>5-10years	34(13.6)	47(18.8)	81(32.4)	71(28.4)	85(34.0)	156(62.4)
>10-15 years	18(7.2)	14(5.6)	32(12.8)	26(10.4)	16(6.4)	42(16.8)
>15 years	37(14.8)	17(6.8)	54(21.6)	9(3.6)	0(0.0)	9(3.6)
Occupational status						
Head Nurse	20(8.0)	11(4.4)	31(12.4)	16(6.4)	36(14.4)	52(20.8)
Staff nurse grade1/ Senior SN	25(10.0)	12(4.8)	37(14.8)	13(5.2)	0(0.0)	13(5.2)
Staff nurse grade 2/ Junior SN	80(32.0)	102(40.8)	182(72.8)	96(38.4)	89(35.6)	185(74.0)
Marital status						
Married	114(45.6)	94(37.6)	208(83.2)	115(46.0)	106(42.4)	221(88.4)
Unmarried	9(3.6)	31(12.4)	40(16.0)	8(3.2)	19(7.6)	27(10.8)
Widowed	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Divorced	2(0.8)	0(0.0)	2(0.8)	0(0.0)	0(0.0)	0(0.0)
Separated	(0.00)	0(0.0)	(0.00)	2(0.8)	0(0.0)	2(0.8)
Bonded agreement in job						
Yes	35(14.0)	33(13.2)	68(27.2)	1(0.4)	15(6.0)	16(6.4)
No	90(36.0)	92(36.8)	182(72.8)	124(49.6)	110(44.0)	234(93.6)

Particulars	Government hospitals (n=250)			Private hospitals (n=250)		
	Rural n=125	Urban n=125	Total	Rural n=125	Urban n=125	Total
Type of family						
Nuclear	105(42.0)	115(46.0)	220(88.0)	110(44.0)	109(43.6)	219(87.6)
Joint	20(8.0)	10(4.0)	30(12.0)	13(5.2)	15(6.0)	28(11.2)
Extended	(0.00)	(0.00)	(0.00)	2(0.8)	1(0.4)	3(1.2)
Monthly Salary(Rs.)						
5000-10000	3(1.2)	6(2.4)	9(3.6)	0(0.00)	0(0.00)	0(0.00)
10000-15000	25(10.0)	8(3.2)	33(13.3)	3(1.2)	4(1.6)	7(2.8)
150001-20000	3(1.2)	13(5.2)	16(6.4)	29(11.6)	17(6.8)	46(18.4)
20001-30000	29(11.6)	19(7.6)	48(19.3)	93(37.2)	104(41.6)	197(78.8)
30001-40000	30(11.6)	52(20.9)	82(32.5)	0(0.00)	0(0.00)	0(0.00)
Above 40000	35(14.1)	27(10.8)	62(24.9)	0(0.00)	0(0.00)	0(0.00)

Number in parenthesis indicates percentage

demographic characteristics of the nurses is presented in Table 1.Demographic profiles provide insights into the diverse characteristics of a specific population, enabling a generalized understanding of the study group.

As observed in Table 1, 34.8% of respondents in government hospitals fell within the age categoryof 40-45 years, while in the private sector, nearly half (50%) of the participants were from the 30-35 years age group. The majority of respondents in both government (69.2%) and private hospitals (76.4%) belong to the Hindu religion.

In terms of job roles, most respondents in government hospitals (72.8%) were classified under the 'Staff Nurse Grade 2' category, whereas in private hospitals (74%) they were categorized as 'Junior Staff Nurses.' Marital status data revealed that the majority of participants were married, with 83.2% in government hospitals and 88.4% in private hospitals.

Regarding employment agreements, a significant proportion of respondents in government hospitals (72.8%) and private hospitals (93.6%) were not bound by any bonded agreements with their employers. Family structure analysis showed that most respondents were from nuclear families, comprising 88% in government hospitals and 87.6% in private hospitals.

In terms of income levels, 32.5% of government hospital respondents earned between Rs. 30,001 and Rs. 40,000 per month, while the majority of private hospital respondents (78.8%) fell into the salary range of Rs.20,001 to Rs.30,000 per month.

As per the table 2, the findings revealed that the majority of nurses in both private hospitals (78%) and government hospitals (72%) did not engage in any form of exercise. Among those who participated in physical activity, walking emerged as the most preferred choice, with 18% of nurses in government

Table 2.Physical activities of the respondents **n=500**

Particulars	Government hospitals (n=250)			Private hospitals (n=250)		
	Rural n=125	Urban n=125	Total	Rural n=125	Urban n=125	Total
Frequency of Exercise						
Regularly	43(17.2)	24(9.6)	67(26.8)	18(7.2)	27(10.8)	45(18.0)
Never	82(32.8)	98(39.2)	180(72.0)	100(40.0)	95(38.0)	195(78.0)
Sometimes	-	3(1.2)	3(1.2)	7(2.8)	3(1.2)	10(4.0)
Total	**125(50.0)**	**125(50.0)**	**250(100.0)**	**125(50.0)**	**125(50.0)**	**250(100.0)**
Type of exercise						
Aerobic	-	5(2.0)	5(2.0)	1(0.4)	1(0.4)	2(0.8)
Dancing	-	2(0.8)	2(0.8)	-	-	-
Physical exercise	6(2.4)	3(1.2)	9(3.6)	8(3.2)	7(2.8)	15(6.0)
Walking	35(14.0)	10(4.0)	45(18.0)	14(5.6)	19(7.6)	33(13.2)
Yoga	2(0.8)	7(2.8)	9(3.6)	2(0.8)	3(1.2)	5(2.0)
Total	**43(17.2)**	**27(10.8)**	**70(28.0)**	**25(10.0)**	**30(12.0)**	**55(22.0)**
Duration of involvement per day						
<1hr	27(10.8)	13(5.2)	40(16.0)	22(8.8)	23(9.2)	45(18.0)
1-2hrs	10(4.0)	11(4.4)	21(8.4)	3(1.2)	7(2.8)	10(4.0)
2-3 hrs	6(2.4)	3(1.2)	9(3.6)	-	-	-
Total	**43(17.2)**	**27(10.8)**	**70(28.0)**	**25(10.0)**	**30(12.0)**	**55(22.0)**

Number in parenthesis indicates percentage

hospitals and 13% in private hospitals opting for it. Similarly, a recent study by Zhao *et al*., (2022) highlighted that healthcare workers, particularly shift workers, often reported walking as their primary form of physical activity, but their involvement in other types of exercise or sports activities remained minimal.

Additionally, the duration of exercise among nurses was generally short, with most respondents in government hospitals (16%) and private hospitals (18%) exercising for less than an hour per session. These findings underscore that physical activity levels among nurses are relatively low, which may have implications for their overall health and wellbeing.

According to table 3, 20 percent of nurses from government hospitals and 22 percent from private hospitals, reported sleeping for less than 5 hours. This inadequate sleep duration adversely impacts their health. Sleep deprivation and resulting fatigue were prevalent among these healthcare professionals, affecting their decision-making

Table 3. Sleeping pattern of the respondents **n=500**

Particulars	Government hospitals (n=250)			Private hospitals (n=250)		
	Rural n=125	Urban n=125	Total	Rural n=125	Urban n=125	Total
Sleep						
<5hrs	35(14.0)	16(6.4)	51(20.4)	21(8.4)	35(14.0)	56(22.4)
5 to 7 hrs	88(35.2)	94(37.6)	182(72.8)	95(38.0)	74(29.6)	169(67.6)
Irregular sleep duration	2(0.8)	15(6.0)	17(6.8)	9(3.6)	16(6.4)	25(10.0)
Total	**125(50.0)**	**125(50.0)**	**250(100.0)**	**125(50.0)**	**125(50.0)**	**250(100.0)**
Time taken to fall asleep						
Sudden sleep	67(26.8)	87(34.8)	154(61.6)	101(40)	65(26.0)	166(66.4)
1/2 an hr	41(16.4)	23(9.2)	64(25.6)	21(8.4)	31(12.4)	52(20.8)
1hr	12(4.8)	15(6.0)	27(10.8)	3(1.2)	22(8.8)	25(10.0)
2hrs	-	-	-	-	7(2.8)	7(2.8)
3 or more hrs	5(2.0)	-	5(2.0)	-	-	-
Total	**125(50.0)**	**125(50.0)**	**250(100.0)**	**125(50.0)**	**125(50.0)**	**250(100.0)**
Sound sleep						
Yes	64(26)	82(32.8)	146(58.4)	68(27.2)	58(23.2)	126(50.4)
No	58(23)	31(12.4)	89(35.6)	38(15.2)	42(16.8)	80(32.0)
Sometimes	3(1.2)	12(4.8)	15(6.0)	19(7.6)	25(10.0)	44(17.6)
Total	**125(50.0)**	**125(50.0)**	**250(100.0)**	**125(50.0)**	**125(50.0)**	**250(100.0)**

Number in parenthesis indicates percentage

abilities, planning skills and alertness. A small proportion of nurses in government (6.8%) and private (10%) hospitals reported irregular sleep patterns.

Research has shown that insufficient sleep is linked to cognitive impairments, mood disturbances, diminished job performance, reduced motivation, increased safety risks and physiological changes. Consecutive night shifts were found to significantly increase fatigue among nurses. Additionally, sleep disturbances and the effects of aging are common challenges faced by shift workers (Suh *et al*., 2023).

The majority of nurses in both government (62%) and private hospitals (66%) reported falling asleep quickly once they went to bed, likely due to the long working hours and exhaustion. Furthermore, 58% of government and 50% of private hospital nurses indicated that they experienced sound sleep. However, these findings contrast with other research studies. For instance, Patel *et al*., (2023) examined sleep patterns among nurses and identified that shift work and irregular

schedules were associated with a high prevalence of sleep disturbances and poor sleep quality among healthcare workers.

This study highlights that the impact of shift work on sleep among nurses in Thiruvananthapuram, in both government and private sectors, was not acknowledged as a significant issue by many respondents.

Table 4 provides an overview of the quality of social and family relationships among nurses in both government and private sectors. A significant proportion of nurses, 51.2% in government hospitals and 57.6% in private hospitals, reported being unable to share family meals together most of the time. The nature of shift work significantly impacted their social relationships, with many respondents acknowledging feelings of social isolation from friends. For some, the only way to maintain connections was through social media platforms.

In this study, 46% of nurses in government hospitals and 16.8% in private hospitals reported that their social relationships had deteriorated. Many nurses in the government sector experienced a noticeable decline in their interactions with family members, relatives and friends.

Other common challenges faced by nurses in both sectors included difficulties in managing responsibilities such as their children's education, addressing health concerns, handling house repairs and attending to other domestic duties. A key issue raised by many was the lack of time to spend with their children and family. As most nurses were married, they expressed concerns about their husbands and children, particularly during night shifts.

A small percentage of nurses in both government and private hospitals stated that their husbands did not fully understand the stress caused by their work schedules. However, some nurses felt fortunate to have support from relatives to manage certain family responsibilities. The burden of shift work was especially pronounced for those whose family members were also engaged in shift based jobs.

The quality of social relationships was found to directly impact both mental and physical well-being. Nurses who lacked a regular routine faced greater difficulties in maintaining stable social and family connections.

To evaluate the potential association between shift work and the lifestyle activities of nurses, parameters such as physical activity scores, sleep scores and social and family relationship quality scores were analyzed. Based on the mean scores for sleep and social relationship quality, nurses from both sectors were categorized into three groups: low scores (below mean - S.D.), medium scores (from mean - S.D. to mean + S.D.) and high scores (above mean + S.D.).

The shift related variables considered for analysis included the number of shift changes per month, the number of night shifts per month and total work experience. These variables were assessed in relation to lifestyle parameters and the findings are presented in Table 5.

The data from table 5, indicates that 48 percent of nurses in government and those who had more than 6 hours of daily shift changes in a month had low physical activity score. Statistically significant difference was found between the scores and number of shifts (p=<.01). In private hospitals 49 percent of nurses who had shifts of more than 6 shift changes in a month had low score but statistically no significant difference was found (p= 0.01). Fifty one percent of nurses in government hospitals and sixty percent of

Table 4. Status on social relationship of respondents **n=500**

Statements	Government hospitals (n=250)				Private hospitals (n=250)			
	Yes	No	Some-times	Total	Yes	No	Some-times	Total
Decline in social interactions and connectedness	115 (46)	47 (18.8)	88 (35.2)	250 (100)	42 (16.8)	65 (26)	143 (57.2)	250 (100)
Recreational and leisure activities is impaired	76 (30.4)	67 (26.8)	108 (43.2)	250 (100)	27 (10.8)	67 (26.8)	156 (62.4)	250 (100)
Decline in the maintenance of close relationship with family members and friends	100 (40)	63 (25.2)	87 (34.8)	250 (100)	42 (16.8)	74 (29.6)	134 (53.6)	250 (100)
Withdrawal and isolation from social gathering	71 (28.4)	89 (35.6)	90 (36)	250 (100)	27 (10.8)	93 (37.2)	130 (52)	250 (100)
Work pattern affected the child rearing and caring practices	27 (10.8)	62 (24.8)	113 (45.2)	202 (80.8)	18 (7.2)	53 (21.2)	118 (47.2)	189 (75.6)
Difficult to maintain balance between childcare and work	24 (9.6)	61 (24.4)	115 (46)	200 (80)	15 (6.0)	75 (30.0)	103 (41.2)	192 (77.2)
Unable to eat together with family	128 (51.2)	67 (27.8)	55 (22.0)	250 (100)	144 (57.6)	63 (25.2)	43 (17.2)	250 (100)
Forced to give up social gatherings even if invited or expected to attend	49 (19)	144 (57.6)	57 (22.8)	250 (100)	28 (11.2)	146 (58.4)	76 (30.4)	250 (100)
The stress inherent in nursing job is understood by spouse	12 (4.8)	36 (14)	201 (80.4)	249 (99.6)	11 (4.4)	30 (1.2)	208 (83.2)	249 (99.6)
Able to keep contact with old friends /distant relatives	22 (8.8)	116 (46.4)	112 (44.8)	250 (100)	28 (11.2)	134 (53.6)	88 (35.2)	250 (100)

Number in parenthesis indicates percentage

Table 5. Association of physical activity score and shift work **n=500**

Shift Variables	Govt. hospitals-Physical activity scores n=250				Private hospitals-Physical activity scores n=250			
	Low	Average	Good	Total	Low	Average	Good	Total
No. of monthly shifts change/month								
1-3	2(0.8)	10(4.0)	1(0.4)	13(5.2)	19(7.6)	11(4.4)	1(0.4)	31(12.4)
4-6	7(2.8)	15(6.0)	4(1.6)	26(10.4)	53(21.2)	19(7.6)	3(1.2)	75(30)
>6	121(48.4)	82(32.8)	8(3.2)	211(84.4)	123(49.2)	20(8.0)	1(0.4)	144(57.6)
Total	130(52.0)	107(42.8)	13(5.2)	250(100.0)	195(52.0)	50(42.8)	5(5.2)	250(100.0)
Chi square(p-value)		19.45(<.01) **				13.01(0.01)		
No: night shift rotation/month								
2	127(50.8)	104(41.6)	13(5.2)	244(97.6)	150(60.0)	40(16.0)	4(1.6)	194(77.6)
3	3(1.2)	3(1.2)	0(0.00)	6(2.4)	45(18.0)	10(4.0)	1(0.4)	56(22.4)
Total	130(52.0)	107(42.8)	13(5.2)	250(100.0)	195(78.0)	50(20.0)	5(2.0)	250(100.0)
Chi square(p-value)		0.40(0.82)				11.4(<.05) *		
Years of experience								
Up to 10yrs	93(37.2)	63(25.2)	8(3.2)	164(65.6)	155(62.0)	39(15.6)	5(2.0)	199(79.6)
>10Yrs	37(14.8)	44(17.6)	5(2.0)	86(34.4)	40(16.0)	11(4.4)	0(0.00)	51(20.4)
Total	130(52.0)	107(42.8)	13(5.2)	250(100.0)	195(78.0)	50(20.0)	2(2.0)	250(100.0)
Chi square(p-value)	4.3(0.12)	1.36(0.51)						

No. in parenthesis indicates percentage

* significant at 5% level of significance

**significant at 1% level of significance

Table 6. Association of sleep scores and shift work **n=500**

Shift Variables	Govt. hospitals-Physical activity scores n=250				Private hospitals-Physical activity scores n=250			
	Low	Average	Good	Total	Low	Average	Good	Total
No. of monthly shiftschange/month								
1-3	4(1.6)	6(2.4)	3(1.2)	13(5.2)	8(3.2)	14(5.6)	9(3.6)	31(12.4)
4-6	7(2.8)	12(4.8)	7(2.8)	26(10.4)	19(7.5)	22(8.8)	34(13.6)	75(30.0)
>6	39(15.6)	69(27.6)	103(41.2)	211(84.4)	15(6.0)	78(31.2)	51(20.4)	144(57.6)
Total	50(20.0)	87(34.8)	113(45.2)	250(100.0)	42(16.8)	114(45.6)	94(37.6)	250(100.0)
Chi square (p-value)			7.3(0. 122)				16.9(<.01) **	
No. of night shift rotation /month2	49(19.6)	84(33.6)	111(44.4)	244(97.6)	32(12.8)	83(33.2)	79(31.6)	194(77.6)
3	1(0.4)	3(1.2)	2(0.8)	6(2.4)	10(4.0)	31(12.4)	15(6.0)	56(22.4)
Total	50(20.0)	87(34.8)	113(45.2)	250(100.0)	42(16.8)	114(45.6)	94(37.6)	250(100.0)
Chi square (p-value)			0.634(0.73)				4.6(0.13)	
Years of experience Up to 10yrs	39(15.6)	50(20.0)	75(30.0)	169(67.6)	36(14.4)	96(38.4)	67(26.8)	199(79.6)
>10yrs	11(4.4)	37(14.8)	38(15.2)	86(34.4)	6(2.4)	18(7.2)	27(10.8)	51(20.4)
Total	50(20.0)	87(34.8)	113(45.2)	250(100.0)	42(16.8)	114(45.6)	94(37.6)	250(100.0)
Chi square (p-value)			5.99 (<.05)*				6.47(<.05)*	

Number in parenthesis indicates percentage

* significant at 5% level of significance

Table 7:Association of quality of social and family relations score with respect to shift work **n=500**

Shift Variables	Govt. hospitals-Quality of social and family relations scores n=250				Private hospitals-Quality of social and family relations scores n=250			
	Not affected	Moderately impaired	Highly impaired	Total	Not affected	Moderately impaired	Highly impaired	Total
No. of shifts change1-3	1(0.4)	6(2.4)	6(2.4)	13(2.5)	7(2.8)	20(8.0)	4(1.6)	31(12.4)
4-6	1(0.4)	22(8.8)	3(1.2)	26(10.4)	19(7.6)	51(20.4)	5(2.0)	75(30.0)
>6	29(11.6)	157(62.8)	25(10.0)	211(84.4)	37(14.8)	96(38.4)	11(4.4)	144(57.6)
Total	31(12.4)	185(74.0)	34(13.6)	250(100.0)	63(25.2)	167(66.8)	20(8.0)	250(100.0)
Chi square (p-value)		14.5(<.01) **				1.3(0.87)		
No: of night shift rotation /month2	30(12.0)	181(72.4)	33(13.2)	244(97.6)	52(20.8)	126(50.4)	16(6.4)	194(77.6)
3	1(0.4)	4(1.6)	1(0.4)	6(2.4)	11(4.4)	41(16.4)	4(1.6)	56(22.4)
Total	31(12.4)	184(73.6)	34(13.6)	250(100.0)	63(25.2)	167(66.8)	20(8.0)	250(100.0)
Chi square(p- value)		0.18(.92)				6.5(<.05)*		
Years of experience Up to 10yrs	21(8.4)	124(49.6)	19(7.6)	164(65.6)	53(21.2)	132(52.8)	14(5.6)	199(79.6)
>10yrs	10(4.0)	61(24.4)	15(6.0)	86(34.4)	10(4.0)	35(14.0)	6(2.4)	51(20.4)
Total	31(12.4)	185(74.0)	34(13.6)	250(100.0)	63(25.2)	137(54.8)	20(8.0)	250(100.0)
Chi square(p- value)		1.65(.44)				1.96(.38)		

Number in parenthesis indicates percentage

* significant at 5% level of significance

**significant at 1% level of significance

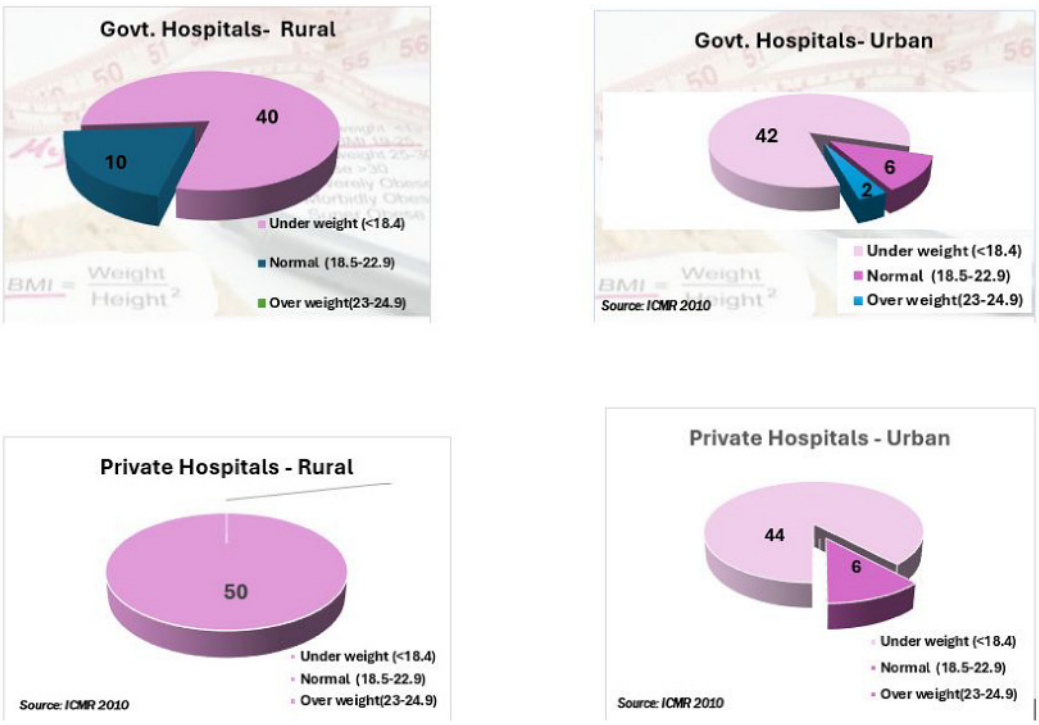

Fig.1. Distribution of respondents according to Body Mass Index (BMI)

nurses in private hospitals who took 2 night rotations in a month had low score. In government hospital no significant association was found (*p =0.82)* between night shift and physical activity scorebut in private the difference in night rotation and score were significant at 5 % level of significance. Thirty seven percent of nurses in government and 62 percent of nurses in private hospitals who had 10 years' experience had low scores in this regard. No statistical significant difference were found between scores and the years of experience (*p*= 0.12*; p*= 0.51).

From the table 6, the significant association was found between shift change and sleep score of respondents from private hospitals *(p =<0.01)*). The average sleep scores mostly belong to the 4-6 category of having shift change in a month. There was no significant association between frequency of night shift rotation and sleep scores, this could be because of the representation of respondents of both categories were not equal. Experience of nurses had significant association with sleep score of respondents of both government (*p =<0.05*) and private (*p=<0.05*) hospitals. Thirty percent of nurses in government who had 10 years of experience had good sleep score and 38 percent of nurses in private sector, who completed 10 years of experience had only average sleep score. From the sleep scores of both sectors, it was found that nurses ingovernment hospitals had good sleep scores and in private hospital nurses had average sleep scores.

The study highlights that shift changes and work experience significantly influenced the sleep quality of nurses, with government hospital nurses reporting better sleep scores compared to those in private hospitals. The absence of a significant association between night shift rotations and sleep scores may be due to unequal representation across categories. Differences between government

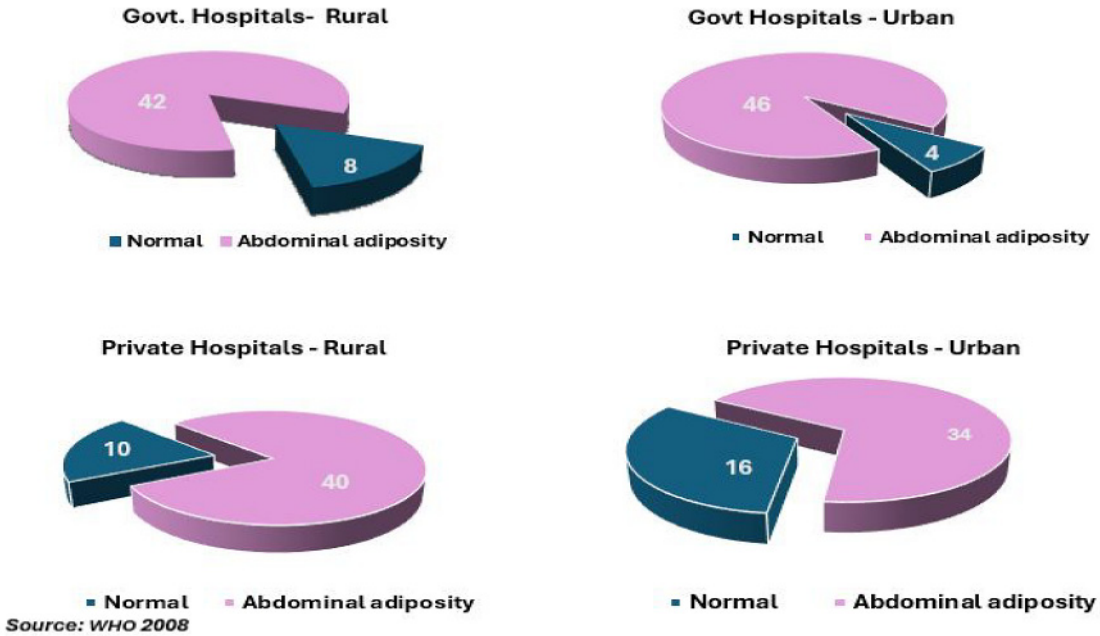

Fig. 2. Distribution of respondents according to WHR

and private sectors could reflect variations in workload, job stability and organizational support, with private hospital nurses experiencing higher stress and workload pressures that may impair sleep (Chung *et al.,* 2021). These findings emphasize the need for workplace interventions such as limiting frequent shift changes and promoting sleep

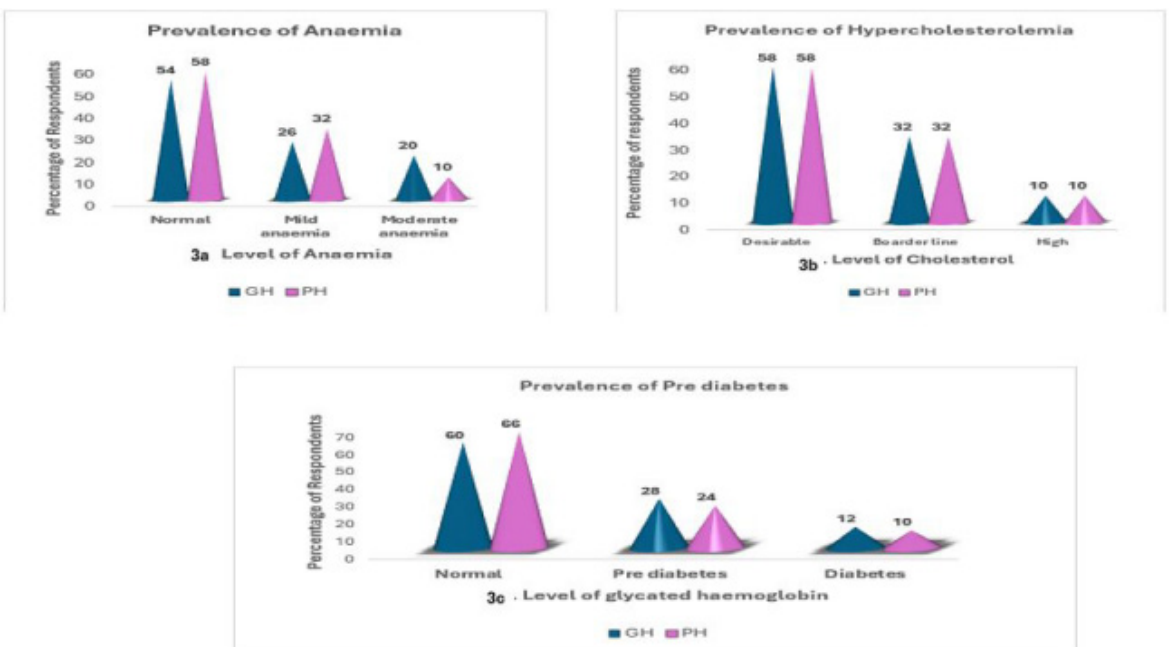

Fig. 3.Distribution of respondents based on biochemical parameters

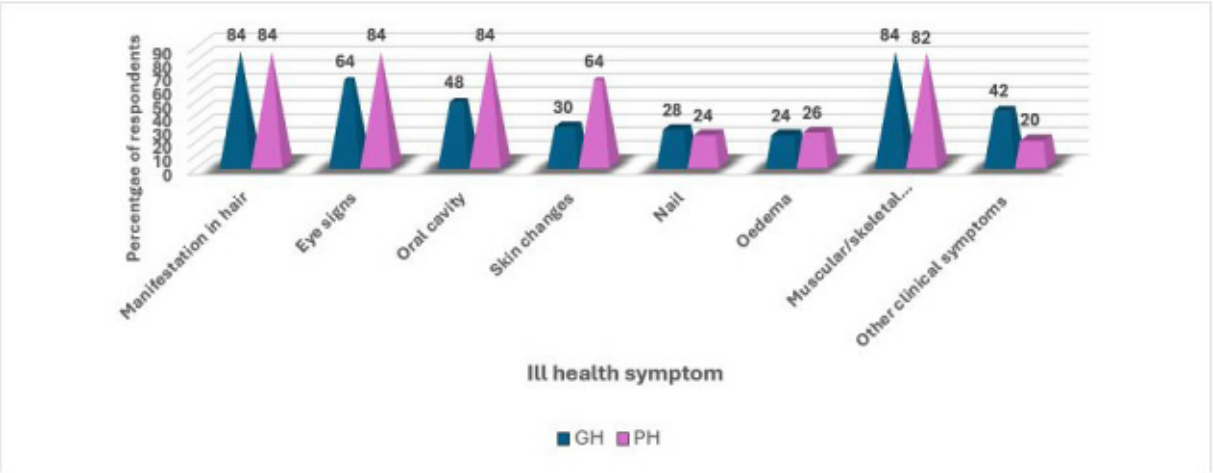

Fig.4. Distribution of respondents based on the clinical examination

hygiene to improve the well-being and performance of nurses (WHO, 2019).

Table 7 shows the significant associationbetween quality of social and family relations with frequency of shift change among the respondents of government hospitals, moderately impaired relationship was seen in 62.8% of respondents who had more than 6 shift change per month in government hospitals (*p=<.01*). No significant association was observed among respondents from private hospitals (*p=.868)*. Night shift rotation had significant association with quality of social and family relationships score among the respondents of private hospitals (*p value-<.05*). Fifty percent of nurses in private hospitals who took 2 night shift rotation had moderately impaired relations. But no

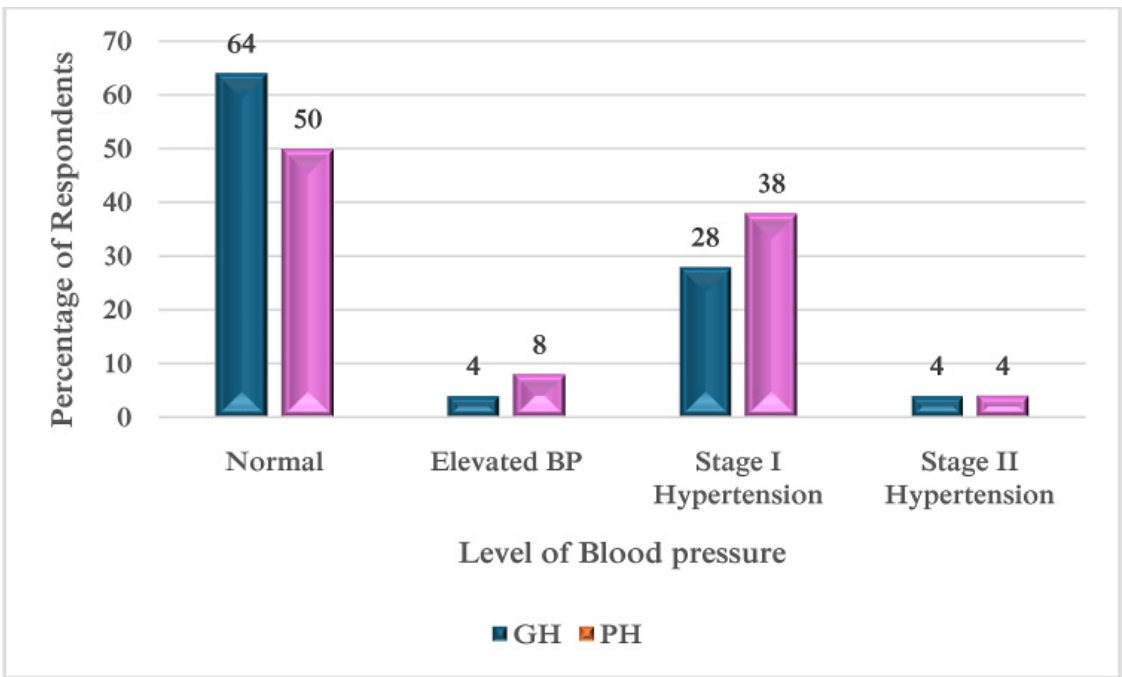

Fig. 5. Distribution of respondents based on blood pressure level

association was found in government hospitals (p= .92). No significant association is found between quality of social and family relations score and years of experience in government (p =.438) and private hospitals (p=.38). Based on family relation score, nurses from both government and private hospitals had moderately impaired relation scores.

The results indicate that frequent shift changes negatively affect social and family relationships among nurses in government hospitals, as shown by the higher proportion (62.8%) of respondents with moderately impaired relationships when exposed to more than six shift changes per month. This supports existing evidence that irregular shifts disrupt work life balance and contribute to social isolation and strained family interactions. In contrast, no such association was observed among private hospital nurses, possibly due to differences in organizational structures and coping mechanisms. However, night shift rotation significantly influenced the quality of social and family relationships among private hospital nurses, with half of those working two-night shifts per rotation reporting moderate impairment. Years of experience did not show a significant relationship with family or social interactions in either group, suggesting that the impact of shift work on relationships may persist regardless of professional experience. Overall, these findings highlight the importance of organizational policies that minimize excessive shift changes and rotations to support nurses' social and family wellbeing (WHO, 2019).

The weight, height, waist and hip circumference of respondents were measured and tabulated for analysis. The BMI were calculated from the measurement of heights and weights of the respondents which is depicted below, based on BMI according to ICMR (2010).

Majority of respondents from both government (82%) and private hospitals (94%) were under weight. There were respondents with normal weight in government (16%) and

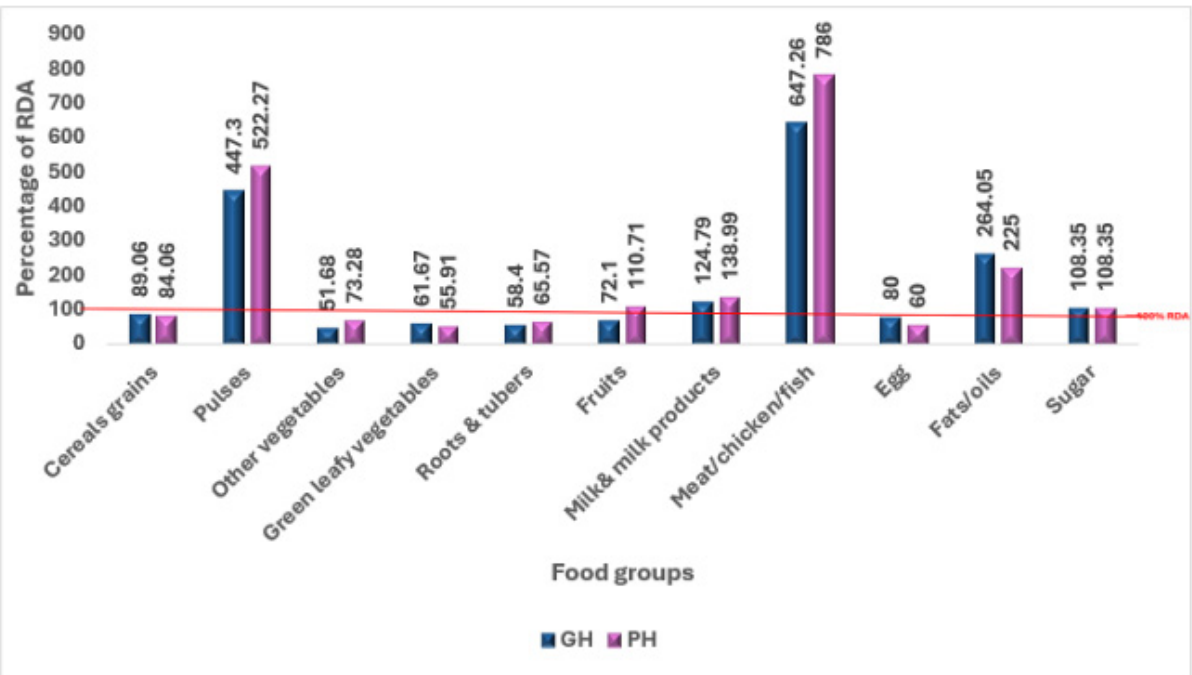

Fig.6. Percentage adequacy of food groups consumed compared to RDA

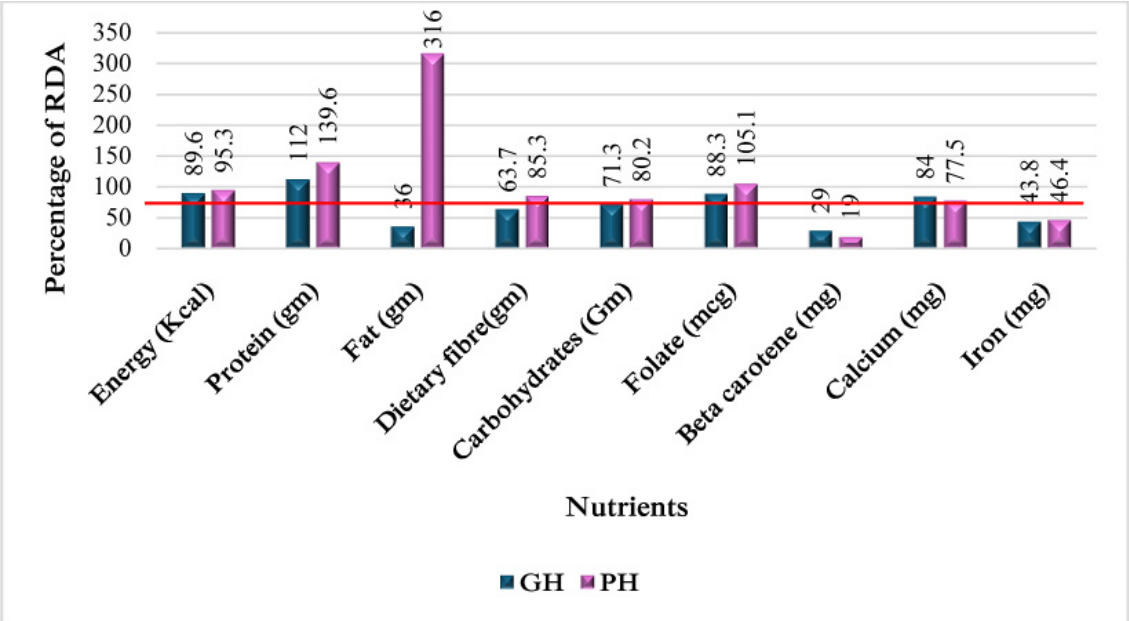

Fig. 7. Percentage adequacy of nutrients compared to RDA

private (6%) hospitals. Only two overweight respondents were found in government urban hospital. Statistically the association of BMI of respondents and hospital type was not found to be significant.

The majority of nurses in government hospitals (88%) and private hospitals (74%) exhibited abdominal obesity, as their waist-to-hip ratio was equal to or greater than 0.85. The proportion of nurses with a normal waist-to-hip ratio in both sectors is relatively low, with 12% in government hospitals and 26% in private hospitals. These findings highlight that a significant number of nurses showed signs of abdominal obesity, even among those classified as underweight.

The biochemical analysis revealed that approximately half of the nurses from both sectors were anemic, with severity ranging from mild to moderate, as depicted in Figure 3(a). Regarding cholesterol levels (Figure 3(b)), 42% of nurses across both sectors had levels classified as borderline to high. The HbA1C results, an indicator of diabetes, showed that nearly one-third of nurses in the government sector and one-fourth in the private sector were in the prediabetic range. Additionally, nearly 10% of nurses in both sectors were found to have diabetes, as shown in Figure 3(c).

The high prevalence of anemia among nurses observed in this study is consistent with previous reports, where healthcare workers, particularly women, were found to have higher rates of anemia due to long working hours, irregular meals and nutritional inadequacies (Chaudhary *et al.,* 2021). Similarly, borderline to high cholesterol levels in nurses may be linked to occupational stress, sedentary work patterns, and shift-related dietary habits, which have been shown to increase the risk of dyslipidemia in health professionals (Sharma *et al.,* 2019). The proportion of nurses in the prediabetic and diabetic range aligns with earlier studies, which reported a higher prevalence of impaired glucose tolerance among shift workers due to circadian misalignment and disrupted metabolic regulation (Hulsegge *et al*., 2016). These findings highlight the dual burden faced by

nurses, where the demands of their profession contribute to both occupational stress and heightened metabolic risks.

Figure 4 illustrates the findings from the clinical examination, revealing that three-fourths of the nurses experienced hair-related issues such as hair loss, thinning, sparse hairand dandruff. Eye-related conditions, including dark circles, photophobia, pale conjunctiva and even night blindness, were also observed among the respondents. Additionally, disorders of the oral cavity, such as stomatitis, fluorosis, oral ulcers and bleeding gums, were more prominent among nurses across both sectors.

The blood pressure levels of nurses indicate that over one-third of the population is affected by high blood pressure, classified as Stage I and II hypertension. This is likely attributed to the stress and irregular schedules associated with their job. According to Chauhan and Sharma (2019), workplace stress significantly contributes to health issues such as hypertension among nurses. In the present study, a notable proportion of nurses in government (64%) and private (50%) hospitals had normal blood pressure. However, 4% of respondents in government hospitals and 8% in private hospitals had elevated blood pressure levels. About 42% of nurses working in private hospitals and 32% in government hospitals were found to be hypertensive. These findings suggest that hypertension is prevalent in nurses from the early stages of their careers, primarily due to job-related stress and unhealthy time schedules, as supported by the literature on the subject.

Several studies have similarly reported a high prevalence of hypertension among nurses, emphasizing the role of occupational stress and irregular schedules(Chauhan and Sharma,2019). These findings further validate the present study, highlighting that hypertension often develops early in nurses' careers due to the demanding nature of their work.

Figure 6 highlights the food items consumed below 100% of the Recommended Dietary Allowance (RDA).The RDA compared here is for sedentary female worker, as per the National Institute of Nutrition classification given (Gopalan *et.al*, 2021). These include cereals and grains, pulses,other vegetables, green leafy vegetables, roots and tubers, fruits, milk & milk products, meat/chicken/fish, eggs, fats/ oils, as well sugar.

The list of food items consumed in quantities exceeding the 100% Recommended Dietary Allowance (RDA), including fats/oils, milk and milk products, meat/chicken/fish, fruits, pulses, and sugar. This indicates a significant deficit in the intake of foods from all major food groups. Nutritional intake was assessed using the 24 hour recall method and the results are showed in Figure 7.

The data revealed a significant nutrient deficiency in the diet of nurses in both sectors, as shown in Figure 7. Their intake of several key nutrients, including calories, fibre, carbohydrates, folate, beta-carotene, calcium and iron, falls below the Recommended Dietary Allowances (RDA). Interestingly, both groups exceeded the RDA for fat, which could contribute to dyslipidaemia. The inadequate intake of iron and folate likely explains the high prevalence of anaemia, a widespread concern in India, where 53% of women are reported to suffer from anaemia, as per the National Family Health Survey (NFHS-5, 2019-2021), a similar finding to the NFHS-4 that reported 53% of women affected by anaemia (NFHS-5, 2019-2021). This issue is also highlighted in the Ministry of Health and Family Welfare's National Health Policy (2017).

Furthermore, the insufficient calcium intake could lead to osteoporosis later in life.

The study found that calorie intake was insufficient in both sectors, primarily due to low carbohydrate consumption. However, fat intake was notably high, constituting 276-300% of the RDA. A common eating habit among this population is skipping breakfast and consuming fried snacks, which are the primary options available at hospital canteens. These findings align with a recent study by Yulyani and Safitri (2022), which reported a similar trend of low calorie and carbohydrate intake among adolescents, though fat intake was high. The study also observed poor nutritional knowledge among participants, which may exacerbate these dietary issues. Highlighting this trend, the NFHS-5 (2019-2021) further reports that 63% of Indian women have an inadequate intake of calcium, which could have implications for bone health in the long term. Similarly, 35% of women and 19% of men are found to have insufficient dietary iron intake, reinforcing the data from the study and raising concerns about iron deficiency anaemia.

By addressing these nutritional gaps, particularly the high fat intake and deficiencies in key micronutrients, targeted interventions can help improve the health outcomes for nurses in both sectors.

CONCLUSION

The study highlighted critical health and lifestyle concerns among nurses in Thiruvananthapuram. A large proportion of respondents reported insufficient physical activity, with 72% of government and 78% of private hospital nurses not engaging in regular exercise; among those who did, walking (17% in government and 13% in private hospitals) was the most common form. Sleep deprivation was prevalent, as 51% of nurses in government hospitals and 56% in private hospitals reported inadequate sleep, with 6.8% and 10%, respectively, having irregular sleep patterns. Social and family relationships were also affected, with 46% of government nurses and 16.8% of private nurses reporting deterioration in their interactions.

Nutritional analysis showed that 41% of government and 47% of private hospital nurses were underweight, while dietary practices revealed poor habits - 40% in government and 70% in private hospitals skipped meals regularly. Biochemical analysis indicated a high prevalence of health issues: 50% of nurses were anemic, 42% had borderline to high cholesterol, and 33% in government and 25% in private hospitals were in the prediabetic range, with nearly 10% diagnosed with diabetes. Blood pressure analysis revealed that 32% of government and 42% of private nurses were hypertensive, highlighting the burden of cardiovascular risk.

These quantitative findings underscore the urgent need for targeted workplace interventions focusing on structured physical activity programs, improved sleep hygiene, stress reduction strategies and nutrition education to address anemia, metabolic risks, and lifestyle-related disorders, thereby enhancing the overall health and productivity of nurses.

REFERENCES

Belczak, C.E.Q., Godoy, J.M.P., Ramos, R.N., Oliveira, M.A., Belczak, S.Q. and Caffaro, R.A. 2018. Influence of working shift on the formation of lower limb edema in normal individuals. Journal Vascular Brasileiro, 7(3): 32–45.

Chaudhary, A., Yadav, A. and Singh, R. 2021. Prevalence of anemia among female health care workers: A cross-sectional study. Journal of Family Medicine and Primary Care, 10(5): 2002–2007.

Chauhan, A. and Sharma, R. 2019. Occupational stress and its impact on

hypertension among nurses: A cross-sectional study. International Journal of Community Medicine and Public Health, 6(4): 1541–1546.

Cheng, X., Zhang, Y. and Liu, H. 2024. Health impacts of COVID-19 on frontline healthcare workers: A review. International Journal of Nursing Studies, 125: 103–112.

Chung, M.H., Chang, F.M., Yang, C.C.H., Kuo, T.B.J. and Hsu, N. 2021. Sleep quality and occupational stress in nurses: The moderating role of coping strategies. Journal of Nursing Management. 29(3): 393–401.

Gopalan, C., Rama Sastri, B.V. and Balasubramanian, S.C. 2004. Nutritive Value of Indian Foods (Updated ed.). National Institute of Nutrition, ICMR, Hyderabad.

Hulsegge, G., Loef, B., van Kerkhof, L.W.M., Roenneberg, T., van der Beek, A.J. and Proper, K.I. 2016. Shift work, sleep disturbances and social jetlag in healthcare workers. Journal of Sleep Research, 28(5): e12802.

ICMR. 2010. Nutrient Requirements and Recommended Dietary Allowances for Indians. National Institute of Nutrition, Hyderabad.

Kumar, A., Sinha, R. and Yadav, S. 2023. Shift work and its effects on lifestyle and health among nurses in India. Asian journal of Nursing Studies, 5(2): 45-54

Ministry of Health and Family Welfare. 2017. National Health Policy 2017. Government of India, New Delhi.

Patel, S., Roy, S. and Sharma, N. 2023. Impact of shift work on sleep quality and health among nurses: A cross-sectional study. Journal of Occupational Health, 65(1): 102349.

Sharma, S., Shukla, A. and Sharma, S. 2019. Dyslipidemia and associated risk factors among health care workers: A hospital-based study. Indian Journal of Community Medicine, 44(3): 256–260.

Suh, S., Jeong, S.H. and Kim, S. 2023. Sleep patterns and health outcomes in shift workers: A systematic review. Sleep Medicine Reviews, 66: 101742.

WHO. 2019. Occupational health: Stress at the workplace. World Health Organization, Geneva.

Yulyani, E. and Safitri, I. 2022. Nutritional status, energy intake, macronutrients, calorie drinks, and nutrition knowledge among adolescents. Journal of Public Health Research and Development, 7(2): 121–128.

Zhao, X., Cheng, Y., Zhou, X. and Wang, L. 2022. Physical activity levels among healthcare workers: A cross-sectional study of influencing factors and patterns. BMC Public Health, 22(1): 234.

Meera, D. K. and Divakar, S. 2025. Nutritional health challenges and lifestyle patterns among nurses in Thiruvananthapuram, Kerala. The Journal of Research ANGRAU, 53(3): 76-94.

DoI: https://doi.org/10.58537/jorangrau.2025.53.3.09

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INFLUENCE OF ECO-FRIENDLY SPECIAL FINISHES ON NATURALLY COLOURED COTTON IN GREEN TEXTILES

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ABSTRACT

Eco-friendly textiles are currently in high demand across the industry. Global warming, pollution and other ecological concerns are receiving increasing attention on one hand; on the other, a growing number of consumers are recognizing the need for safe and sustainable fashion. The concept of green textiles encompasses eco-conscious production, sustainable clothing and environmentally responsible fashion—designed to be both safe and secure. Eco-friendly special finishes, including bio-finishes, have emerged as vital enhancements in the textile industry, imparting desirable properties to fabrics while reinforcing the ethos of eco-fashion. In 2021, a study was undertaken to evaluate the influence of specialized eco-finishes on DDCC-1 (Dharwad Desi Coloured Cotton-1) fabric. The fabric underwent bio-desizing to reduce residual sizing agents, followed by bio-polishing to eliminate protruding surface fibers, thereby enhancing smoothness. Subsequently, it was treated with a silicon-based softener to improve its tactile feel and overall comfort. This multi-stage eco-finishing process aimed to elevate both the aesthetic and functional qualities of DDCC-1 in alignment with sustainable textile practices. The control and finished fabrics were evaluated for their mechanical and functional properties, with statistical analysis conducted using the t-test to determine the significance of observed changes. The study revealed that the application of a silicone softener finish notably enhanced the flexibility, drape and pliability of naturally coloured cotton khadi fabric, resulting in improved softness and surface smoothness. Furthermore, tensile strength increased substantially—from 26.00 kgf to 42.88 kgf in the warp direction, and from 15.10 kgf to 25.24 kgf in the weft. These improvements underscore the potential for greater consumer satisfaction through the development of bio-finished, eco-friendly naturally coloured cotton textiles.

Keywords: Eco-friendly clothing, Enzymatic finish, Green textiles, Khadi Fabrics, Naturally Coloured Cotton, Silicon Softener Finish

INTRODUCTION

Textile industries use various chemicals in different processes like scouring, bleaching, dyeing, finishing, etc. The textile finishing & dyeing industry consumes large quantities of water and produces large volumes of waste water from various processes. Waste water from textile processing contains residues and requires appropriate treatment before being released into the environment. Interest in eco-friendly processing in the textile industry has increased in the current scenario because of increased awareness of environmental issues as well as concern for human health.

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The nonprofit Sustainable Technology Education Project (STEP) defines eco-fashions as "clothes that take into account the environment, the health of consumers and the working conditions of people in the fashion industry." Clothes and accessories that meet such criteria are usually made using organic raw materials such as cotton grown without pesticides.As a result, the eco-fashion industry has provided an opportunity to bring back a long-standing fiber, naturally coloured cotton, which has been a part of nature for 5000 years and has produced environmentally friendly clothing. Four species *viz.,Gossypium arboretum, Gossypium herbaceum, Gossypium hirsutum and Gossypium barbadense* were responsible for a variety of lint hues including brown, black, mahogany red, red, khaki, pink, blue, green, filthy white and of course white.

Brown cotton lines from the University of Agricultural Sciences, Dharwad are at the forefront in the All India Coordinated Research Project trials and DDCC-1 was proposed for release in 2021. The Khadi and Village Industries Board of Karnataka had a nearby unit, which wove the cotton and made shirts out of it (Menon, 2020). The dyeing process is omitted when naturally coloured lint is used for the manufacturing of the fabric, reducing the cost of production (Keshamma, 2022). Naturally coloured cotton has become a popular and environmentally sustainable replacement for commercially dyed cotton during this phase (Madhu, 2024).

Bio-finish is mainly applied to the fabric by using enzymes which are naturally occurring proteins capable of catalysing specific chemical reactions. They are required in a small quantity which only catalyses the reactions and are not consumed. Enzymes *viz.,* amylases, pectinases, lipases, proteases, catalases, etc., are used in special finishes like bio-desizing, bio-scouring, bio-polishing, bio-stoning, bio-softening and so on. (Shahid *et al.,* 2016).

Silva *et al.,* 2017 conducted a study on application of an enzymatic pool in bio-scouring of cotton knit fabric and envisaged that a comparison between the enzymatic treatment and the scouring confirmed that bio-scouring can be as effective as the conventional process. It is more environmentally sustainable as it occurs at neutral pH and consumes less water and energy.

The studies by Raafi *et al.,* 2023 and Manasmita *et al.,* 2024, depict that being highly specific biological catalysts, enzymatic scouring is advantageous to conventional chemical scouring in terms of reduced usage of water, chemicals and power as well as milder temperature and pH conditions. By prioritizing eco-friendly finishes, the textile industry can foster a harmonious balance between fashion and environmental responsibility, meeting the growing demand for sustainable and ethically produced textiles.

In response to growing environmental concerns and the rising demand for sustainable textiles, this study explores the potential of eco-friendly, naturally dyed cotton as a pathway to a greener future. Specifically, it focuses on Dharwad Desi Coloured Cotton (DDCC-1), treated with enzymatic special finishes to enhance softness and lustre without compromising ecological integrity. A comparative analysis of mechanical and functional properties between untreated (control) and treated fabrics is undertaken to assess the effectiveness of bio-finishing techniques. The findings aim to support the advancement of naturally coloured cotton as a viable, sustainable alternative in modern textile innovation which is trying to move towards greener future.

MATERIAL AND METHODS

Fabric

DDCC-1 (Dharwad Desi Coloured Cotton-1), *Gossypium arboreum*, the naturally coloured cotton yarn, was procured from Khadi

Fig. 1. White Cotton and DDCC-1 plain woven fabrics

Nekar Sahakar iSangh Niyamita, Uppin-betageri, Dharwad district and was woven with plain weave (Fig 1).

Treatment

The khadi fabric was specially finished with eco-user-friendly enzymes by subjecting them to bio-desizing followed by bio-polishing and finally finished with a silicon softener finish. The commercially used method was followed for finishing the fabric. After final finishing, the treated fabrics were then run in a hydro extractor for 15 mins to remove excess finishing solution and tumble dried below 120°C. (Table 1)

Table 1. Parameters of special finishes

Sl. No.	Parameters	Bio-desizing	Bio-polishing	Silicon Softener
1	MLR(Material Liquor Ratio)	1:10	1:10	1:10
2	Treatment time	20 min	45 min	20 min
3	Treatment temperature	40°C	50°C	-
4	pH	-	4.5-5	4.5-5
5	Acid	-	Acetic acid	Acetic acid
6	Clariant desize	30ml / kg of fabric	-	-
7	Refnol lubricant	25 ml / kg of fabric	25 ml / kg of fabric	-
8	Novo Nordisk enzyme	-	30 ml / kg of fabric	-
9	Resil Silicon	-	-	25 ml / kg of fabric
10	Pidilite Softener	-	-	50 ml / kg of fabric
11	Finishing machine	Drum washer	Drum washer	Drum washer
12	Method incorporated	Hot method	Hot method	Cold method

Assessment of physical properties

Laboratory tests included the assessment of mechanical and functional properties of the naturally coloured cotton fabric. The mechanical properties included yarn count, cloth count, cloth weight, cloth thickness, crease recovery angle, cloth stiffness and shrinkage test, which in turn affected functional properties such as tensile strength, abrasion resistance, drapability and pilling. The tests were conducted by following the standard methods.

RESULTS AND DISCUSSION

Mechanical properties

The treatment has improved the mechanical properties of the khadi fabric by enhancing the yarn fineness with higher density, making the fabric more compact and increasing the fabric weight. This may be because the yarn has become finer after the removal of starch and protruding fibres from the fabric surface. This has made the yarns more compact in the fabric. The bio-polishing and softener treatment also have an impact on the fibre surface, which lowers the intermolecular attraction by penetrating into the fibre system. The weight has increased from 219.44 g/m^2 to 240.88 g/m^2 and the thickness from 0.82 mm to 0.85mm of the treated fabric after treatment; it may be because of the deposition of silicone softener in all the pores of the fabric creating a coating on it and the yarns have become finer on treatment with silicone softener. This is supported by the study conducted by Chowdhury (2018) on effect of special finishes on the functional properties of cotton fabrics where after chemical implementation on both woven and S/J fabrics with various finishing formulations, GSM has increased because chemical has covered up all the pores of the fabric and a chemical coating is created on the fabric. Therefore, the water is not allowed to penetrate into the fabric for water repellent finishes. (Fig. 2, 3, 4 & 5)

Reduction in cloth stiffness from 4.29 cm to 1.54 cm in warp and 2.19 cm to 1.53 cm in weft and increase in the crease recovery angle from 78 to 93 degree in warp and 53.6 to 77 degree in weft of the treated naturally coloured cotton in both warp and weft may be due to removal of size and the effect of the softener must have imparted softness and smoothness to the finished fabric, thus making the fabric more pliable.The exceptional softness of the treated fabric may be attributed to inter-fibre softening and the deposition of hydrophobic hydrocarbons, which form a thin film on the surface. This treatment has also imparted excellent dimensional stability, likely due to the removal of sizing agents applied during warping. The absence of size allows the warp yarns to relax more freely, resulting in a higher percentage of shrinkage during the first wash—thereby stabilizing the fabric for subsequent use. The t-test is found to be significant at 5% in all the mechanical properties. The application of user-friendly and eco-conscious finishes have significantly enhanced the mechanical properties of khadi fabrics—achieved without the use of harmful chemicals. This chemical-free approach not only preserves the integrity of the fabric but also contributes positively to consumer health and well-being, reinforcing the value of sustainable textile innovation. Statistical t-values are also calculated for more accuracy of our experimental results using equation.

Where, d is mean differences between treated and control

s_d is standard deviation of the differences

n is number of paired observations (here n=2 i.e wrap and weft).

These t values proven, *Stiffness*, *Crease Recovery*, *Shrinkage* and *Weight* all have t-values above the typical threshold of ±2, suggesting these properties differ meaningfully from the baseline or control. While *Crease Recovery* shows the strongest positive change,

while *Stiffness* shows the strongest negative change. *Thickness* has a t-value of +1.22, which is below the usual significance threshold. This implies that any observed change in thickness may be due to random variation rather than a true effect.

$$t = \frac{d}{s_d / \sqrt{n}}$$

Functional properties

The elongation percentage has increased from 10.66 % to 13.15% in warp and 7.04 % to 7.22 % in weft on treatment, which may be due to the formation of a thin film of softeners on the fabric surface that lowers the intermolecular attraction within the fibres. This in turn strengthens the fibre and helps to absorb more force, resulting in greater cloth elongation. Finally, the tensile strength of the fabric has also increased from 26.00 kgf to 42.88 kgf in warp and 15.10 kgf to 25.24 kgf in weft, maybe because after treatment, the fabric has become softer and more pliable due to finer yarns but the deposition of silicon softener has added to its strength. However, the drape of the fabric is improved to a large extent from 130.64 % (control) to 61.23 % (treatment), which may be because the treatment has imparted excellent softness and also a reduction in bending length and crease recovery angle positively supports the improvement in the drapability. Thus, the treated samples have shown excellent abrasion resistance and no pilling was observed, which may be because after bio-polishing, the small protruding fibres on the fabric have been removed, resulting in less balling up of fibres.

Pu *et al.*(2015) cited that compared to the traditional softening finishing in aqueous

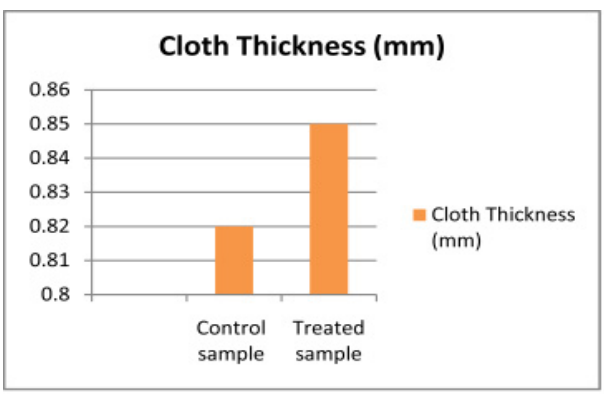

Fig. 2. Cloth Thickness

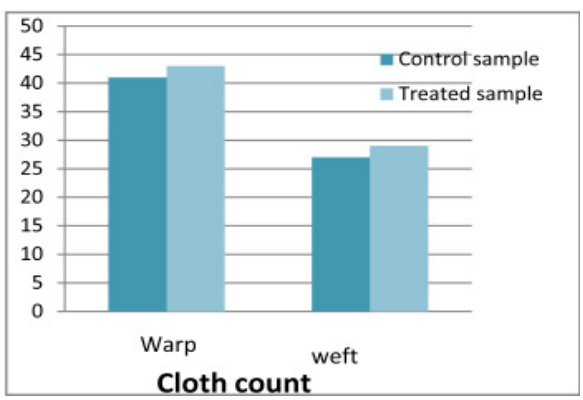

Fig. 3. Cloth Count

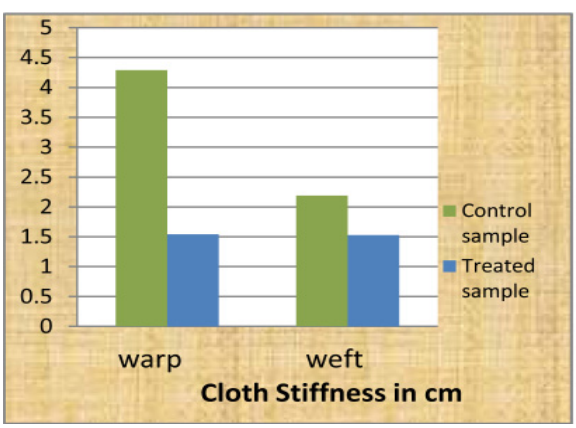

Fig. 4.Cloth Stiffness

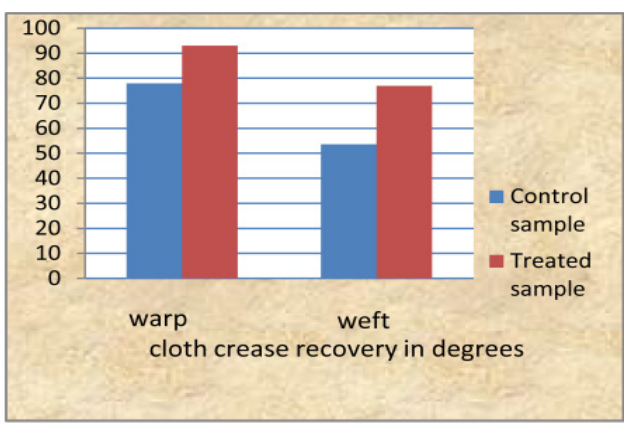

Fig. 5. Cloth Crease Recovery

Table 2. Impact of special finishes on mechanical properties of naturally coloured cotton khadi fabric

Sl. No.	Khadi fabrics	Sample Type	Yarn Count (Ne)		Cloth Count (Numerical expression)		Cloth Thickness (mm)	Cloth Weight (g/mt^2)	Cloth Stiffness (cm)		Cloth Crease recovery (degrees)		Cloth Shrinkage (%)	
			warp	weft	warp	weft			warp	weft	warp	weft	warp	weft
1.	Naturally Coloured Cotton	Control sample	2/6s	2/8s	41	27	0.82	219.44	4.29	2.19	78	53.6	8.44	0.67
		Treated sample	2/8s	2/8s	43	29	0.85	240.88	1.54	1.53	93	77	0.00	0.00
		t-value					**1.22**	**3.42**	**-4.17**		**4.47**		**-2.83**	

bath, the novel softening finishing system can obtain almost the same softening finishing effect and the adsorption rate of silicone softener is about 75 percent.

Varieties with fibre lengths of 25–29 mm and fibre strengths of 20–23 g/tex are required by the textile industry. Depending on the spinning mills' acceptability, a couple of the more recent varieties might be taken into consideration for the purpose. The handloom companies should work with the Khadi Gram Udyog to use coloured cotton types with short fibre (<24 mm) and enhance the production of eco-friendly, naturally coloured cotton fabric.

CONCLUSION

The study revealed that eco-finishing treatments significantly enhanced the flexibility, drape and pliability of naturally coloured cotton khadi fabric resulting in a softer handle, smoother texture, excellent abrasion resistance and complete absence of pilling. Statistical analysis marked by significant *t* values confirmed notable improvements in mechanical properties-particularly through increased yarn fineness and density, which contributed to a more compact structure and elevated fabric weight. These enhancements were achieved using safe and secure eco-friendly finishing methods, entirely free from harmful chemicals that could compromise consumer health or environmental integrity. As a result, consumers benefit from greater satisfaction and value, securing bio-finished, sustainable khadi fabrics that uphold both quality and ecological responsibility. This approach offers a meaningful contribution to green textile development and the reduction of environmental pollution.

REFERENCES

Chowdhury, K.P. 2018.Effect of Special Finishes on the Functional Properties of Cotton Fabrics. Journal of Textile Science and Technology, 4(2): 49-66. https://doi.org:10.4236/jtst.2018.42003

Table 3. Impact of special finishes on functional properties of naturally coloured cotton khadi fabric

Sl. No.	Khadi fabrics	Sample Type	Cloth elongation (%)		Cloth tensile Strength (kgf)		Cloth Abrasion resistance (cycles)	Drape Coefficient (%)	Cloth pilling (Ratings)
			warp	weft	warp	weft			
1.	Naturally Coloured Cotton	Control sample	10.66	7.04	26.00	15.10	Above 10,000	130.64	1
		Treated sample	13.15	7.22	42.88	25.54	Above 10,000	61.23	1

Keshamma, E. 2022. An Overview on Colour Cotton Research – A Review. International Journal of Engineering Technology and Management Sciences, 5(6): 272-278.

Madhu, A. 2024. Naturally Coloured Cotton: A Sustainable Innovation. DOI: 10.5772/intechopen.113290. https://www.intechopen.com/chapters/88495

Manasmita, M., Kumar, S and Mehra, D. 2024. Recent advancements in textile finishing focused on eco-friendly and plasma technology approach. Journal of University of Shangai for Science and Technology, 26(4): 310-321. ISSN: 1007-6735

Menon, M. 2020. Naturally-coloured cotton from India could help reduce the environmental pollution caused by dyes. https://scroll.in/article/975377/naturally-coloured-cotton-from-india-could-help-reduce-the-environmental-pollution-caused-by-dyes.

Pu, D. J., Zhong, Q and Wang, J. P. 2015. A novel softening finishing of cotton fabrics by Silicone Softener/ D5 Dispersion system. Key Engineering Materials, 671: 186-190. https://doi.org/10.4028/www.scientific.net/KEM.671.186

Raafi, M., Arju, S.N., Asaduzzaman, Md., Khan, H. H and Rokonuzzaman, Md. 2023. Eco-friendly scouring of cotton knit fabrics with enzyme and soapnut: An alternative to conventional NaOH and synthetic surfactant based scouring. Science Direct, 9(4). https://doi.org/10.1016/j.heliyon.2023.e15236

Shahid, M., Mohammad, F., Chen, G., Tang, R.C and Xing, T. 2016. Enzymatic processing of natural fibres: white biotechnology for sustainable development. Green Chemistry, 18(8): 2256-2281.https://doi.org/10.1039/C6GC00201C

Silva, L.G. de Melo da, Oliveira, D. de, Souza, A.A. Ulson de, Souza and S.M. GuelliUlson de. 2017. Study and application of an enzymatic pool in bioscouring of cotton knit fabric. The Canadian Journal of Chemical Engineering, 95 (7):1253-1260. https://doi.org/10.1002/cjce.22780

Namrata, M., Turamari, R. I. and Tangod, V. B. 2025. Influence of Eco-Friendly Amazing Finishes on Naturally Colored Cotton in Green Textiles. The Journal of Research ANGRAU, 53(3): 95-101

DoI: https://doi.org/10.58537/jorangrau.2025.53.3.10

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CONSUMER AWARENESS ON ENVIRONMENTALLY SUSTAINABLE REGENERATED BAMBOO HOME FURNISHINGS

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INTRODUCTION

In today's world of intense competition, environmental concerns have entered the mainstream. Recognizing the causes of environmental issues such as deforestation, pollution, global warming and ozone depletion, green marketing is an essential trend observed today. The terms environmental, ecological and nature-friendly pertain to products and services, regulations and procedures that have a negligible or nonexistent negative impact on ecosystems or the environment. Due to the increasing significance attributed to environmental protection, consumers worldwide have begun to demonstrate concern and abstain from purchasing products that have detrimental effects on the environment. The emergence of green consumerism can be ascribed to increased awareness regarding the depletion of natural resources, thereby elevating the significance of environmental protection (Geeta Rani and Sharma, 2019). Thus, green interiors are presently a prevailing trend in the field of interior designing.

Milcah Paul and Radha Rani (2018), opined that environmentally conscious consumers opt for eco-friendly building material and décor items. Decorative material is an integral part of interior design and selection of appropriate decorative material is crucial to improvise the overall aesthetics of the space. The interior design integrates furnishings from many periods of design history and holds a significant role in beautifying the interiors (Anita *et al.,* 2017). The increasing customer demand for protective, comfortable and eco-friendly products has prompted extensive research and development of renewable and biodegradable materials especially in the textile sector, as well as the implementation of environmentally conscious production procedures.

Regenerated bamboo is a type of cellulose fiber that is commonly utilized in the production of clothing and household textiles. Rathod and Kolhatkar (2014) found that regenerated bamboo fibers possess notable characteristics such as elevated tensile strength, UV protection, antibacterial and biodegradable properties, high moisture absorption and softness, and brightness, flexibility, breathability and rapid drying. These qualities contribute to the exceptional comfort provided by this fabric. Regenerated bamboo fiber is employed in the production of undergarments, personal care products.

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Bamboo textiles, which possess antibacterial, biodegradable, moisture-absorbing, soft and UV-protective properties, are much sought after. The fabric, composed of regenerated bamboo blend, enhances the natural and comfortable ambiance of homes.

The purpose of the study was to determine the awareness and perspective of consumers on environmentally sustainable regenerated bamboo home furnishings. This study undertaken in 2023 employed techniques of convenience sampling for its methodology. The samples were chosen from Saibaba colony and R.S Puram in the Coimbatore district of Tamil Nadu. A total of two hundred samples were chosen in equal proportions from both locations. The survey approach was used to obtain the primary data, utilizing a structured interview schedule. The interview schedule was developed to ascertain consumers' awareness on sustainable regenerated bamboo fabrics for home furnishings.

The participants chosen were middle and higher-income group consumers. The sample size was evenly drawn from both the middle and higher-income groups of customers. The interview schedule was divided into three sections. The first section focused on the demographic characteristics of the participants, whereas Section 2 examined their level of awareness regarding environmentally friendly materials for interior décor. The final portion focused on customer awareness and perception of regenerated bamboo home furnishings**.** The scoring for the sample was done on the basis of Yes/No response with a score of 2/1 respectively. The secondary data were sourced from a variety of books published journals, and other pertinent academic resources. The gathered data was scrutinized and deciphered using percentage and Chi-square analysis.

RESULTS AND DISCUSSION

Socio - demographic variables, including age, employment status, educational attainment, economic status, were gathered by the investigator. Age has been classified into four distinct categories. As per the

Table 1. Socio-demographic profile of the selected respondents

n=200

Variables	Categories	Frequency	Percentage
Age	Up to 30 years	36	18.00
	31 - 40 years	77	38.50
	41 – 50 years	65	32.50
	Above 50 years	22	11.00
Employment status	Full time Homemakers	95	47.50
	Employed	105	52.50
Educational Status	Higher Secondary	22	11.00
	Under Graduation	91	45.50
	Post – Graduation	72	36.00
	Professional course	15	7.50
Economic Status	Higher Income	100	50.00
	Middle Income	100	50.00

Table 2. Consumer awareness on eco - friendly materials for home furnishings

Eco-friendly materials	Consumer awareness on selected eco-friendly materials			
	Aware	Percentage	Not Aware	Percentage
Cotton	200	100	-	-
Jute	92	46.00	108	54.00
Coir	60	30.00	140	70.00
Bamboo	22	11.00	178	89.00

demographic profile, it was found that 18 per cent of the respondents belonged to less than 30 years, 38.5 per cent were between the ages of 31 and 40 years, and 32.5 per cent were between the ages of 41 and 50 years. Eleven percent of the participants surpassed the age of fifty. The study enrolled a majority of respondents (38.5%) within the age range of 31 to 40 years. Eleven per cent of the total respondents were above 50 years of age.

In this study, most of the respondents (52.50%) stated they were working in various sectors and 47.5 percent of respondents were homemakers. The levels of education of the majority of the respondents were under-graduates (45.5%) and 36 percent of respondents were qualified with post–graduation. Regarding consumer income, an equal sample size was selected from both middle-income and higher-income respondents.

Sustainable practices for interior decoration continue to restrict the use of eco-friendly products. Additionally, consumer awareness of eco-friendly products is limited. Consumer awareness of specific eco-friendly materials for interior decoration, including cotton, jute, coir and linen, was assessed in the study.

The consumer awareness pertaining to a range of eco-friendly materials suitable for interior design is depicted in Table 2. Cent percent of the respondents were aware of cotton-based materials utilized in interior design while awareness on utilizing jute-based materials for interior decorating was reported by 46 percent of the respondents. The results revealed that over 60 percent of the respondents lacked awareness regarding alternative eco-friendly materials like linen, besides cotton, jute and coir that could be utilized for interior design and decoration. However, least percent (11%) were aware of Bamboo as an eco-friendly material for home furnishing.

Association between Consumer awareness on regenerated bamboo home furnishings and socio-demographic factors

The chi-square test was utilized to investigate the relationships between personal variables and consumer awareness and results are presented in Table 3. Out of 200 respondents, 22 of respondents had awareness on regenerated bamboo home furnishings while 178 of respondents are not aware of the products for interiors.14.3 percent of employed participants had awareness regarding regenerated bamboo home furnishings, whereas the remaining 85.7 percent were not aware (Seman *et al*., 2025). And 7.4 percent of fulltime homemakers are aware of the products, while 92.6 percent of participants are not aware of home furnishings which are made by using regenerated bamboo fabrics.

Table 3. Association between Consumer awareness on use of regenerated bamboo home furnishings and socio-demographic factors n=200

Variables	Categories	Consumer awareness				X2 value	Df	P value
		Yes		No				
		f (n=22)	%	f (n =178)	%			
Occupational status	Homemakers	7	7.4	88	92.6	2.669	2	.263 (Ns)
	Working women	15	14.3	90	85.7			
Educational status	Up to Schooling	-	-	22	100.0	10.271	4	.036(*)
	Under Graduation	8	8.8	83	91.2			
	Post – Graduation	14	19.4	58	80.6			
	Professional course	-	-	15	100.0			
Economic status	Middle-Income group	5	5.0	95	95.0	7.354	1	.007(**)
	High-Income group	17	17.0	83	83.0			

Ns- Not significant, *-Significant at 5 % level, **-Significant at 1 % level, df – Degrees of freedom

Additionally, the statistical results indicate that there is an association between educational status and awareness on regenerated bamboo home furnishings. Specifically, 19.4 percent of postgraduate participants and 8.8 percent of Undergraduates had awareness, whereas. The analysis demonstrates statistical significance at the 1% level, and the obtained value is 10.271(p=0.036), representing a difference of 4. With regard to the respondents' economic status and awareness, the findings indicated that while 17 percent of high income respondents and 5 percent of middle income respondents were cognizant of regenerated bamboo home furnishings, at minimum of 5 per cent significance. The Chi-Square test yielded a significant value of 7.354 (p=0.007) at the 5% level. Consumer awareness on regenerated bamboo home furnishings is insufficient, according to the findings of the study.

Consumer opinion on the market availability of regenerated bamboo home furnishings

A total of 2.5 per cent of the respondents indicated that the products were widely available in other Indian states, while 5 per cent of the respondents mentioned that the home furnishings are available in online platforms. Regarding the availability throughout all sources 51.5 per cent of the participants were unaware. 2 per cent of the respondents indicated the availability of few items of the home furnishings which were made by using regenerated bamboo fabrics available in local market. According to the findings of the study, the majority of respondents reported being unaware of the product availability in the market places. Amanda and Xiao (2016) reported that in the United States alone, more than two hundred retailers carry bamboo textile products, including Bed Bath & Beyond,

Table 4. Consumer opinion on the market availability of regenerated bamboo home furnishings **n=200**

Variables		Opinion on the market availability of regenerated bamboo home furnishings in percentage					X2 value	Df	P value
		Available	Not Available	Available in other other States in india	Available in online platform	No idea on availability			
Based on Educational status	Up to schooling	-	22.7	-	9.1	68.2	27.800	16	**.033(**)**
	Under Graduation	1.1	37.4	9.9	4.4	61.5			
	Post-graduation	4.2	40.3	9.7	5.6	37.5			
	Professional course	-	66.7	-	-	33.3			
Based on Economic Status	Middle - Income	-	34.0	1.0	3.0	46.0	19.776	4	**.001(*)**
	Higher - Income	4.0	44.0	4.0	7.0	57.0			

Ns- Not significant, *-Significant at 5 % level, **-Significant at 1 % level, df – Degrees of freedom

Walmart and Macy's. These items are particularly well-liked by youthful, environmentally conscious "green" consumers who lead an eco-friendly way of life. However the bamboo home furnishings are not still popular in Coimbatore.

The findings of this investigation are presented in Table 4 indicate that 40.3 percent of postgraduates reported that the products were not widely accessible on the market in their region. Additionally, 46 per cent of middle-income category opined the lack of availability of products. However, 4 per cent of higher income who mentioned the availability in other states in India. The statistical analysis revealed the Chi – Square value of 27.800(p=.033) with significance at 5% level. Regarding, economic status of the consumers and market availability also achieved chi – square value is 19.776(p=.001), significant level at 1%.

CONCLUSION

Regenerated bamboo fabric is a new and innovative décor that is also sustainable, environmentally friendly and offers both aesthetic appeal and a healthy, low-carbon indoor environment, where art and material considerations work together to create a safer and more pleasant area. The findings clearly reveal a significant lack of awareness among consumers with only 11 percent aware of bamboo products for home furnishings. The chi-square analysis indicated that consumer awareness is significantly influenced by personal variables such as employment status, educational status and income level. The chi-Square test yielded a significant value of 7.354 at the 1% level regarding association between economic status and awareness and a significance of 10.271 at the 5% level regarding education and awareness. In terms of consumer opinion on market availability of bamboo products, the results showed significant variation in both educational status and income status of the respondents. This gap underscores the need for greater awareness campaigns and accessibility of bamboo-based products. Overall, the research highlights findings brought out a critical need for targeted educational and marketing efforts to bridge the awareness gap and promote sustainable alternatives like regenerated bamboo in the home furnishings sector. With growing interest in eco-friendly lifestyles, there is potential for increased consumer engagement if these products are made more visible and accessible. Consequently, regenerated bamboo blend fabrics have the potential to serve as a valuable option for home furnishing on both a national and international scale in the future.

Bamboo fabric is growing in popularity, it isn't always readily available in local stores. This means that deciding where to purchase the material can sometimes be difficult. However, there is online availability of the at (https://www.goingzerowaste.com/blog/bamboo-fabric-sustainable-or-hype/#/). Based on the conclusions of the study, the vast majority of the individuals are not aware of the availability of the regenerated bamboo home furnishings from any source and the awareness is significantly related to the employment status, educational status and income level of the respondents. Bamboo fabric is a material that is frequently lauded for its environmentally friendly nature.

REFERENCES

Anita, R., Nirmal, Y and Nisha. 2017. Consumer preferences for theme based home furnishing. Asian Journal of Home Science.12 (1): 2.

Amanda Thompson and Xiao Tong. 2016. Factors influencing college students' purchase intention towards Bamboo textile and apparel products.

International Journal of Fashion Design, Technology and Education. 9 (1): 62.

Geeta Rani and Ajaipal Sharma 2019. Study of Consumer awareness towards Eco-Friendly Packaged Products. International Journal of Advanced Research in Commerce, Management & Social Science, 2 (4): 48-54.

Milcah Paul and Radha Rani, P. 2018. Deliberations for designing theme Based Interiors - A strategy to increase the consumers interest and demand for handloom products, Journal of Scientific Research & Reports, 20 (2): 2.

Noor Aslinda Abu Seman, Siti Fatimah Ibrahim, Juliana Abdul Halip, Nurazwa Ahmad, Arifha Mohamad, UmiKartini Rashid and MohdKhairun Anwar Uyup.2025. Adopting Bamboo as an Alternative Material in the Furniture Industry: A Systematic Literature Review (SLR) on Awareness and Readiness of Adoption. International Research Journal of Multidisciplinary Scope (IRJMS), 2025; 6(2): 152-164

Rathod, A. and Kolhatka, A. 2014. Analysis of Physical Characteristics of Bamboo Fabrics. International Journal of Research in Engineering and Technology. 3(8): 21-24.

Radhika,S. and Thilakam M.R. 2025 . Consumer Awareness on Environmentally Sustainable regenerated Bamboo Home Furnishings. The Journal of Research ANGRAU, 53(3): 102-108

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CLIMATE VULNERABILITY ASSESSMENT OF SMALL AND LARGE-SCALE PADDY FARMERS IN PALAKKAD DISTRICT, KERALA

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ABSTRACT

Palakkad has a total paddy area of 76503.68 hectare, of which the wet paddy area is 76361.21 hectare and total dry paddy area of 142.47 hectare. Weather, pest, disease, drought, and flood are the common natural or external risks. The external sources of risk cannot be controlled by farmers, which generally come from the natural environment. In this context, the study looks into the production risks pertaining from the external sources among the small and large scale farmers in the Palakkad district, Kerala. A vulnerability index is developed consisting of exposure, sensitivity and adaptive factors to understand the climate induced production risks among the selected sample farmers during 2005 to 2022.The data reveals that the exposure index is low (<= 11.96) for only minority of small farmers and most of themfell in high and very high category (more than 13.46). In the sensitivity category, majority of small and large farmers wereincluded in the high sensitivity index category group (11.45to 13.66).But the severities of these factors effecting them are different. Exposure factors had medium impact on large number of sample farmers, while, sensitivity factors create high impact on large number of farmers. Likewise, adaptive factors had high impact on small and large scale farmers. Even though adaptation practices are implemented in the district,more efforts were needed to implement them in a timely and systematic way.

Keywords: Adaptation, Exposure, Sensitivity, Vulnerability

INTRODUCTION

Paddy is the principal crop extensively cultivated in all the districts of Kerala, having a unique three season pattern viz. Autumn (July- October), Winter (November – February) and Summer (March – June) and it is the staple food for the people in Kerala. Still now in rural areas, agricultural sector absorb more labour and acts as a leading income generating sector. Among the grand total of paddy area (76503.68 hectare.), total wet paddy area in the Palakkad is 76361.21 hectare and total dry paddy area is 142.47 hectare. In 2021-22, rate of growth of agriculture and associated sectors was 4.91 percent. In 2022-23, it declined to 0.87 percent (Agricultural statistics 2022-23). The growth in crop sector was 0.74 percent as compared to 3.67 percent in 2021-22 (Department of Economics and Statistics 2023, GoK).The contribution of the district among the

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total paddy area to the state was 39.09 percent (Agricultural Statistics, 2021-22).Palakkad is the rice bowl of Kerala because it holds foremost position in the rice production as well as its productivity. Compared to all other agricultural crops, the rice crop is more vulnerable due to exogenous and endogenous factors.The vulnerability associated with the agricultural sector is more than that of non-agricultural sector. Agricultural risks or vulnerabilities occur through external and internal factors. Weather, pest, disease, drought, and flood are the natural risks or external risks. Besides nature, risks can also be caused by marketing and other activities known as internal sources. The external sources of risk which are natural and which cannot be controlled by farmers (Riaman *et.al*.,2021). In this context, this study drives to analyze the production and financial risks among the small and large scale paddy farmers from external sources in Palakkad district. Vulnerability is a multidimensional static process affected due to social, political, and economic forces interacting from local to international scales (Bohle, *et al*., 1994).

MATERIAL AND METHODS

In this study, a vulnerability index was developed comprising exposure, sensitivity and adaptive factors to understand the production risks among the selected sample farmers because of climate variability.The study aims to examine the relation between the production and climatic factors among the small and large scale farmers and also the extent of vulnerability of rice production due to external sources. The study also suggests some concrete solutions to reduce the magnitude of vulnerable situations in the Palakkad district, Kerala.

Vulnerability index was constructed by integrating three key components: exposure, sensitivity, and adaptive competences of the farmers. These factors reflect different dimensions of susceptibility to climate- induced risks.Correlation analysis was carried out to understand the climate impact on agricultural production. This study also gave the extent and magnitude of its impact. In addition, a t-test was applied to examine the substantial differences in exposure, sensitivity, and adaptive competences that exist between large and small scale farmers. This analysis provided the different experiences and responds of small and large groups. Furthermore, to explore the association of specific sensitivity factors between large and small farmers, a chi-square test was applied. A trend line wasfitted by using data for the period 2005 to 2022 for climate variablesto understand the long –term changes.Together, these analytical approaches provided a comprehensive understanding of vulnerability of climate on production by using exposure, sensitivity and adaptive capacity among small and large scale farmers.

Palakkad district was purposively chosen as it has first position with 76503.68 hectare (39.09 percent of total paddy area in the state) under cultivation of paddy. The study carried out by taking 150 sample farmers constituting of 105 small and 45 large scale farmers. The selection of sample was purely based on simple random sampling method from the total paddy farmers in the district. To study the magnitude of the production risk, vulnerability index was developed consisting of exposure, sensitivity and adaptive factors. The vulnerability of the crop is measured by taking the lower values of the exposure, sensitivity and adaptive factors as the threshold level. It is operationalized as the minimum levelof climatic factors (temperature, rainfall, humidity, precipitation and wind) that create noticeable impact- either positive or negative. There will be a close connection between crop production and uncertainty. Better policy and

Table 2.Correlation Analysis

Variable		Tempera-ture	Wind Speed	Rainfall	Precipi-tation	Relative Humidity
Production	Pearson Correlation	-0.441*	-0.038	0.439*	0.639**	0.550*
	Sig. (2-tailed)	0.067	0.879	0.068	0.004	0.018

Source: Computed

management decision helps to increase productivity of agriculture (Amer Ait Sidhoum, 2023)

RESULTS AND DISCUSSION

For the study, it was assumed that the internal factors such as labour charges, use of irrigation, fertilisers and pesticides are constant. The climatic factors such as rainfall pattern, temperature, relative humidity, precipitation and wind speed which are external in nature that affect the yield of the seasonal crop of rice . The data was collected from 150 farmers which includes both small (105) and large (45) scale farmers.The small scale farmers are those having below 2 acres of land and large scale farmers are those having above 5 acres of land. Table 1 represents the frequency table of sample farmers.

Source: Primary data

Table 2 represents the correlation between the production of rice and climate variables. To calculate correlation, climate variables such as temperature, rainfall, wind speed, precipitation, and relative humidity were taken. For the correlation analysis, data of 18 years from 2005 to 2022was used. The study found that there was significant negative correlation between the temperature and production. As the temperature was seen increasing, production was continuously declined.Wind speed and production were not significantly correlated. Rainfall and production were positively correlated. Likewise, a positive relation was noted in precipitation and relative humidity.

Table 1. Details of Sample Farmers

Farmers	Frequ-ency	Per-cent	Cumul-ative Percent
Small	105	37	70
Large	45	16	100
Total	150	53	

The table 3 represents the impact of exposure factor which is one of the vulnerability factors among the small and large scale farmers. The exposure factor includes variables such as acres of land affected due to flood and drought, number of times affected, impact of pesticides and diseases, problems due to the non-use of climate adaptive seeds etc. The mean value of vulnerability of exposure factor more or less impacted on both small and large scale farmers because both categories have no proper adaptive and mitigation measures to overcome the vulnerability of climate change. The impact of climate change are not evenly distributed., by intensifying the exposure to environmental hazards it reveals the existing inequalities in vulnerability shaped by race ,class, ethnicity and gender (Denton, 2002; Leichenko and Silva, 2014; Shepherd and Binita, 2015). The table 3 also represents the mean difference of the exposure factor among the small and large scale farmers. The exposure factor is high

Table 3. Mean value of sample farmers

INDEX	Farmer	N	Mean	Std. Deviation	Std. Error Mean
ExposureFactor	Small	105	13.2762	1.54107	0.15039
	Large	45	13.8444	1.29607	0.19321

Source:Computed

Table 4. Independent sample t -test

Exposure index		F	Sig.	t-value	df	Sig.(2-tailed)
Exposure	Equal variances assumed	3.199	0.076	-2.166	148	0.032
	Equal variances not assumed			-2.321	98.219	0.022

Source: Computed

for the large scale farmers compared to small. This indicates that large scale farmers having more acres of land are more susceptible to climate variability.

To study the hypothesis of significant difference in the exposure factors among small and large scale farmers, t – test was calculated. The results exhibited that there wasnotable difference exhibited between the exposure index among the small and large scale farmers.

Table 5 represents the value of exposure index among the small and large scale farmers. The intensity of exposure is categorised into four such as low, medium, high and very high. The data reveals that the exposure index is low (<= 11.96) for only 12 small farmers and most of the small farmers lies in high to very high category (more than 13.46). There has been direct link between climate variability and change through flooding, drought, changes in average temperatures and extreme weather events. Apart from the natural resource inputs, climate variability and climate change can affect the production and marketing of agricultural products (Acosta-Moreno and Skea, 1996). By using stochastic specification model under uncertain situation, efficiency and productivity of crops can increase (Chavas, 2008). River based flooding and landslides had direct impact on infrastructure and indirect effects on agricultural activity, human migration and water supply. Even though these impacts were different in rural and urban areas but had very sensitive to climate variability and change (Scott *et al.,* 1996).

Table 6 represents the impact of sensitivity factor among the large and small scale farmers. The variables includes for the sensitivity are the decrease in quantity of production, the amount of loss in straw, decrease in amount of harvesting, amount of purchase in rice for consumption quantity of imports etc. In the sensitivity category, majority of small and large scale farmers were in the sensitivity index category group of 11.45 – 13.66 which is included in the high sensitivity index. It indicates that more farmers, irrespective of the category are vulnerable due to climate variability.

Table 7 represents the adaptive measures taken by the selected farmers in the Palakkad district. The data reveals that the small and large scale farmers practised high

Table 5.Farmers Exposure Factor Cross tabulation

Farmers		Exposure (Low, Medium, High and Very High)				
		<= 11.96	11.97-13.45	13.46-14.94	14.95+	Total
Small	Count	12	44	26	23	105
	% within farmers	11.4%	41.9%	24.8%	21.9%	100.0%
	% of Total	8.0%	29.3%	17.3%	15.3%	70.0%
Large	Count	2	15	15	13	45
	% within farmers	4.4%	33.3%	33.3%	28.9%	100.0%
	% of Total	1.3%	10.0%	10.0%	8.7%	30.0%
Total	Count	14	59	41	36	150
	% within farmers	9.3%	39.3%	27.3%	24.0%	100.0%
	% of Total	9.3%	39.3%	27.3%	24.0%	100.0%

Source: Computed

adaptive techniques to overcome the extent of vulnerability. Out of 105 small farmers, 60 farmers use high to very high adaptation measures because their adaptation value is higher than 7.47. Among 45 large scale farmers, 39 farmers lie in the category of High adaptation group, were aware of adaptive measures but not practiced in the agricultural sectors. New methods will be needed to overcome the climate change induced loss in agricultural production to withstand the risks associated with climate variability and avoid the shifting of occupation.

Table 8 reveals the mean values between the exposure, sensitivity and adaption factors among the small and large scale farmers. The result shows that both farmers had similar impacts arises from climate variability. But in case of adaptation, large scale farmers were more adaptive than small

Table 6. Farmers Sensitivity Factor Cross tabulation

Farmers		Sensitivity (Low, Medium, High and Very High)				
		<= 9.22	9.23-11.44	11.45-13.66	13.67+	
Small	Count	24	23	39	19	105
	% within farmers	22.90%	21.90%	37.10%	18.10%	100.00%
	% of Total	16.00%	15.30%	26.00%	12.70%	70.00%
	Count	10	10	20	5	45
Large	% within farmers	22.20%	22.20%	44.40%	11.10%	100.00%
	% of Total	6.70%	6.70%	13.30%	3.30%	30.00%
Total	Count	34	33	59	24	150
	% within farmers	22.70%	22.00%	39.30%	16.00%	100.00%
	% of Total	22.70%	22.00%	39.30%	16.00%	100.00%

Source: Computed

Table 7.Farmers Adaptation Factors Cross tabulation

Farmers		Adaptation (Low, Medium, High and Very High)				
		<= 6.13	6.14 - 7.46	7.47 - 8.79	8.80+	Total
Small	Count	33	12	44	16	105
	% within farmers	31.40%	11.40%	41.90%	15.20%	100.00%
	% of Total	22.00%	8.00%	29.30%	10.70%	70.00%
Large	Count	0	6	27	12	45
	% within farmers	0.00%	13.30%	60.00%	26.70%	100.00%
	% of Total	0.00%	4.00%	18.00%	8.00%	30.00%
Total	Count	33	18	71	28	150
	% within farmers	22.00%	12.00%	47.30%	18.70%	100.00%
	% of Total	22.00%	12.00%	47.30%	18.70%	100.00%

Source: Computed

Table 8. Group Statistics

Factors	farmers	N	Mean	Std. Deviation	Std. Error Mean
Exposure	small	105	13.2762	1.54107	0.15039
	Large	45	13.8444	1.29607	0.19321
Sensitivity	small	105	11.4476	2.38578	0.23283
	Large	45	11.4222	1.78998	0.26683
Adaptation	small	105	7.1714	1.45084	0.14159
	Large	45	8.1333	0.62523	0.0932

Source: Computed

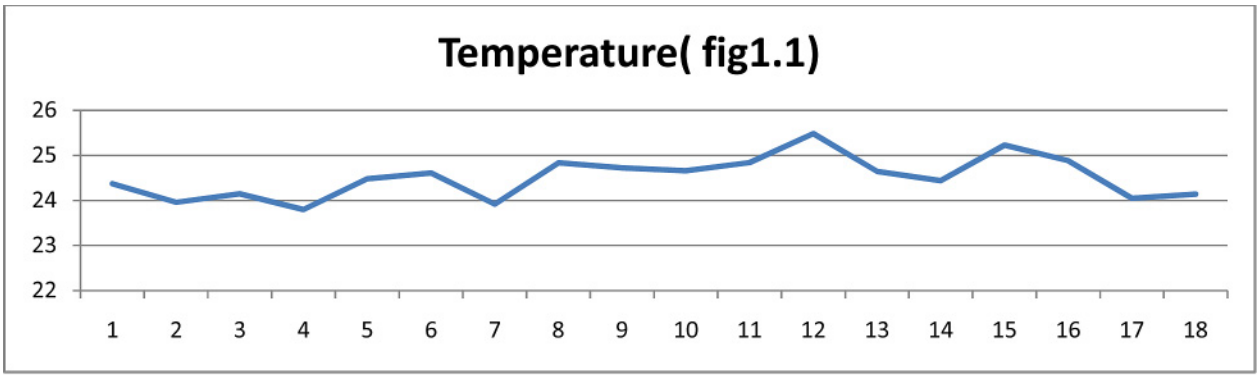
farmers because the mean value (8.1333) of large scale farmers is higher than the small (7.1714).

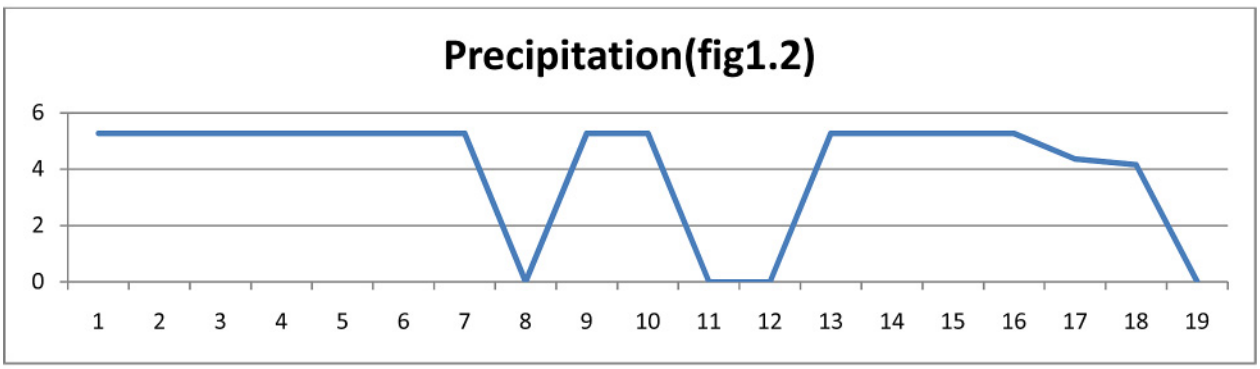
Table 9 represents the outcome of the t-test which shows that there is substantial difference between the exposure and adaptation factors among the small and large scale farmers because the t value is significant at 5 percent. From the analysis, it is clear that all the three indexes such as exposure, sensitivity and adaptation are significant that determine the vulnerability among the small and large scale farmers.

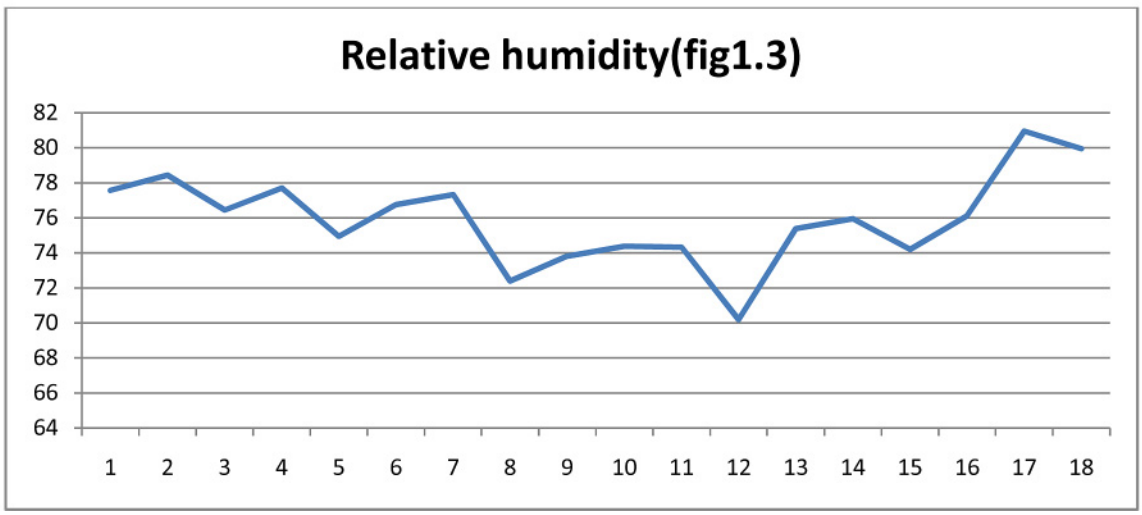
Table 10 represents the value of overall vulnerability between the small and large scale farmers. The mean value of largescale farmers was higher than that of the small because large scale farmers were unable to adjust the climate impact easily because of holding sizable acres of land. Different types of practices can improve mitigation and adaptation methods among farmers (McNeeley *et al*., 2017)

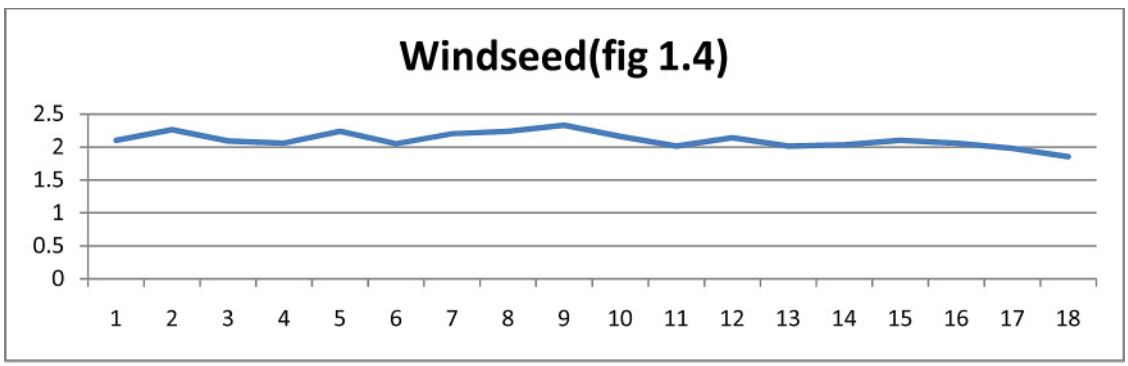
Table 11 represents the findings of the t- test which states that there is notable difference in the overall vulnerability among the small and large scale farmers at 1 percent significant level.

From the following depicted figures, it was noted the temperature (fig1.1) goes on


Temperature(fig1.1)
26
25
24
23
22
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18


Precipitation(fig1.2)
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19


Relative humidity(fig1.3)
82
80
78
76
74
72
70
68
66
64
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18


Windseed(fig 1.4)
2.5
2
1.5
1
0.5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

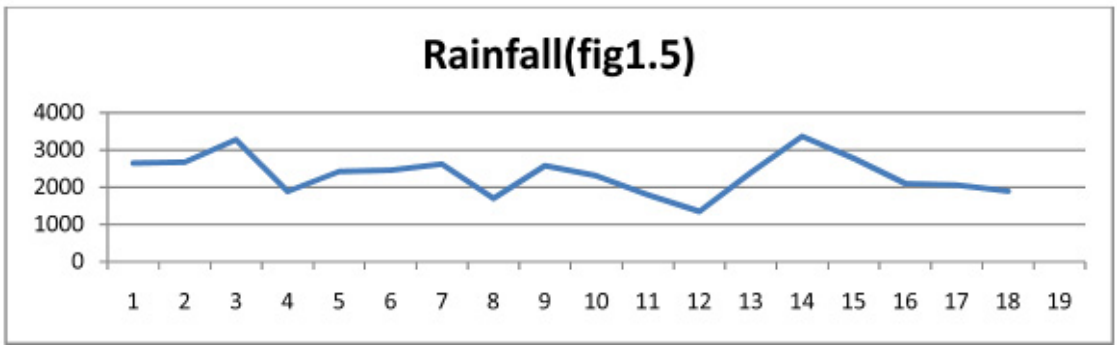


Fig 1.1, 1.2, 1.3, 1.4 &1.5 - Trends of climate variables from 2005 – 2022

Table 9. Test Results Independent Samples Test

Index		F	Sig.	t value	df	Sig. (2-tailed)
Exposure	Equal variances assumed	3.199	0.076	-2.166	148	0.032
	Equal variances not assumed			-2.321	98.219	0.022
Adaptation	Equal variances assumed	46.873	0	-4.274	148	0
	Equal variances not assumed			-5.675	147.982	0

Source: Computed

Table 10. Group Statistics-overall vulnerability

Vulnerability index	Farmers	N	Mean	Std. Deviation	Std. Error Mean
	Small	105	0.5712	0.14787	0.01443
	Large	45	0.6581	0.09041	0.01348

Source: Computed

Table 11. Test Results Independent Samples Test

Vulnerability index	F	Sig.	t value	df	Sig. (2-tailed)
Equal variances assumed	7.924	0.006	-3.659	148	0
Equal variances not assumed			-4.404	130.274	0

Source: Computed

increasing from 2013 onwards and the actual rainfall (fig.1.5) received in the district is showed fluctuating but it goes on declining from year 2000 onwards. These are the important climate variables which affect the production directly. Wind speed (fig.1.4) in the district shows more or less same trend but the relative humidity (fig.1.3) and precipitation (fig. 1.2)

also showed very high rate. These would create negative impact the production of rice in the district.

CONCLUSION

The study reveals that the exposure, sensitivity and adaptation factors had a significant impact on farmers. But the severities of these factors on them are different. Exposure factor had medium impact and sensitivity factor created high impact on large number of sample farmers. Likewise, adaptation factor had high impact on small and large farmers. Even though adaptation practices are implemented in the district but it is not in the proper way. Therefore, improved methods like planting of climate resistant varieties, timely application of fertilisers and pesticides, better irrigation facilities and correct meteorological information etc. are needed. These are the important determinants to increase the production of rice and thereby reduce the financial risks associated with it. Better and improved agricultural insurance policies helps to manage the risks associated with the external factors.Proper understanding of the problems will help to reduce the negative impacts through the development of proper adaptive measures. Communication of proper and correct weather forecasts through various channels helps the farmers to mitigate the risks by taking quick and best adaptation measures.

REFERENCES

Agricultural Statistics.2021-22. Directorate of Economics and Statistics, Ministry of Agriculture, Government of Kerala.

Agricultural Statistics.2022-23.Directorate of Economics and Statistics, Ministry of Agriculture, Government of Kerala.

Amer Ait Sidhoum. 2023. Measuring farm productivity under production uncertainty. Agricultural and resource economics, 672-687.

Acosta-Moreno, R. 1997. Interview with S. Agrawala, Bonn, Germany, March 4.

Bohle, H. G., Downing, T. E.and Watts, M. J. 1994. Climate change and social vulnerability:-Toward a sociology and geography of food insecurity. Global Environmental Change, 4(1): 37–48.

Chavas, 2008.Stochastic Specification of Production Functions and Economics Implications.Journal of Econometrics, 7: 67- 86.

Denton, F. 2002. Climate change vulnerability, impacts, and adaptation: Why does gender matter? Gender and Development, 10(2): 10-20.

McNeeley, S. M., Even, T. L., Gioia,J. B. M., Knapp, C. N.and Beeton, T. A. 2017. Expanding vulnerability assessment for public lands: The social complement to ecological approaches. Climate Risk Management,16:106–119.

Riaman, R.; Sukono, S.; Supian, S. and Ismail, N. 2021.Analysing the decision making for agricultural risk assessment:An application of extreme value theory. Decis. Sci. Lett., 10: 351–360.

Riaman, R., Sukono, S., Supian, S. and Ismail, N. 2021.Determining the premium of paddy insurance using the extreme value theory method and the operational value at risk approach.Journal of Physics: Conference Series, *1722*(1) 012059.

Scott, C.A.and M.F. Walter, E.S. 1996. Impacts of historical changes in land use and dairy herds in water quality in the Catskills Mountains. Journal of Environmental Quality, 27:410-1417.

Sumathy, M., Smitha, P. and Manju Varghese. 2025. Climate Vulnerability Assessment among Small and Large Paddy Farmers in Palakkad District, Kerala.
The Journal of Research ANGRAU, 53(3):109-117

DoI: https://doi.org/10.58537/jorangrau.2025.53.3.12

J. Res. ANGRAU 53 (3) 118-126, 2025

DEALERS PERSPECTIVES ON NANO FERTILIZERS AND THEIR ROLE IN PRODUCT POSITIONING

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ABSTRACT

This study explores dealers' perceptions about nano fertilizers in Guntur district, Andhra Pradesh. The study was conducted in 2024. The study employed a sample of 35 dealers and percentage analysis, mean scores and chi square technique were employed to analyse the data. The findings revealed that dealers perceived nano fertilizers as cost-effective and efficient. These were viewed as having high ease of use owing to their effective storage, dissolution and application characteristics. Dealers, as first point of contact, shape farmers input choices, thereby making their perceptions as proxy for positioning and perceived effectiveness of nano fertilizer. Recommendations from agricultural departments and fellow farmers identified as crucial for adoption among farmers and promotions by company representatives and media influence were found less impactful. The chi-square analysis highlighted that dealers prioritized affordability for lower customer footfall (fewer than five customers), while ease of use was emphasized for higher footfall (more than five customers). The demand for nano fertilizers is expected to grow, with adoption likely to increase due to their ease of use and reduced perceived risks through farmer education. Enhancing product benefits and implementing focused media promotions could further accelerate adoption among farmers.

Keywords: Cost effective, Nano fertilizers, Perception, Promotion

INTRODUCTION

Agriculture provides livelihood to over half of Indian population and employment to more than 50 % of work force. With the population projected to 1.70 billion by 2050, the food grain demand is estimated at nearly 400 million tonnes, posing significant challenges. The green revolution and subsequent technological interventions substantially increased food grain production but they also created many challenges. Some of these include indiscriminate use of fertilizers, pesticides, depletion of natural resources and environmental degradation (Pingali, 2012; FAO, 2021). These practices have contributed to soil health deterioration, nutrient runoff, water pollution and vulnerability to weather uncertainties.

These concerns highlight the need for adoption of sustainable agricultural practices, particularly in fertilizer management. Approaches such as neem-coated urea, balanced nutrient application, nutrient-efficient genotypes, bio fertilizers, water soluble fertilizers and others have been promoted to address these issues. In recent years,

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technological innovations have shown potential to transform agriculture, with nanotechnology emerging as a promising solution. Nano fertilizers, engineered to enhance nutrient delivery and minimize environmental impact, represent a breakthrough in sustainable fertilizer management (Iqbal *et al*., 2024).

Despite their potential, adoption of nano fertilizers in India remains limited, largely due to a significant knowledge gap among key stakeholders, including dealers, manufacturing companies and farmers (Kumar *et al.,* 2020). Agricultural input dealers, serving as crucial link between manufacturers and farmers, play a pivotal role in the dissemination and acceptance of this (Kumar, 2021). Their awareness, understanding of benefits and limitations of nano fertilizers, ability to communicate these aspects to farmers and their strategies for positioning these products in the market significantly impact the adoption among farmers. If dealers are well informed of nano fertilizers and confident in their benefits, they are more likely to promote them effectively to the farming community. Thus, the current study undertaken to examine dealers' perceptions towards nano fertilizers and propose strategies for enhancing their integration into Indian agriculture.

MATERIAL AND METHODS

Erstwhile Guntur district of Andhra Pradesh was selected purposively for the present study as the district is the hub for commercial and cash crops with majority of farmers adopting intensive agricultural practices. The list of dealers in Guntur district was obtained from Agriculture Development Office(ADO).From the list, a separate list of dealers selling the nano fertilisers was prepared and 35 dealers were selected randomlyfor study.The sample size was limited to 35 due to the relatively low number of dealers selling nano fertilizers in the study area. Consequently, a sample of 35 respondents was selected for the study. To accomplish the above objectives, primary data pertaining to socio-demographic, other information particulars and dealers perception of nano fertilizers were collected through survey method with the help of well-structured schedule. To study the dealers perception on nano fertilizers, the schedule developed comprised of 20 statements, developed on 5 point Likert scale with scale agreements ranging from strongly disagree to strongly agree. Later, for better understanding, these statements were grouped into six factors namelyproduct benefits, perceived ease of use, perceived risk factor,influential factors, media factorand nano usage Tech – savvy dealers. The information collected was analysed using mean, ranking,index scoring and chi-square tests.

Chi-square analysis:

Chi-square test was employed to examine the association between dealers' product perspectives and customer footfall. This signifies whether differences in customer engagement are significantly linked to the way nano fertilisers are positioned by dealers. P value of less than 0.01 indicates the significant association between variables. While Cramer's value ranges between 0 to 1 indicating no association to strong association. Values of above 0.5 signifies indicative of strong association

It is computed through the formulae

$$\chi^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)}{E_i} (or) \sum \frac{(O-E)^2}{E}$$

(D.F = K-1)

Where, O_i = Observed number of cases in the i^{th} category

Table 1. Profile characteristics of sample dealers **n =35**

S.No	Profile Characteristics	Frequency	Percentage
1	**Age**		
	Upto 30years	3	8.57
	31-40years	7	20.00
	41- 50years	16	45.71
	Morethan 50years	9	25.71
	Total	35	100
2	**Education level**		
	Primary Education	02	05.71
	Secondary Education	18	51.43
	Intermediate	10	28.57
	Graduation and above	05	14.29
3	**Market experience**		
	Upto 5years	05	14.28
	6 to 10years	09	25.71
	11to15years	13	37.14
	>15years	08	22.85
4	**Credit sales(in '000 Rs.)**		
	Upto 25	06	17.14
	26 to 50	20	57.14
	51 to 75	07	20.00
	76 to 100	02	05.71
5	**Source for inputs**		
	Company Representative	24	68.57
	Other dealers	06	17.14
	Digital platforms	03	08.57
	Government agencies	02	05.71
6	**Purchase of inputs**		
	Directly from the company	20	57.15
	Third party	09	25.71
	Both	06	17.14
	Total	35	100
7	**Channel for inputs**		
	Online	02	05.71
	Offline	28	80.00
	Both	05	14.29

S.No	Profile Characteristics	Frequency	Percentage
8	**Sales through online**		
	Less than 5 %	28	80.00
	5 -10%	03	08.57
	10 - 15%	02	05.71
	Greater than 15 %	02	05.71
9	**Main products selling**		
	Agro chemicals	23	65.71
	Fertilisers	08	22.86
	Seeds	04	11.43
10	**Since how long you have been selling nano fertilisers**		
	Since 1 year	14	40.00
	Since 2 years	15	42.86
	Since 3 years	06	17.14
11	**Channel for nano fertilisers**		
	Directly from company	24	68.57
	Third party	07	20.00
	Both	04	11.43
12	**Average footfall for nano fertilisers (per day)**		
	Less than 5	15	42.86
	5 to 10	17	48.57
	Greater than 10	03	08.57
13	**Perspective of nano fertilisers**		
	Premium	03	08.57
	Affordable product	13	37.14
	Ease of use	17	48.57
	Eco friendly	02	05.71
14	**Aware of digital platforms**		
	Yes	14	40
	No	21	60
15	**Willing to continue recommendation of nano fertilizers**		
	Yes	26	74.29
	No	9	25.71

Table 2. Product perspective Vs Customer footfall for nano fertilisers (Chi-square Tests)

		Product Perception				
		Premium	**Affordable**	**Ease Of Use**	**Eco Friendly**	**Total**
Average Footfall Per Day	Less than 5	1	1	12	1	15
	5 To 10	0	11	5	0	17
	More Than 10	2	1	0	2	3
	Total	3	13	17	3	35

Chi-square Tests	value	df	Asymp.Sig.(2-sided)
Pearson Chi-Square	26.562[a]	6	**< 0.01**
Likelihood Ratio	23.588	6	< 0.01
Linear-by-Linear Association	10.183	1	0.001
Cramer's V (Effect size)	0.616	Strong association	
N of Valid Cases	35		

a. 8 cells (66.7%) have expected count less than 5. The minimum expected count is .17.

E_i = Expected number of cases in the category i^{th} when is true.

K = Number of categories

If the value of χ^2 is greater than the table value of χ^2 at specified level of significance for (K-1) degrees of freedom, it will be significant and then we shall be justified in suspecting significant divergence between the fact and theory and rejecting the null hypothesis of equality of two sets of observed and expected frequencies.If the value χ^2 of is non-significant, it justifies the agreement between the observed fact and the theory or hypothesis.

On the basis of the mean scores, rank order was calculated. The item securing highest mean score was given first rank and the next higher second rank and so on.

RESULTS AND DISCUSSION

The information pertaining to profile characteristics of sample dealers were collected and the results are presented in Table1.

Table 1. revealed that the majority of dealers (45.71 percent) were between 41 and 50 years old, possessed secondary education (51.43 percent), with a significant proportion of dealers having 11 to 15 years of market experience (37.14 percent). Most of dealers were obtaining information related to inputs from company representatives (68.57 percent) and around 80 per cent of dealers were purchasing inputs through offline channel. Around 42.86 percent of dealers were selling nano fertilizers from past two years. Most of the dealers (48.57 percent) perceived that

Table 3. Dealers perception on nano fertilizers **n =35**

Factors	Statement	Mean score	Rank
Product benefits	Nano are priced less over traditional fertilizers	4.17	1
	Nano fertilizers are more effective than traditional fertilizers	3.62	2
	Nano fertilisers reduces the input cost of farmers	3.34	3
	Nano fertilizers reduces the reliance on traditional fertilizersby farmers	3.28	4
	Nano fertilizers leads to improvements in Yields	3.11	5
	Nano fertilizers are eco friendly	2.91	6
Ease of usage	Nano fertilizers are easy to store	4.05	1
	Nano fertilizers dissolve easily for spraying	3.71	2
	Nano fertilizers are easy to apply on the farm	3.54	3
Perceived risk factor	Farmers are reluctance to shift from routine farm operations	3.71	1
	Farmers has limited knowledge on nano fertilizers	3.57	2
	Potential of increasing costs due to additional equipment and labour	3.31	3
Influential Factors	Advices from Agri Dept & other institutions facilitates the adoption of nano fertilizers among farmers	4.11	1
	Advices from fellow farmers facilitates the adoption of nano fertilizers nano fertilizers among farmers	3.71	2
	Advices from Agri input dealers facilitates the adoption of nano fertilizers nano fertilizers among farmers	3.22	3
	Promotions by company persons facilitates the adoption of nano fertilizers among farmers	2.91	4
Media Factor	Promotion through mass media platforms facilitates the adoption of nano fertilizers nano fertilizers among farmers	3.48	1
	Promotion through social media platforms facilitates the adoption of nano fertilizers nano	3.11	2
Nano usage demand	The Demand for nano fertilizers will continue in the near future	3.97	1
	More farmers are willing to use nano fertilizers in the near future	3.77	2

nano fertilizers are easy to use. A significant number of dealers (60 per cent)were not aware of digital platforms,74.29 percent of dealers expressed their continuous willingness of recommending nano fertilizers to farmers. The average footfall for nano fertilizers was observed to be ranging between 5 to 10 number by 48.57 percent of sample respondents.

Product Positioning of nano fertilisers by dealers in the study area

Chi-square test was employed to identify whether there exists any significant association between product positioning of dealers and customer footfall for nano fertilisers and the results are presented below:

Null Hypothesis (H0): There exists no significant association between product perspective vs customer footfall for nano fertilisers

Alternate Hypothesis (H1): There exists a significant association between product perspective vs customer footfall for nano fertilisers

The results presented in Table 2. indicated that, there exists a significant association between dealers perspective about nano fertilizers and footfall of customers for nano fertilisers (Vishakha *et al.* 2023) as indicated from thechi-square values for the average footfall of customers less than 0.05 (<0.01). This indicated that majority of dealers were perceiving nano fertilizers as affordable and easy to use in agriculture. Dealers construct their perceptions of nano fertilizers from information disseminated by agro-input companies and governmental agricultural agencies at both state and central levels. Acting as intermediaries, they transmit and position these perceptions at farmer level, thereby shaping the promotion of nano fertilizers in the market, rather than reflecting farmers' independent assessments.Dealers who experienced a footfall of lower than five customers per day predominantly emphasized on the ease of use of nano fertilizers. In contrast, those with higher customer footfall were more likely to focus on their affordability relative to conventional fertilizers.Thus, rejecting null hypothesis stating that there exists significant association between product perspective of dealers and footfall of customers for nano fertilisers.

The constraint in sample size is primarily due to difficulty in identifying dealers selling nano fertilisers, as it is still a relatively new product in the market. Despite the limitations arising from the small sample size (n = 35) and the presence of low expected frequencies in several cells, the effect size was measured through Cramer's V (0.616) and this indicated a strong association between dealers' product perspectives and customer footfall for nano fertilisers. Cramer's V value in chi square test ranges from 0 (no association) to 1 (strong association). Value of 0.616 for the current study reflects a strong association, suggesting that dealers' perspectives on nano fertilisers are strongly linked with the level of customer footfall.

Dealers' perception on nanofertilizers

The information pertaining to dealers perception of nano fertilisers were collected on a schedule developed with 20 statements on a five point Likert scale,with scale agreements ranging from strongly disagree to strongly agree and were assigned scores from 1 to 5, with one being strongly disagree and five being strongly agree. The mean scores were computed and ranks were given accordingly and the results are presented in Table 3 & Table 4

The results presented in Table 3 shows that, with regard to product benefits sample dealers strongly perceived that nano fertilisers

are less costly over traditional fertilizers (4.17) and more effective than traditional fertilizers (3.62). However, they hold neutral views regarding whether nano fertilizers reduces farmers' input costs (3.34) and decreases reliance on traditional fertilizers (3.28) or lead to yield improvements (3.11). Findings align with results of Kumar *et al.* (2021), who noted that various intermediaries expressed uncertainty about the economic returns of nano inputs in the absence of large-scale demonstrations. Additionally, the sample dealers disagreed with the notion that nano fertilizers are eco-friendly (mean score: 2.91), as they still perceive them as another form of fertilizer, similar to Mahapatra *et al.* (2022) that highlighted the scepticism among stakeholders regarding the environmental concerns for nano-based products.With regard to perceived ease of use for nano fertilizers, sample dealers strongly perceived that they can be easily stored (4.05), get dissolved easily while spraying (3.71) and are easy to apply on farm field (3.54).

With regard to perceived ease of use for nano fertilizers, sample dealers strongly perceived that they can be easily stored (4.05), get dissolved easily while spraying (3.71) and are easy to apply on farm field (3.54). Raliya *et al.,* (2018), also emphasized the advantages of nano formulations in terms of storing, handling and application compared to bulk fertilizers.

With regard to influential factors, sample dealers strongly perceived that advice from agricultural departments and other institutions facilitates the adoption of nano fertilizers among farmers (4.11) followed with advices from fellow farmers is influential (3.71). However, they were neutral about the influence of advice from agricultural input dealers (3.22) and disagreed with the influence of promotions by company representatives (2.91). With regard to media factors, sample dealers perceived that promotion through mass media (3.48) and social media platforms (3.11) had less influence in increasing the adoption of nano fertilizers. With regard to demand for nano urea, sample dealers perceived that the demand for nano fertilizers will continue in the near future (3.97) and more farmers willing be using nano fertilizers soon (3.77). However, Ganiger (2012) highlighted that addressing challenges such as technical skill gaps and communication issues is crucial to improving dealers' effectiveness in promoting new products like nano fertilizers.However, addressing the training needs of input dealers is crucial for enhancing their knowledge while also ensuring effective dissemination of various technologies as highlighted by Waghmode *et al*.,(2014).

CONCLUSION

This present study aims to understand the perception of nano fertilizers among dealers in Guntur district of Andhra Pradesh, how these fertilizers are positioned and strategies to increase their adoption. The study reveals that sample dealers view nano fertilizers as both cost-effective and more efficient than traditional fertilizers and do not consider them eco-friendly. Dealers strongly believe in the ease of use of nano fertilizers, particularly in terms of storage, dissolution and application. Advice from agricultural departments and fellow farmers was identified as crucial for adoption while promotions by company representatives and media influence are less impactful. While chi square results indicated that, dealers in the study area were positioning nano fertilizers as affordable and easy to use, emphasizing affordability for lower footfall (fewer than 5 customers) and ease of use for higher footfall (more than 5 customers). Results implicate that the demand for nano fertilizers is expected to grow, with more farmers likely to adopt them in the near future. Sample dealers anticipate growing demand for

nano fertilizers, primarily due to their ease of use, including application, dissolution, and storage. Reducing perceived risks through farmer awareness and education could further encourage adoption. State agricultural department promotions and peer advice are influential, while enhancing product benefits and targeted media promotions could also drive wider adoption among farmers.

REFERENCES

Food and Agriculture Organization. 2021. Soil pollution: A hidden reality, FAO, Rome

Iqbal, S., Sutharsan, S and Thenuja, M. 2024. A study on the adaptability of farmers to n-nano fertilizer usage in *Oryza Sativa* L. cultivation in selected divisional secretariat divisions of Ampara district of Sri Lanka. International Journal of Botany Studies, 9(1): 8-14.

Kumar, S., Roy, S., Atal, R., Panda, C. K and Sohane, R. K. 2020. Knowledge gap of agri-input dealers in farm production. Current Journal of Applied Science and Technology, 39(4): 92-101.

Kumar, Y. 2021. Sales promotion and marketing strategy of Nano urea (liquid). Indian Journal of Fertilisers, 17(9): 882-891.

Ganiger S. 2012. Knowledge perception and role performance of input dealers in agro advisory services in northern dry zone of Karnataka. Ph. D. Thesis. Acharya N.G. Ranga Agricultural University, Guntur.

Mahapatra, D. M., Satapathy, K. C and Panda, B.2022. Biofertilizers and nanofertilizers for sustainable agriculture: Phycoprospects and challenges. Science of The Total Environment*, 803*: 149990

Pingali, P. 2012. Green revolution: Impacts, limits and the path ahead. Proceedings of the National Academy of Sciences,*109* (31):12302–12308

Raliya, R., Saharan, V., Dimkpa, C and Biswas, P. (2018). Nanofertilizer for precision and sustainable agriculture: Current state and future perspectives. Journal of Agricultural and Food Chemistry, 66(26): 6487–6503.

Vishakha, K., Deepa, N., Rohini, A., Vidhyavathi, A and Ravikumar, R. 2023. Awareness and Perception of Farmers and Dealers on Nano Urea in Gondia District of Maharashtra, India. International Journal of Environment and Climate Change, 13(10): 981-991.

Waghmode, Y., Borate, H.V and Gulkari, K.D. 2014. Training needs of agricultural input dealers in transfer of technology. Gujarat Journal of Extension Education, 25(1): 543-546

Durga Prasad, K., Prabhavathi, Y., Hymajyothi, S. and Lavanya, P. 2025. Dealers Perspectives on Nano Fertilizers and their role in Product Positioning. The Journal of Research ANGRAU, 53(3):118-126.

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SENSORY EVALUATION OF SALADS INCORPORATED WITH EDIBLE BLOOMS OF *HULTHOLIA MIMOSOIDES*

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The plant known as Cheemullu,Kumullu, Karthikamullu in Kerala exists under the formal name *Hultholia mimosoides*(Lam.) formerly known as *Caesalpinia mimosoides* (Lam). The plant functions as an edible species and local groups in the area use its flowers for culinary purposes. The plantpossesses three distinct abilities which include antioxidant properties with anti-inflammatory benefits along with anticancer effects and antimicrobial activity (Rangsinth *et al*.,2019). The Fabaceae family spiny shrub *Hultholia mimosoides* Lam. grows in the regions of Southeast Asia. Research shows that *Caesalpinia* plants with more than 500 species contain three main phytochemical compounds that include flavonoids together with diterpenes and steroids which exhibit multiple therapeutic activities that range from anti-inflammatory properties to anticancer treatment and antidiabetic properties and also provide antimicrobial protection and antirheumaticbenefits.The vibrant yellow blooms of *Hultholia mimosoides* are traditionally consumed in rural areas of Kerala and have potential culinary applications as decorative elements in salads. Rich in health benefits, these flowers offer both aesthetic appeal and nutritional value. This study investigates their use in salads and presents a sensory evaluation to assess their acceptability, paving the way for their broader incorporation into modern culinary practices.

The study was conducted in the Department of Community Science, College of Agriculture, Vellayani, Kerala Agricultural University, Thiruvananthapuram. The flowers of *Hultholia mimosoides* were procured from rural areas of Thiruvananthapuram district. The flowers were collected in ziplock pouches and stored in refrigerated temperature. Purple cabbage and peanuts were purchased from Thiruvananthapuram local market.

The composition of salad includes *Hultholia mimosoides* flowers together with purple cabbage and peanuts at total proportions of 100%. The percentages of salad mixture ingredients were modified to total 100% based on the information presented in Table 1. All the ingredients were selected to verify any physical damage, contamination and undesirable materials. The methodology of Domínguez-Domínguez *et al*., (2021)was followed for salad preparation. All the ingredients were then washed in 1% sodium hypochlorite solution for 3-5 minutes. Purple cabbage was sliced into long segments, approximately 5 cm × 1 cm in size, suitable for salad presentation. Peanuts were washed, immersed and pulverized before being added into salad. Additional ingredients such as lime, honey, pepper and salt were utilized to make the salad dressing and incorporated according to flavor requirements. All the salad ingredients were weighed separately to guarantee

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Table 1: Proportion of salad ingredients

Formulation	*Hultholia mimosoides* flowers (%)	Purple Cabbage(%)	Peanuts(%)
S_1	20	60	20
S_2	15	65	20
S_3	10	70	20
S_4	5	75	20
C	0	80	20

proportion, the ingredients were manually placed in disposable plates for sensory evaluation.

Sensory evaluation of the salads

Sensory evaluation of the prepared salads was performed using a 9 point hedonic scale testing using 35 semi trained panelists. The evaluation utilized a hedonic scale ranging from 1, indicating 'dislike extremely', to 9, representing 'like extremely'. The sensory evaluation of salads was used to evaluate the sensory attributes appearance, aroma, texture, taste and overall acceptability.The sensory evaluations were conducted in an environment with regulated temperature and lighting. Five salad samples were provided to each evaluator. The samples were presented in white disposable cups, each marked with a randomized three-digit code. To prevent flavor carry over, panelists were instructed to consume water and cleanse their palate between tasting different samples.

Statistical analysis

Statistical analysis was performed using non parametric Kruskalwallis test to determine significant differences between treatments using GRAPES1.1.0 software.

The comprehensive sensory evaluation data results displayed in Table 2 systematically documents the sensory panelists responses to multiple organoleptic attributes across all experimental salad formulations, providing the analytical foundation upon which the most appealing *Hultholia mimosoides* incorporated salad treatment was identified and subsequently selected for further development and recommendation.

Appearance

The appearance attribute evaluation revealed significant visual differences among the salad formulations, with the *Hultholia mimosoides* flower incorporated treatments exhibiting enhanced chromatic appeal,

Fig. 1. *Hultholiamimosoides* flowers

particularly sample S_3 which received the highest mean scores due to its balanced color contrast between the vibrant purple cabbage and the distinctive floral elements compared to control sample devoid of the flowers.

Aroma

The aroma attribute assessment demonstrated notable olfactory distinctions among the salad treatments, with the *Hultholia mimosoides* flower incorporated formulations presenting a uniquely pleasant fragrance profile. Sample S_3, containing the optimal 10:70 ratio of flowers to purple cabbage, received superior ratings (9) for its harmonious aromatic balance, which effectively combined the subtle floral notes with the characteristic fresh vegetable scents, creating an inviting sensory experience that appealed strongly to the evaluating panelists.

Texture

The texture attribute evaluation of the prepared salad formulations revealed significant tactile differences among treatments, with the *Hultholia mimosoides* flower incorporated samples demonstrating enhanced textural complexity. Sample S_3 with its 10:70 ratio of flowers to purple cabbage achieved the highest texture scores (9) due to its optimal balance of crispness and tenderness. Panelists particularly appreciated the textural contrast created by the delicate flower petals interspersed among the firmer cabbage components, which provided a multi-dimensional mouthfeel that enhanced the overall eating experience without compromising structural integrity during consumption.

Taste

The taste attribute analysis revealed pronounced flavor distinctions among the salad formulations, with *Hultholia mimosoides* flower added treatments demonstrating exceptional taste profiles. Sample S_3, featuring the 10:70 ratio of flowers to purple cabbage, garnered the highest taste scores (9) from panelists who particularly valued its well-balanced flavor complexity. The distinctive tangy notes contributed by the *Hultholia mimosoides* flowers complemented the mild peppery undertones of the purple cabbage, creating a harmonious taste experience that avoided overwhelming bitterness while providing sufficient flavor intensity to engage the palate. This optimal flavor equilibrium distinguished S_3 from other treatments and substantially contributed to its overall sensory superiority.The control sample garnered the lowest score (6.2) for taste attribute assessment, primarily due to the absence of *Hultholia mimosoides* flowers which resulted in a noticeably less complex flavor profile.

According to Figure 2, Sample S_3 scored highest mean value of (9) for all the attributes among all the samples and control sample scored the lowest score (6.3) for overall acceptability. The research conducted by Mleck *et al*. (2021) examines edible flowers for gastronomic purposes by assessing their organoleptic properties as well as taste and total impression. Flower appearance along with their colors shapes consumer buying habits. The fragrance of salads was evaluated in all samples as pleasant with various levels of intensity. Sample S_3 was identified as the salad formulation with the most pleasant scent (9) liked extremely by the panelists, because the scale ranged from liked extremely (=9) through neither like or dislike (=5) to dislike extremely (=1). Buds of the flowers will be odorless, hence only fully ripened blossoms were collected. The other salad formulations were rated from 6.8, 7.7, 8.2, corresponding to a lower intensity scent. Research by Mleck *et al*., (2021) concluded that edible flowers can serve as a natural source for food supplements loaded with bioactives.

A study by Simoni *et al*., (2018) analyzed the salad acceptance of edible flowers through a study conducted with 35 participants. The

Table 2. Sensory evaluation of salads **n=35**

Sl.No	Appearance	Aroma	Texture	Taste	Overall acceptability
S_1	8.6^{b}	7.8^{c}	7.7^{c}	6.9^{d}	7.7^{c}
S_2	8.6^{b}	7.8^{c}	8.2^{b}	7.8^{c}	8.1^{cb}
S_3	9.0^{a}	9.0^{a}	9.0^{a}	9.0^{a}	9.0^{a}
S_4	8.1^{c}	8.6^{b}	8.2^{b}	8.6^{b}	8.4^{b}
C	6.3^{d}	6.1^{d}	6.8^{d}	6.2^{d}	6.3^{d}
χ^2value	131.5	144.810	132.390	142.919	142.862
p value	0.00	0.00	0.00	0.00	0.00

acceptance criteria for edible flowers in salads consist of color, texture, aroma, and overall aspects but flavor remains the only trait that leads to rejection. The research also stated that people accept edible flowers yet they will not respond unless detailed information about the flowers and different dish options are provided.

Food sensory attributes play a fundamental role for both consumer markets and production centers due to their strong relationship with product quality metrics and user acceptance levels. (Jadhav *et al*., 2023).The field of sensory science shows rising interest in edible flower preferences yet most research has been performed without professional panel evaluation techniques. Edible flowers possess high perishability linked to transpiration and respiration processes which create primary factors for both quality decline and post-harvest losses. The metabolic rate of fresh flowers together with shelf life duration depends heavily on temperature because it affects the natural breakdown processes of harvested flowers(Demasi *et al*., 2021; Bhat *et al*., 2023).

The unique color, appearance, and flavor of edible flowers in culinary cuisines make them valuable for specific dishes. But they may also include harmful compounds like alkaloids and

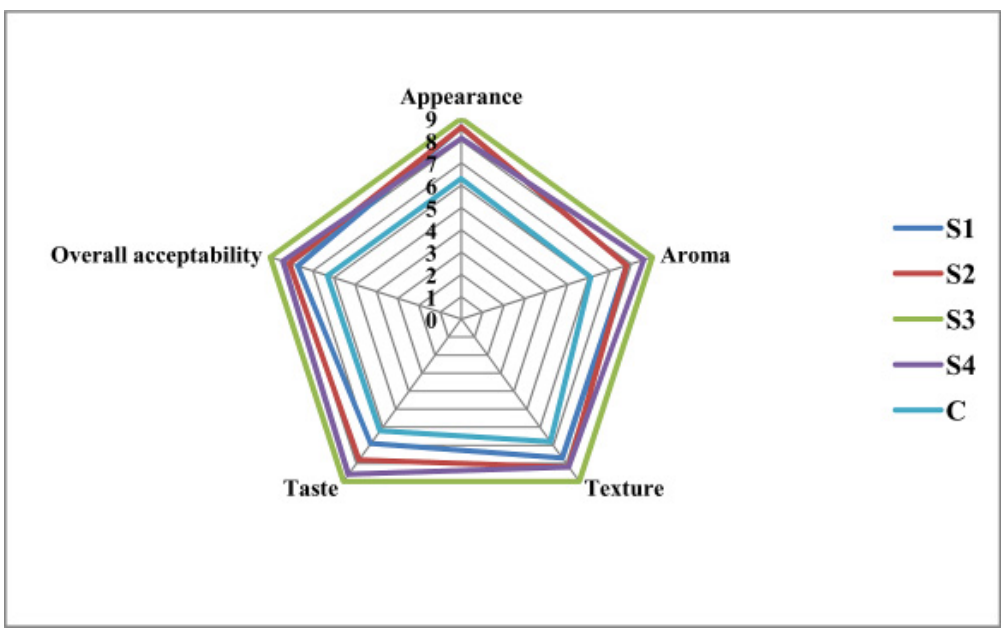

Fig. 2. Sensory evaluation of salads

anti-nutritional elements that might disrupt the metabolism or absorption of nutrients. There is lacking data on the application and appropriate dosages of edible flowers.

The study proves that *Hultholia mimosoides* flowers supply a nutritious salad option which provides marketable taste and visual value. The unique visual appeal of these flowers also brings out a natural tangy flavor which makes vegetable salads more enjoyable to the senses. The combination of *Hultholia mimosoides* flowers to purple cabbage in a ratio of 10:70 resulted in the highest sensory judgment scores for all considered attributes and it brings new nutritional variety to regular meals. Appearance and aroma of the salads can impact the liking of *Hultholia mimosoides* flowers, purple cabbage and peanut salad without causing any aversion. These neglected floral resources enable a connection between consumers and traditional food components. The investigation validates *Hultholia mimosoides* flowers as a valuable food ingredient which meets requirements of aesthetic appeal, nutritional excellence and authentic flavor in contemporary culinary development.

REFERENCES

Bhat, P., Patil, V. S., Anand, A., Bijjaragi, S., Hegde, G. R., Hegde, H. V., & Roy, S. 2023. Ethyl gallate isolated from phenol-enriched fraction of *Caesalpinia mimosoides Lam.* Promotes cutaneous wound healing: A scientific validation through bioassay-guided ractionation. Frontiers in Pharmacology, *14*, 1214220. https://doi.org/10.3389/fphar.2023.1214220

Demasi, S., Mellano, M.G., Falla, N.M., Caser, M. and Scariot, V. 2021. Sensory profile, shelf life, and dynamics of bioactive compounds during cold storage of 17 edible flowers. Horticulturae, *7*(7), p.166.

Domínguez-Domínguez, A., Herrera-Corredor, J.A., Argumedo-Macias, A., de Jesus Ramirez-Rivera, E., López-Aranda, E., Romero-Cruz, A. and López-Espíndola, M. 2021. Amaranth microgreens as a potential ingredient for healthy salads: Sensory liking and purchase intent. Agro Productividad, *14*(4).

Jadhav, H.B., Badwaik, L.S., Annapure, U., Casanova, F. and Alaskar, K. 2023. A review on the journey of edible flowers from farm to consumer's plate. Applied Food Research, *3*(2), p.100312.

Mlcek J, Plaskova A, Jurikova T, Sochor J, Baron M, Ercisli S. 2021 Chemical, Nutritional and Sensory Characteristics of Six Ornamental Edible Flowers Species. Foods. 31;10(9):2053. doi: 10.3390/foods10092053. PMID: 34574164; PMCID: PMC8472405.

Mlcek, J., Plaskova, A., Jurikova, T., Sochor, J., Baron, M. and Ercisli, S. 2021. Chemical, nutritional and sensory characteristics of six ornamental edible flowers species. Foods, 10(9), p.2053.

Rangsinth, P., Prasansuklab, A., Duangjan, C., Gu, X., Meemon, K., Wink, M. and Tencomnao, T. 2019. Leaf extract of *Caesalpinia mimosoides* enhances oxidative stress resistance and prolongs lifespan in *Caenorhabditis elegans*. BMC complementary and alternative medicine, *19*, pp.1-13.

Simoni, N.K., Santos, F.F., Andrade, T.A., Villavicencio, A.L.C. and Pinto-e-Silva, M.E.M. 2018. The use of edible flowers in human food: sensory analysis of preparations. Int. J. Food Eng, *4*(2), pp.140-143.

Shruthi, P. and Divakar, S. 2025. Sensory Evaluation of Salads incorporated with Edible Blooms of *Hultholia mimosoides*. The Journal of Research ANGRAU, 53(3): 127-131

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AWARENESS AND USE OF ECO-FRIENDLY ELECTRONIC GADGETS- AN ANALYSIS

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Eco-friendly products, often referred to as “green” or “environment-friendly,” are characterized by their biodegradability, low carbon footprint and minimal adverse effects on both people and the planet.The prevalent presence of electronics has become a cornerstone of modern life, with a constant influx of new gadgets designed to enhance convenience and enjoyment. However, this technological boom comes with a significant environmental cost. The manufacturing and disposal of electronic devices pose substantial risks, primarily due to the hazardous materials they contain. This not only impacts the environment but also presents a serious threat to human health. In response to these challenges, eco-friendly electronic gadgets are gaining traction in the global effort to combat climate change and reduce greenhouse gas emissions (Brough,2016). Governments worldwide are supporting this transition by promoting renewable energy sources like solar and wind power, pricing carbon emissions and implementing policies to lower overall greenhouse gas output (McNeely, 2021). This research aims to assess the level of awareness and usage of eco-friendly electronic gadgets among consumers. Specifically, this study seeks to determine the extent of respondents’ awareness regarding these gadgets and identify the key barriers preventing their wider adoption.

A descriptive research design was employed for this study, which was conducted during 2024 in Vadodara, Gujarat. The objective was to assess the awareness and usage of a specific set of eco-friendly electronic gadgets. The research population was comprised of 722 respondents (323 male and 397 female) who were selected using a cluster sampling technique. Data was collected via a structured questionnaire that included questions on a range of eco-friendly electronic gadgets.

To analyze the relationship between awareness and usage with personal variables (age, academic background, occupation, and monthly income), relational statistics were applied. Specifically, ANOVA was used to determine if there were statistically significant differences in knowledge and usage among different personal variable groups. An independent samples t-test was also conducted to compare the differences in knowledge and usage between male and female respondents.Further, categorization of respondents into Low, Moderate and High was based on class interval range.

Profile of Respondents

The demographic analysis of the 722 respondents revealed a diverse but distinct profile. The average age was 46 years. A closer

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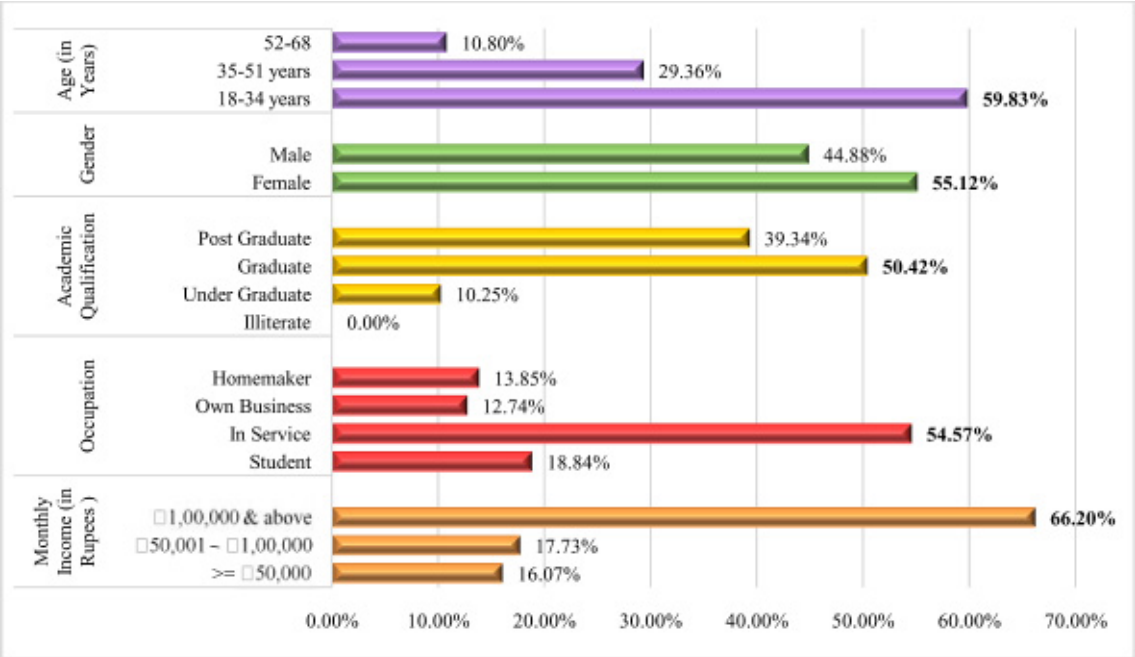

Fig.1. Background Information of the respondents

examination of the generational distribution showed a strong representation of older generations: Baby Boomers constituted the largest group at 31%, followed by Millennials at 28% and Generation X at 27%. This demographic breakdown suggests a prevalence of older consumers, who may possess greater financial stability to invest in sustainable products and have a longer-term perspective on environmental issues. However, an apparent contradiction was observed in the data, as 59.83% of the respondents were in the 18-34 age group. In the gender section, females accounted for 55.12% of the respondents. In terms of educational background, half of the respondents (50.42%) were graduates. The majority of respondents were professionally employed, with 54.57% engaged in service-oriented occupations. Moreover, more than three - fifth (66.20 per cent) of the respondents had their family monthly income Rs.1,00,001 & above.

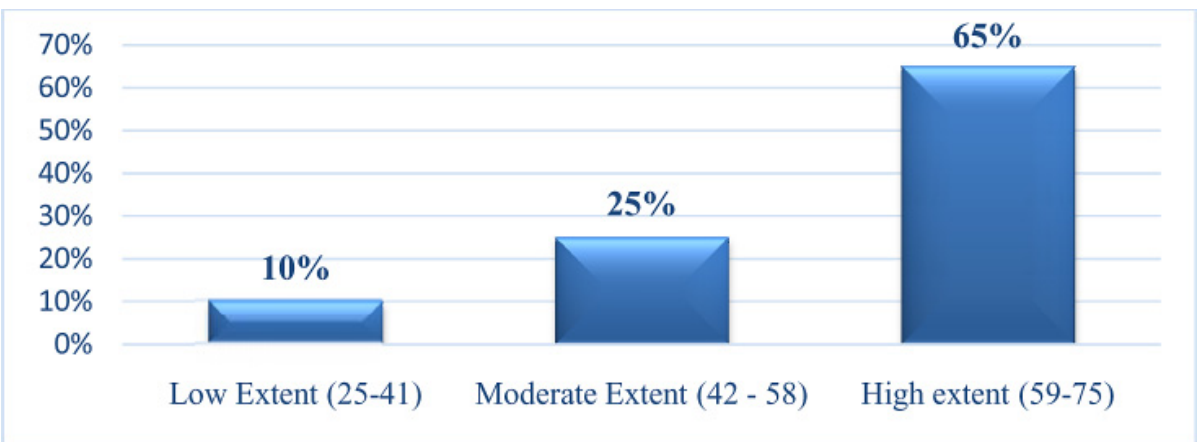

Fig. 2: Extent of Awareness of the Respondents regarding Eco-Friendly Electronic Gadgets

Extent of Awareness of the Respondents regarding Eco-Friendly Electronic Gadgets

The data in the present study revealed that 65 per cent of the respondents had high extent of awareness regarding Eco-Friendly Electronic Gadgets, followed by 25 per cent of the respondents with Moderate extent of awareness and 10 per cent of respondents had Low extent of awareness regarding Eco-Friendly Electronic Gadgets.

Extent of Usage of Eco-Friendly Electronic Gadgets

The results of the current study also showed that 10.80 percent of respondents exclusively used eco-friendly electronic gadgets to a high level, while 16.62 per cent of respondents used them to a moderate amount. The vast majority of respondents (72.57 per cent) reported using eco-friendly electronic gadgets to low extent. This demonstrates that even while individuals are aware of the product, there are still certain circumstances that contribute to its extremely low utilization. Finding the causes is necessary in order to provide remedies that will encourage more people to use these items.

According to Table 1, the F-value computation revealed a significant variation (α=0.01) in the respondents' level of awareness about eco-friendly electronic gadgets with their age, academic background, accupation and monthly income, as well as a significant variation (α=0.05) in the respondents' level of awareness regarding eco-friendly electronic gadgets with regard to their occupation. Hence, it can be inferred that Extent of Awareness of the respondents regarding Eco-Friendly Electronic Gadgets varied with their Age, Gender, Academic Background, Occupation and Monthly Income.

Examining gender disparities offers a distinctive viewpoint for elucidating the variations in green consumption patterns among individuals. Presently, majority of studies have examined green consumption from the perspectives of consumer attitude, psychological ownership, moral identity and other relevant aspects (Wang, 2019). Based on the statistical analysis, significant differences in awareness of eco-friendly electronic gadgets were observed across several demographic variables. In category of age group, 52 to 68 years age group showed a significant difference in awareness (α=0.01 *et al*). In terms of academic qualification, postgraduates demonstrated significantly different levels of awareness compared to both undergraduates and graduates (α=0.01). When examining occupation, homemakers' awareness levels were found to be significantly different from those in other occupations (α=0.05). Furthermore, respondents with a monthly income of Rs. 50,000 or less exhibited significantly different awareness levels than those with incomes of Rs. 50,001 to Rs. 1,00,000 and Rs.1,00,000 and above

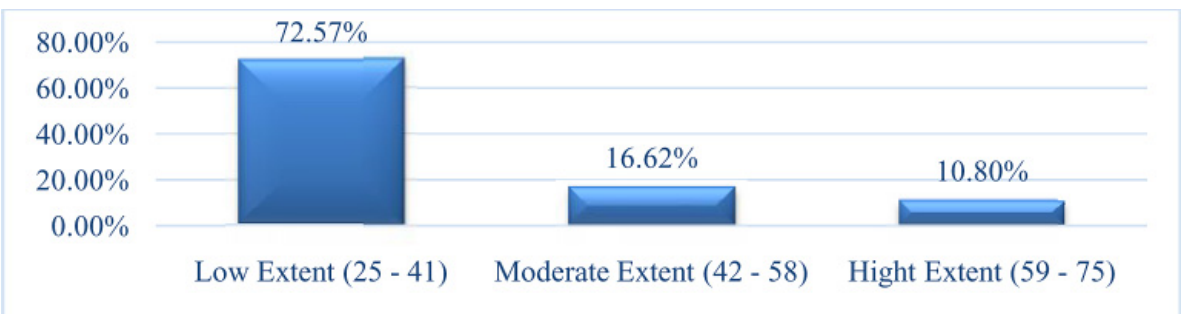

Fig. 3: Extent of Usage of respondents regarding Eco-Friendly Electronic Gadgets

Table 1. Analysis of variance showing variation in the extent of Awareness of the Respondents regarding Eco-Friendly Electronic Gadgets with their personal variables

Selected variables	df	Sum of squares	Mean of squares	F-value	Level of significance
Extent of Awareness of the respondents regarding Eco-Friendly Electronic Gadgets					
Age (inYears)					
Between groups	2	726	363	4.79	0.01
Within groups	719	54464.29	75.75		
Academic Qualification					
Between groups	2	3414.82	1707.41	23.71	0.01
Within groups	719	51775.46	72.01		
Occupation					
Betweengroups	3	913.88	304.62	4.02	0.05
Within groups	718	54276.41	75.59		
Monthly Income(inRs.)					
Between groups	2	6392.51	3196.25	47.09	0.01
Within groups	719	48797.77	67.86		

(α=0.01). These findings suggest that personal factors play a crucial role in shaping an individual's perception of eco-friendly technology.

According to Baker and Ozaki (2008), gender cannot be ignored because it was a significant factor in the psychological differences that affected green consumption. Additionally, gender equality and the various social stigmas that men and women face have a significant impact on their green consumption and other pro-environmental behavior. According to the t-value calculation, female respondents' knowledge of eco-friendly electronic gadgets differed from that of male respondents (Table 2).

Analysis of Variance (ANOVA) was computed to test the variation of the extent of usage of Respondents towards Eco-Friendly Electrical Gadgets varies with their personal Variable (Age,Academic Background, Occupation and Monthly Income). The

Table 2. t- test showing variation in the extent of awareness of the respondents regarding Eco-Friendly Electronic Gadgets with their personal variables (Gender).

Selected Variables	Mean	df	Level of Significance
Gender			
Male	37.16	700	0.01
Female	38.29		

computation of F-value (Table 4) showed significant variation (α=0.01) in extent of Extent of usage of the respondents regarding Eco-Friendly Electronic Gadgets with the age, academic background and monthly income and (α=0.05) in extent of awareness of the respondents regarding Eco-Friendly Electronic Gadgets with the occupation. Hence, according to table 4, it can be inferred that extent of usage of the respondents regarding Eco-Friendly Electronic Gadgets varied with their age, academic background, occupation and monthly income.

According to Tischner and Hora (2019), the requirement for environmentally friendly electrical device design stems from consumer demand and may be met by investigating eco-friendly alternatives.Significant differences in the usage of eco-friendly electronic gadgets were identified across various demographic categories (Table 3). The analysis revealed that respondents between the ages of 52 and 68 years showed a significant difference in usage compared to other age groups (α=0.01). With regard to academic qualification, undergraduates demonstrated a significantly different extent of usage than both postgraduates and graduates (α=0.01). For occupation, homemakers' usage levels were found to be significantly different from those in other occupations (α=0.05). Furthermore, as stated by Hicks-Webster(2021), at the lowest incomes, there is the basic challenge of affording things. Because people think buying green costs more, they are less likely to splurge for it on a tight budget. Respondents with a monthly income of Rs. 50,000 or less exhibited significantly different usage patterns than those with incomes of Rs. 50,001 to Rs.1,00,000 and Rs.1,00,000 and above (α=0.01). This suggests that personal factors, including age, education, occupation, and

Table 3. Analysis of variance showing variation in the extent of Usage of Eco-Friendly Electronic Gadgets with their personal variables.

Selected variables	df	Sum of squares	Mean of squares	F-value	Level of significance
Extent of Usage of the respondents regarding Eco-Friendly Electronic Gadgets					
Age (inYear)					
Between groups	2	3902.66	1951.33	11.38	0.01
Within groups	719	123246.60	171.41		
Academic Qualification					
Between groups	2	5564.73	2782.36	16.45	0.01
Within groups	719	121584.54	169.10		
Occupation					
Between groups	3	1779.78	393.26	3.39	0.05
Within groups	718	125639.49	174.60		
Monthly Income(inRs.)					
Between groups	2	12023.09	6011.54	37.54	0.01
Within groups	719	115126.18	160.11		

Table 4. t-test showing difference in the extent of Usage of Eco-Friendly Electronic Gadgets with their Gender.

Selected Variables	Mean	df	Level of Significance
Gender			
Male	37.97	699	0.01
Female	38.79		

income, are all critical determinants of eco-friendly gadget adoption.

Green consumption practices are strongly associated with femininity and are embodied by feminine characteristics. Competence and ambition, on the other hand, are less associated with male traits like energy conservation and carbon consumption reduction (Brough *et al.,* 2016). According to Nanggong and Bandu (2018), Males possess less Active attribute towards green consuming behavior as compared to women. The computed t-value revealed that the extent of usage of eco-friendly electronic gadgets differed among male and female (Table 4). This gender discrepancy highlights a gap between awareness and adoption, indicating underlying barriers to usage. Statistical analysis showed that awareness of respondents regarding eco-friendly electronics Gadgets differed significantly with age, education, income (α=0.05), and occupation (α=0.01). These results confirm that demographic factors play important role in both awareness and adoption of eco-friendly electronics. The study underscores the urgent need for targeted promotional strategies to encourage wider adoption of eco-friendly electronics gadgets.

REFERENCES

Brough, A., James, W., Jingjing, M., Isaac, M. and Gal, D. 2016. Is Eco-Friendly Unmanly? The Green-Feminine Stereotype and Its Effect on Sustainable Consumption. Journal of Consumer Research, 43. ucw044. 10.1093/jcr/ucw044.

Hicks-Webster, C. 2021. To sell green products, target the middle class. Network for Business Sustainability (NBS). https://nbs.net/to-sell-green-products-target-the-middle-class/

McNeely, J. A. 2021. Nature and COVID-19: The pandemic, the environment, and the way ahead. Ambio, 50(4), 767–781. https://doi.org/10.1007/s13280-020-01447-0

Nanggong, A., Bandu R. 2018. Gender differences of sustainable consumer behavior in technology adoption: evidence from Indonesia. J. Int. Conf. Proc, 1 1–10. 10.3253/jicp.v1i2.267

Tischner, U. and Hora, M. 2019. Sustainable Electronic Product Design. In Waste Electrical and Electronic Equipment (WEEE) Handbook, edited by Vannessa Goodship, AbStevels, Jaco Huisman, 443 – 482. doi:10.1016/B978-0-08-102158-3.00017-3.

Wang, Ahmad, F., Abdullah, Z. and Magsi, N. 2019. TrZust and Consumers' Purchase Intention in a Social Commerce Platform: A Meta-Analytic Approach. SAGE Open, 12. 1-15. 10.1177/215824402210912

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