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Improving the quality and shelf-life of chevon meatballs by incorporating fruit and fruit by-products

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ABSTRACT

In this study the anti-oxidant and antimicrobial effect of fruit, viz. starfruit (*Averrhoa carambola*) and guava (*Psidium guajava*) and fruit by-product, viz. watermelon (*Citrullus lanatus*) rind were studied to evaluate the quality and shelf-life of chevon meatballs. The fruit and fruit by products were incorporated in the meatball mixture in dry powder form at the rate of 1.0%, 1.5% and 2.0% based on w/w basis. In addition, the effect of these powders on the physico-chemical characteristics, textural profile and sensory attributes were also analyzed. For storage studies, the product was stored at refrigeration temperature (4±1°C) for a period of 21 days. The treated samples had a significantly lowered values for Thiobarbituric Acid Reacting Substances (TBARS) and an improved microbiological quality. Effect of fruit and fruit by-product powder on the proximate parameters, physico-chemical characteristics and textural profile attributes of the chevon meatballs was significant but with a few exceptions. The treated products, compared to control, had better physico-chemical properties, desirable textural properties and enhanced sensorial characteristics. These attributes together indicated that starfruit powder, guava powder and watermelon rind powder can be added to chevon meatball mixtures to create products which not only have better quality and acceptability but an improved shelf-life and has the potential to perform as a functional food.

Keywords: Chevon meatball, Guava powder, Physico-chemical characteristics, Shelf-life, Starfruit powder, Textural profile analysis, Watermelon rind powder

In today's era, meat represents as an essential part of human diet. It has high moisture content and is composed of proteins, fats, substantial quantities of vitamins and minerals of high degree of bioavailability. Due to this very composition, meat under normal storage conditions, is most prone to bacterial spoilage and oxidative deterioration (Fung 2010). For the objective of preservation, the meat industry is highly dependent upon synthetically derived antimicrobials and anti-oxidants. Consumption of such chemicals for prolonged periods of time is hazardous thus consumers are actively in search of natural alternatives which contain bio-active or functional components which would not only preserve the food but will also give additional benefit to their health status. Moreover, number of epidemiological studies has established that natural anti-oxidants greatly reduce the health risks usually associated with cardio-vascular diseases and cancer (Temple 2000).

Nature has immense potential and we require continuous exploration and efforts to manifest its magnificence in our lives. It is an established fact that agricultural co-products and by-products are rich in natural antioxidants and anti-microbials (Balasundram *et al.* 2006, Tiwari *et al.* 2009). In the past, various experiments have been conducted with the objective of using fruit and fruit by-products as preservatives. A variety of foods have been developed by incorporating fruit fibers into meat products (Fernandez-Lopez *et al.* 2008 & Sanchez-Zapata *et al.* 2010), bakery products (Martinez-Cervera *et al.* 2011) and dairy products (Sendra *et al.* 2008). In case of meat products, studies indicating the efficiency of starfruit, guava and watermelon rind powders as anti-oxidant and anti-microbials for chevon based products are very limited.

This study was conducted with the objective of evaluating the anti-oxidant and anti-microbial effect of starfruit powder (SFP), guava powder (GP) and watermelon rind powder (WRP) on cooked chevon meatballs stored under refrigerated (4±1°C) temperature. The quality characteristics comprising of proximate parameters, physico-chemical characteristics, textural properties and sensory attributes of the meatball mixture as well as the cooked meatballs were also studied.

MATERIALS AND METHODS

Fruits were purchased from the local market. These were thoroughly washed, cleaned and dried. For starfruit and

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guava, the fruits were transversely cut into thin slices whereas for watermelon rind the white part underlying the rind was removed and then the rind was cut into small thin slices. These were then spread on individual trays, placed in a hot air oven at 47±2°C and dried for a period of approximately 24 h. The dehydrated fruit slices were then ground to a fine powder using a laboratory mill and sieved through a fine mesh. This powdered sample was then packed and preserved in UV sterilized Low Density Polyethylene (LDPE) containers at –18±1°C, until further use.

Meatball preparation was carried out as per the methodology established by Kumar (2001), with slight modification. Fresh lean chevon samples were purchased from slaughter houses run by the Kolkata municipal slaughter house, West Bengal. The mincing of meat was practiced in two segments, firstly the meat was minced by a 10 mm plate and then it was minced using a 5 mm plate. The minced meat was divided into three sets, one each for treatment with starfruit powder (SFP), guava powder (GP) and watermelon rind powder (WRP), respectively. The ingredients required for meatball preparation were procured from the local market. A dry spice mix powder was prepared by mixing all the ingredients in a fixed proportion, and then it was dried at 50°C for 4 h in a hot air oven. These dried spices were then ground into a fine powder. A condiment mixture containing garlic, ginger and onions in the proportion of 1:1:3 was prepared by grinding all into a smooth paste. Only food grade quality chemicals were used in the preparation of these meatballs.

The minced chevon from each set was mixed with rest of the ingredients in proportions as mentioned in Table 1.

Table 1. Meatball formulation

Ingredients (%)	Treatment			
	C	S1/G1/W1	S2/G2/W2	S3/G3/W3
	(%)	(%)	(%)	(%)
Fruit powder	0	1.0	1.5	2.0
Minced leanchevon	70	69	68.5	68.0
Salt	1.6	1.6	1.6	1.6
Tripolyphosphate	0.3	0.3	0.3	0.3
Ice flakes	8.70	8.70	8.70	8.70
Sugar	0.3	0.3	0.3	0.3
Sodium nitrite	0.015	0.015	0.015	0.015
Rice bran oil	7.0	7.0	7.0	7.0
Dry spice powder	1.8	1.8	1.8	1.8
Egg albumin	1.285	1.285	1.285	1.285
Condiment mixture	4.0	4.0	4.0	4.0
Refined wheat flour	3.0	3.0	3.0	3.0

S1, Treatment containing 1.0% startfruit powder; W1, treatment containing 1.0% watermelon rind powder; G1, treatment containing 1.0% guava powder; S2, treatment containing 1.5% starfruit powder; W2, treatment containing 1.50% watermelon rind powder; G2, treatment containing 1.50% guava powder; S3, treatment containing 2.0% startfruit powder; W3, treatment containing 2.0% watermelon rind powder; G3, treatment containing 2.0% guava powder.

For each fruit powder, four batches of meatball mixtures were prepared namely the control batch (C), treatment 1 namely S1 for starfruit powder, G1 for guava powder and W1 for watermelon rind powder. For treatment 2, S2 for starfruit powder, G2 for guava powder and W2 for watermelon rind powder and treatment 3, S3 for starfruit powder, G3 for guava powder and W3 for watermelon rind powder. Twenty five grams of this mixture was then molded manually into balls using a metal shaper having both diameter and thickness of 3.5 cm (Serdaroglu *et al.* 2004). The balls were placed in metal containers and steam cooked at 121°C temperature for 20 min under a pressure of 6.8 kg. (Kumar *et al.* 2013).

In order to determine the anti-oxidant effect of fruit powders on cooked meatballs, TBRAS values, i.e. Thiobarbituric Acid Reacting Substances were determined as per procedure established by Tarladgis *et al.* (1960) whereas for analyzing the anti-microbial effect of the fruit powders on meatballs, yeast and mould count (YMC), total coliform count (TCC), total psychrotrophic count (TPSC) and total plate count (TPC) were conducted. All the samples were stored at refrigerated (4±1°C) temperature and the analysis was made on 0, 3rd, 7th, 14th and 21st day of storage. Microbiological analysis was carried out in readymade media supplied by Hi-Media Laboratories Ltd., Mumbai and the procedures followed were in accordance with the standards as established by APHA (2001). Each and every plate was replicated four times and the counts were expressed as colony forming units (cfu) per gram.

The proximate parameters, viz. percentage moisture, crude protein, fat and ash were determined by methods described by AOAC (2001). The pH was recorded using a digital pH meter following the methodology as explained by Troutt *et al.* 1992. Whereas the % cooking yield (Murphy *et al.* 1975), % fat retention, % moisture retention (El-Magoli *et al.* 1996), and % shrinkage (Adams 1994) of the cooked meatball were calculated by standard equations. Standard procedure established by Kondaiah *et al.* (1985) was followed to determine the emulsion stability of the meatball mixture. Texture profile analysis was conducted on day zero of meatball processing, using the procedure described by Bourne (1978) using a TA-HDi Texture Analyzer (Stable Micro Systems, UK).

Sensory evaluation of the product was carried out only for day zero. Using rice-bran oil the samples were deep fried at a 150–160°C. They were cooked till an internal temperature of 65°C was attained; in between they were turned upside down until the desired brown color developed. A panel of seven judges evaluated the product for different quality attributes using an eight point hedonic scale, where 8 denoted extremely desirable and 1 unacceptable. Sensory evaluation for the product was conducted only for day zero.

For this study, the experiments were conducted in six sets and each set was replicated four times making n=24. The data obtained during the trials were statistically analyzed using SPSS-24® software package. For analyzing microbial counts and the TBARS values the data were evaluated and interpreted using a two-way ANOVA with interaction, taking storage time and treatment as main effects. Rest of the quality characteristic attributes, apart from sensory evaluation were evaluated using one-way ANOVA. To compare means, Duncan's multiple range test (Duncan 1955) was adopted. For the data concerning different criteria of sensory evaluation, The Kruskal-Wallis H test (Kruskal *et al.* 1952) was adopted. All the interpretations were expressed as mean along with standard error (Mean±SE) and a probability value of P<0.05 was described as significant.

RESULTS AND DISCUSSION

Table 2 represents the TBARS values indicating the effect of SFP, GP and WRP on the rate of lipid oxidation for both control and fruit powder treated cooked meatballs stored at refrigerated (4±1°C) temperature. Similarly Table 3 indicates the microbial plate count values for fruit powder treated chevon meatball samples, cooked and stored at refrigerated (4±1°C) temperature. Both the TBA and microbial plate count values were recorded on 0, 3, 7, 14 and 21 of storage. The results obtained were statistically significant (P<0.05) and with each passing day there was a significant increase (P<0.05) in values.

On studying the TBARS values as depicted in Table 2, it can be noted that on day zero no significant difference (P>0.05) was observed between the control and the treated samples. With passage of time, the TBARS values increased and a significant difference (P<0.05) was observed between the control and the treated samples. According to Georgantelis *et al.* (2007), meat sample exhibits rancid flavor when MDA concentration rises above 0.6 mg/kg and after reaching a threshold limit of 2 mg/kg, it is considered as spoilt (Verma and Sahoo 2000). Addition of SFP, GP and WRP to the meatball mixture resulted in decrease of MDA production. When compared to control, addition of fruit powder at the rate of 1.0%, 1.5% and 2.0% decreased the levels of MDA production by 9.62%, 14.30% and 19.24%, respectively for SFP; for GP the reduction was 8.82%, 11.69% and 17.23%, respectively and for WRP, it was 6.61%, 11.02% and 16.03%, respectively. The trend observed was in the order:

SFP2.0% > GP 2.0% >SFP 1.50% > GP1.50% > SFP1.0% > GP 1.0% > WRP 2.0% >WRP 1.50% >WRP 1.0%

Similar reduction trends were observed by Verma *et al.* (2013) who added guava powder as an anti-oxidant to mutton nuggets; Das *et al.* (2014) who added bael pulp residue as an anti-oxidant to chevon nuggets; rind of kinnow and pomegranate and seed of pomegranate was added to goat patties by Devatkal *et al.* (2010) and starfruit juice was added as an anti-oxidant agents to pork nuggets by Thomas *et al.* (2016). The anti-oxidant effect of SFP, GP and WRP is due to the presence of dietary fibers (Nakhaen *et al.* 2001 and Al-Sayed *et al.* 2013), phenolic compounds (Guanghou *et al.* 2004 and Mien *et al.*) and ascorbic acid (Charles *et al.* 2006). Moreover starfruit is rich in epicatechins, gallic acid, caramboflavone and pro-anthocyanins (Lim and Lee 2013), whereas guava is rich in myricetin, apigenin (Miean *et al.* 2001), ellagic acid and anthocyanins (Misra *et al.* 1968) and watermelon rind contains citrulline (Leong *et al.* 2002 and Lewinson *et al.* 2005). These compounds together reduce the lipid oxidation and free radical formation hence improving the product's anti-oxidant abilities.

When the bacterial load of surface of the meat samples attain a range of 7 log10 cfu/g the defects related to microbial spoilage become evident and the sample is considered to be spoilt. Phyto-ingredients are known to have anti-microbial effect and significant difference (P<0.05) was observed in the plate counts of the control and the treated samples. Based on TPC, TPSC, TCC and YMC values both the control and the treated meatball samples were un-spoilt till 21 days of refrigerated (4±1°C) storage. On day zero the TPC,TPSC, TCC and YMC values both the control and the treated meatball samples of cooked chevon meatballs

Table 2. Thiobarbituric Acid Reacting Substances (TBARS) values of control and treated samples stored at refrigerated (4±1°C) temperature (mg mda/kg)

TBARS values for starfruit, guava and watermelon rind treated chevon meat balls					
Treatment	Storage days				
	Day 0	Day 3	Day7	Day 14	Day 21
C	$0.322{\pm}0.017^{eA}$	$0.509{\pm}0.017^{dA}$	$0.647{\pm}0.013^{cA}$	$1.058{\pm}0.015^{bA}$	$1.325{\pm}0.019^{aA}$
S1	$0.313{\pm}0.016^{eB}$	$0.441{\pm}0.016^{dD}$	$0.53{\pm}0.016^{cD}$	$0.747{\pm}0.018^{bE}$	$1.208{\pm}0.02^{aB}$
S2	$0.315{\pm}0.016^{eB}$	$0.382{\pm}0.015^{dG}$	$0.473{\pm}0.016^{cF}$	$0.674{\pm}0.017^{bG}$	$1.136{\pm}0.02^{aE}$
S3	$0.31{\pm}0.013^{eC}$	$0.334{\pm}0.015^{dH}$	$0.438{\pm}0.02^{cG}$	$0.613{\pm}0.016^{bI}$	$1.063{\pm}0.017^{aF}$
G1	$0.31{\pm}0.015^{eC}$	$0.466{\pm}0.016^{dC}$	$0.555{\pm}0.017^{cC}$	$0.714{\pm}0.018^{bF}$	$1.126{\pm}0.02^{aD}$
G2	$0.315{\pm}0.014^{eB}$	$0.431{\pm}0.017^{dE}$	$0.516{\pm}0.014^{cE}$	$0.672{\pm}0.016^{bG}$	$1.148{\pm}0.013^{aE}$
G3	$0.315{\pm}0.017^{eB}$	$0.38{\pm}0.016^{dG}$	$0.507{\pm}0.014^{cE}$	$0.625{\pm}0.016^{bH}$	$1.041{\pm}0.017^{aG}$
W1	$0.317{\pm}0.015^{eB}$	$0.476{\pm}0.014^{dB}$	$0.611{\pm}0.018^{cB}$	$0.946{\pm}0.016^{bB}$	$1.221{\pm}0.017^{aB}$
W2	$0.325{\pm}0.014^{eA}$	$0.46{\pm}0.015^{dC}$	$0.548{\pm}0.02^{cC}$	$0.917{\pm}0.016^{bC}$	$1.21{\pm}0.018^{aB}$
W3	$0.317{\pm}0.016^{eB}$	$0.417{\pm}0.012^{dF}$	$0.511{\pm}0.017^{cE}$	$0.872{\pm}0.014^{bD}$	$1.172{\pm}0.015^{aC}$

n=24. Data (mean ± SE) with different capital letter superscripts in the same column differ significantly (P<0.05); Data (mean ± SE) with different small letter superscripts in the same row differ significantly (P<0.05).

Table 3. Effect of addition of starfruit powder, guava powder and watermelon rind powder on the microbiological parameters of control and treated samples stored at refrigerated (4±1°C) temperature ($\log_{10}$ cfu/g)

Treatment	Storage days				
	Day 0	Day 3	Day 7	Day 14	Day 21
			Total plate count (TPC)		
C	3.544±0.027^{eB}	3.949±0.022^{dA}	4.45±0.024^{cA}	4.85±0.027^{bA}	5.344±0.025^{aA}
S1	3.649±0.026^{eA}	3.745±0.023^{dB}	3.949±0.027^{cE}	4.651±0.025^{bC}	5.149±0.029^{aC}
S2	3.64±0.026^{eA}	3.744±0.026^{dB}	3.846±0.029^{cF}	4.4352±0.026^{bE}	4.843±0.024^{aE}
S3	3.547±0.024^{eB}	3.745±0.028^{dB}	3.752±0.028^{cG}	4.147±0.026^{bF}	4.743±0.027^{aF}
G1	3.639±0.022^{eA}	3.755±0.026^{dB}	4.145±0.026^{cC}	4.751±0.025^{bB}	5.251±0.026^{aB}
G2	3.548±0.026^{eB}	3.747±0.025^{dB}	3.954±0.024^{cE}	4.647±0.027^{bC}	4.95±0.025^{aD}
G3	3.542±0.028^{eB}	3.74±0.026^{dB}	3.845±0.026^{cF}	4.351±0.027^{bE}	4.851±0.022^{aE}
W1	3.648±0.026^{eA}	3.744±0.029^{dB}	4.251±0.028^{cB}	4.751±0.027^{bB}	5.247±0.027^{aB}
W2	3.452±0.026^{eC}	3.657±0.027^{dC}	4.046±0.025^{cD}	4.649±0.027^{bC}	5.15±0.028^{aC}
W3	3.539±0.027^{eB}	3.742±0.029^{dB}	3.949±0.025^{cE}	4.455±0.027^{bD}	5.047±0.024^{aD}
			Total Psychrotopic Count (TPSC)		
C	1.148±0.026^{eA}	2.541±0.03^{dA}	3.947±0.024^{cA}	4.446±0.028^{bA}	5.147±0.025^{aA}
S1	ND	ND	1.951±0.024^{cF}	3.45±0.027^{bE}	4.653±0.026^{aC}
S2	ND	ND	1.648±0.027^{cH}	3.154±0.025^{bF}	4.245±0.027^{aG}
S3	ND	ND	1.45±0.026^{cJ}	2.948±0.024^{bG}	3.848±0.029^{aH}
G1	ND	1.515±0.024^{dE}	2.348±0.027^{cE}	3.647±0.023^{bD}	4.548±0.026^{aD}
G2	ND	0.945±0.026^{dF}	1.749±0.028^{cG}	2.849±0.027^{bH}	3.445±0.026^{aI}
G3	ND	0.85±0.027^{dG}	1.551±0.029^{cI}	2.25±0.029^{bI}	3.249±0.028^{aJ}
W1	ND	1.751±0.027^{dB}	3.149±0.024^{cB}	4.154±0.025^{bB}	4.748±0.028^{aB}
W2	ND	1.544±0.026^{dC}	2.748±0.025^{cC}	3.942±0.023^{bC}	4.45±0.027^{aE}
W3	ND	1.448±0.027^{dD}	2.446±0.029^{cD}	3.645±0.025^{bD}	4.352±0.025^{aF}
			Total Coliform Count (TCC)		
C	ND	ND	ND	1.549±0.029^{bA}	1.856±0.027^{aA}
S1	ND	ND	ND	ND	1.367±0.019^{aG}
S2	ND	ND	ND	ND	1.345±0.021^{aH}
S3	ND	ND	ND	ND	1.322±0.013^{aI}
G1	ND	ND	ND	ND	1.568±0.021^{aE}
G2	ND	ND	ND	ND	1.552±0.022^{aF}
G3	ND	ND	ND	ND	1.516±0.013^{aG}
W1	ND	ND	ND	ND	1.669±0.019^{aB}
W2	ND	ND	ND	ND	1.647±0.018aC
W3	ND	ND	ND	ND	1.618±0.015^{aD}
			Yeast and Mould Count (YMC)		
C	ND	ND	1.157±0.024^{cA}	1.646±0.027^{bA}	1.848±0.026^{aA}
S1	ND	ND	ND	1.27±0.015^{bG}	1.373±0.015^{aF}
S2	ND	ND	ND	1.256±0.015^{bG}	1.355±0.018^{aG}
S3	ND	ND	ND	1.224±0.011^{bH}	1.328±0.015^{aH}
G1	ND	ND	ND	1.365±0.023^{bE}	1.562±0.025^{aD}
G2	ND	ND	ND	1.358±0.016^{bE}	1.561±0.016^{aD}
G3	ND	ND	ND	1.325±0.015^{bF}	1.530±0.015^{aE}
W1	ND	ND	ND	1.473±0.014^{bB}	1.669±0.015^{aB}
W2	ND	ND	ND	1.455±0.015^{bC}	1.665±0.017^{aB}
W3	ND	ND	ND	1.423±0.015^{bD}	1.627±0.015^{aC}

n=24. ND, Not Detected. Data (mean±SE) with different capital letter superscripts in the same column differ significantly ($P<0.05$); Data (mean±SE) with different small letter superscripts in the same row differ significantly ($P<0.05$).

did not differ significantly ($P>0.05$) but with each passing day, a significant difference ($P<0.05$) was observed. When compared between the treated samples, on day 3 these treatments did not present any significant difference ($P>0.05$), with each passing day the microbial load on the samples increased. When accounted for the same day, a higher concentration of fruit powder was capable of reducing the microbial load more effectively. The fruit powders were capable of inhibiting coliform and yeast and mould growth till 14 and 7 days of refrigeration, respectively. Based on Total Plate Count the extent of anti-microbial action was:

SFP2.0% > GP 2.0% > SFP 1.50% > WRP 2.0% > GP1.50% > WRP 1.50% > SFP1.0% > GP 1.0% > WRP 1.0%

Similar observations were made by Thomas *et al.* (2016) who studied the anti-microbial effect of starfruit juice on pork nuggets, Das *et al.* (2014) who studied the effect of bael pulp residue on TPC and TPSC of goat meat nuggets;

El-Nashi *et al.* (2015) who studied the anti-microbial effect of pomegranate peel on beef sausage and Haryapetan *et al.* (2012) who used pomegranate peel extract as natural anti-microbial agent on chicken liver patties. The anti-microbial property of the phyto-ingredients is either due to high phenolic content, presence of anti-microbial components, lower pH or a combination of any of the above mentioned factors. SFP has a low pH and contains flavones and glycosides (Payal, *et al.* 2012), GP has phenolic compounds (Kamanth *et al.* 2008) as well as high content of ascorbic acid which lowers the pH of the meatball, whereas, WRP has high phenolic compound (Al-Sayed *et al.* 2013). All these components together prolong the lag phase of microbial multiplication and constrict the log phase of microbial growth.

Values indicative of the proximate and physico-chemical parameters of both the control and fruit powder treated meatball mixture (for emulsion stability) as well as for cooked chevon meatballs are presented in Table 4. The values observed were statistically significant ($P<0.05$).

Addition of fruit powder to the meatball mixture in an increasing order of concentration lead to a gradual and significant ($P<0.05$) decrease in the percentage of moisture, protein, fat, moisture retention and cooking yield and a gradual increase in the percentage of ash, along with a few exceptions. For percentage moisture, no significant difference ($P>0.05$) was observed between the SFP treated samples and between 2.0% SFP and 2.0% WRP treated samples. Similarly, for fat percentage, no significant difference ($P>0.05$) was observed between the samples treated with 1.0% GP and 1.0% WRP and 1.0% GP and 2.0% WRP. In case of percentage moisture retention, no significant difference ($P>0.05$) was observed between the samples treated with 1.0% GP and 1.0% WRP; 1.0% SFP and 1.5% WRP and 1.5% SFP and 1.5% WRP. Similarly, the observations made in context to pH, percentage fat retention, percentage shrinkage and emulsion stability were statistically significant ($P<0.05$) but with certain exceptions. Emulsion stability of the meatball emulsion portrayed, no particular trend. For percentage shrinkage, SFP incorporation did not illustrate any particular trend but for GP and WRP the percentage shrinkage SFP decreased with increase in their individual concentrations. The values obtained were statistically significant ($P<0.05$) and also differed significantly ($P<0.05$), except for 1.0% GP and 1.0% WRP and 2.0% GP and 1.0% WRP treated samples. For the samples treated with 1.0% WRP had the highest pH and it was observed that the pH of the product decreased with an increase in fruit powder concentration. The 1.5% WRP treated samples had the best fat retention properties but unlike SFP and GP treated samples, no particular trend was observed for WRP treated samples, whereas, in case of SFP and GP treated chevon meatballs the percentage fat retention increased with increase in fruit powder concentration. These observations were similar to those made by Huda *et al.* (2014), El-Nashi *et al.* (2015), Malav *et al.* (2015) and Vivar-Vera *et al.* (2018), who incorporated

Table 4. Effect of addition of starfruit powder, guava powder and watermelon rind powder on the proximate and physico-chemical parameters of cooked chevon meatballs on fresh weight basis (mean±SE)

Treatment	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	pH	% Moisture retention	% Fat retention	% Cooking yield	Shrinkage %	Emulsion stability
C	63.016±0.658^{a}	16.202±0.019^{a}	12.238±0.650^{a}	2.141±0.114^{i}	6.517±0.054^{b}	61.002±0.699^{a}	89.463±0.119^{c}	96.828±0.311^{a}	3.282±0.104^{d}	95.54±0.141^{bc}
S1	61.954±0.255^{c}	16.066±0.015^{c}	10.997±0.321^{e}	2.599±0.092^{e}	6.117±0.018^{f}	58.887±0.309^{c}	80.777±0.213^{fg}	95.059±0.263^{c}	3.608±0.166^{c}	94.976±0.112^{f}
S2	61.91±0.419^{c}	16.004±0.008^{f}	10.114±0.163^{g}	2.711±0.084^{c}	5.742±0.076^{h}	58.168±0.157^{d}	82.238±0.097^{e}	94.32±0.217^{e}	3.261±0.136^{d}	95.764±0.139^{a}
S3	61.45±0.414^{cd}	15.869±0.011^{i}	9.767±0.325^{h}	2.942±0.07^{ab}	5.447±0.057^{j}	57.189±0.256^{f}	87.533±0.136^{d}	93.366±0.425^{h}	3.57±0.227^{c}	95.61±0.029^{ab}
G1	62.464±0.483^{b}	16.053±0.007^{d}	11.376±0.159^{cd}	2.428±0.107^{f}	6.424±0.033^{e}	59.503±0.506^{b}	79.74±0.411^{g}	95.316±0.321^{b}	4.811±0.219^{a}	94.782±0.368^{g}
G2	61.908±0.540^{c}	16.007±0.007^{f}	10.426±0.155^{f}	2.733±0.015^{c}	5.814±0.013^{g}	58.519±0.578^{d}	81.722±0.441^{ef}	94.547±0.203^{d}	4.681±0.151^{b}	92.546±0.329^{h}
G3	61.145±0.414^{d}	15.911±0.002^{h}	9.749±0.049^{h}	2.965±0.032^{a}	5.619±0.061^{i}	57.631±0.218^{e}	87.058±0.176^{d}	93.666±0.544^{g}	3.283±0.199^{d}	95.591±0.371^{b}
W1	62.519±0.268^{b}	16.092±0.017^{b}	12.022±0.085^{b}	2.41±0.117^{f}	6.545±0.022^{a}	59.445±0.152^{b}	91.266±0.122^{b}	95.085±0.267^{c}	4.763±0.154^{ab}	95.152±0.275^{e}
W2	61.87±0.412^{c}	16.004±0.007^{e}	12.022±0.103^{c}	2.659±0.069^{d}	6.491±0.034^{c}	58.756±0.387^{cd}	93.515±0.173^{a}	95.008±0.213^{c}	3.156±0.117^{d}	95.415±0.533^{cd}
W3	61.13±0.380^{d}	15.987±0.014^{g}	11.276±0.116^{d}	2.908±0.044^{b}	6.459±0.032^{d}	57.306±0.613^{f}	90.54±0.142b^{c}	93.957±0.26^{6f}	2.79±0.149^{f}	95.262±0.164^{de}

n=24. Data (mean±SE) with different small letter superscripts in the same column differed significantly ($P<0.05$).

apple pomace, pomegranate peel, cabbage powder and starfruit dry fiber concentrate, respectively, to meat products. The observations of this study were contrary to those made by Verma *et al.* (2013) who added guava powder to sheep meat nuggets and Ho *et al.* (2016) and Naknean *et al.* (2016), who added WRP to noodles and cookies, respectively.

The trend observed for the results related to the proximate parameters is due to the composition of meatball mixture where on addition of fruit powders a proportionate amount of lean meat is removed from the meatball formulation. The pH of SFP, GP and WRP is 3.62, 4.35, and 6.37, respectively. Compared to the control samples, the acidic nature of SFP and GP causes lowering of pH of meatball mixture. This resulted in higher fat loss, poor moisture retention and poor cooking yield. On the contrary, when compared between treated samples the percentage ash and the percentage fat retention increased gradually due to increase in fiber content of the meatball mixture.

Values displayed in Table 5 revealed the impact of SFP, GP and WRP on textural parameters of cooked meatballs. All the values observed were found to be statistically significant ($P<0.05$).

On analyzing the Textural Profile parameters, it was studied that all the observations were statistically significant ($P<0.05$). The control samples had the highest hardiness, cohesiveness, gumminess and chewiness values, whereas for springiness, the samples treated with 1.5% SFP and/or 2.0% WRP showed the best results. With an increase in the SFP concentration there was a gradual decrease in hardiness, cohesiveness, gumminess and chewiness values for the treated samples, springiness showed no particular trend. For GP treated samples, there was a gradual decrease in the values of hardiness and a gradual increase in the values of gumminess, rest of the factors showed no particular trend. Whereas for WRP for cooked and treated chevon meatballs the hardiness, cohesiveness and gumminess values reduced with increase in WRP concentration in the cooked chevon meatballs, the springiness values increased with the increase in the WRP concentration. No statistically significant difference ($P>0.05$) was observed for springiness values between 1.5% SFP treated and 2.0% WRP treated meatballs. Similarly, for gumminess no statistically significant difference ($P>0.05$) was observed between 2.0% SFP treated and 1.0% GP treated meatballs. These findings were in coherence with Thomas *et al.* (2016), Naknean *et al.* (2016), Ho *et al.* (2016), Verma *et al.* (2013), Banerjee *et al.* (2015), Das *et al.* (2014), Huda *et al.* (2014) and Sanchez-Zapata *et al.* (2010) whereas contrary to Malav *et al.* (2015) and Vivar-Vera *et al.* (2018).

Addition of fruit powders to meatball mixtures resulted in reduction in pH values and these values further declined with increase in fruit powder concentration. This reduced pH resulted in denaturation of proteins which impacted textural property of the product by lowering the strength of the protein gel matrix, leading to poor hardiness, cohesiveness, gumminess and chewiness of the end product. Since WRP has good oil absorption abilities (Al-Sayed *et al.* 2013), hence the enhanced springiness. The gradual increase in the gumminess of the GP treated meatball samples may be due to the increase in dietary fiber content which gets incorporated in the meatballs on addition of guava fruit powder.

The results for sensory evaluation of meatballs are represented in Table 6. All the values observed were found to be statistically significant ($P<0.05$).

For chevon meatballs, the addition of SFP, GP and WRP had a significant effect ($P<0.05$) on the colour, odour, tenderness and juiciness of the final product except for the outer texture and the overall acceptability which were found to be non-significant ($P>0.05$). These findings were in coherence with the studies conducted by Das *et al.* (2014), which stated that the overall acceptability of goat meat nuggets increased with addition of bael pulp residue but the difference was statistically non-significant ($P>0.05$). For guava treated chevon meatball samples odour, flavor and juiciness aspect showed a decrease in score with increase in concentration of the treatment. These findings were in coherence with the findings of Verma *et al.* (2013) which stated that sheep meat nuggets can be enriched by guava powder without any significant effect on the sensory attributes. For rest of the treatment involving starfruit

Table 5. Effect of addition of starfruit powder, guava powder and watermelon rind power on the Texture Profile Analysis parameters of cooked chevon meatballs (mean+S.E.)

Treatment	Hardiness (N/cm^2)	Springiness (cm)	Cohesiveness	Gumminess (N/cm^2)	Chewiness (N/cm)
C	60.294 ± 0.002^{a}	0.707 ± 0.002^{g}	0.325 ± 0.003^{a}	15.204 ± 0.002^{a}	12.013 ± 0.002^{a}
S1	49.423 ± 0.001^{b}	0.723 ± 0.002^{d}	0.284 ± 0.002^{d}	14.283 ± 0.003^{b}	11.914 ± 0.002^{c}
S2	45.295 ± 0.002^{f}	0.736 ± 0.002^{a}	0.274 ± 0.002^{e}	14.204 ± 0.002^{c}	11.206 ± 0.002^{d}
S3	43.516 ± 0.003^{i}	0.726 ± 0.003^{c}	0.254 ± 0.002^{f}	10.873 ± 0.002^{i}	8.216 ± 0.001^{h}
G1	47.216 ± 0.002^{d}	0.727 ± 0.002^{c}	0.292 ± 0.002^{c}	10.874 ± 0.002^{i}	9.243 ± 0.001^{g}
G2	46.223 ± 0.003^{e}	0.734 ± 0.003^{b}	0.295 ± 0.001^{b}	11.283 ± 0.004^{g}	10.216 ± 0.002^{f}
G3	45.216±0.002g	0.715 ± 0.002^{c}	0.239 ± 0.003^{h}	12.014 ± 0.002^{f}	8.204 ± 0.002^{i}
W1	48.214±0.001c	0.717 ± 0.002^{e}	0.284 ± 0.002^{d}	13.823 ± 0.002^{d}	10.853 ± 0.002^{e}
W2	44.295 ± 0.002^{h}	0.717 ± 0.003^{e}	0.275 ± 0.002^{e}	12.874 ± 0.001^{e}	12.006 ± 0.001^{b}
W3	43.125 ± 0.003^{j}	0.737 ± 0.003^{a}	0.245 ± 0.003^{g}	11.004 ± 0.001^{h}	7.826 ± 0.002^{j}

n=24. Data (mean±SE) with different small letter superscripts in the same column differ significantly ($P<0.05$).

Table 6. Effect of addition of starfruit powder, guava powder and watermelon rind powder on the sensory evaluation parameters of cooked chevon meatballs on day zero (mean±SE)

Treatment	Outer texture	Tenderness	Flavour	Colour	Juiciness	Odour	Overall acceptability
C	6.583±0.803	6.688±0.749^{b}	6.708±0.806	6.792±0.466^{a}	6.667±0.643^{c}	6.667±0.789^{a}	6.271±0.908
S1	6.604±0.751	6.813±0.749^{a}	6.625±0.647	6.688±0.462^{a}	6.729±0.859^{b}	6.375±0.784^{d}	6.708±0.751
S2	6.438±0.838	6.333±0.88^{de}	6.667±0.654	6.646±0.541^{b}	6.646±0.814^{c}	6.208±0.464^{e}	6.833±0.761
S3	6.438±0.742	6.354±1.005^{d}	6.917±0.702	6.708±0.674^{a}	6.838±0.815^{a}	6.292±0.721^{d}	6.542±0.884
G1	6.292±0.706	6.500±0.692^{c}	6.875±0.741	6.729±0.642^{a}	6.667±0.843^{c}	6.542±0.751^{b}	6.521±0.667
G2	6.083±0.702	6.646±0.714^{b}	6.792±0.706	6.750±0.766^{a}	6.542±0.988^{d}	6.500±0.808^{c}	6.688±0.87
G3	5.854±0.616	6.271±0.551^{ef}	6.792±0.674	6.438±0.577^{c}	6.396±0.722^{e}	6.354±0.634^{d}	6.875±0.784
W1	6.208±0.999	6.104±0.834^{h}	6.458±0.658	6.292±0.44^{d}	6.021±0.403^{f}	5.667±0.816^{f}	6.542±1.052
W2	6.500±0.872	6.229±0.821^{fg}	6.646±0.683	6.188±0.438^{e}	5.833±0.525^{h}	5.396±0.691^{a}	6.646±0.89
W3	6.417±0.803	5.958±0.793^{i}	6.604±0.722	6.458±0.53^{c}	5.979±0.759^{g}	5.646±0.89^{f}	6.354±0.878

n=24. Data (mean±SE) with different small letter superscripts in the same row differ significantly (P<0.05).

powder and watermelon rind powder, no particular trend was observed.

Incorporation of SFP, GP and WRP to chevon meatballs at the rate of 1.0%, 1.5% and 2.0% had resulted in an improved shelf life of the product under refrigerated (4±1°C) temperature by enhancing its anti-oxidant and anti-microbial abilities. The physico-chemical characteristics and the textural profile were enhanced. Sensory evaluation of the product revealed it to be better than the control batch and the overall acceptability of the product was enhanced. Thus concluding that SFP, GP and WRP can not only act as natural preservatives to enhance the shelf-life of cooked chevon meatballs, but also yield products having better acceptability and augmented functional properties.

REFERENCES

AOAC. 2001. Association of Official Analytical Chemists International. Official Methods of Analysis. 17th ed. AOAC Inc., Arlington, USA.

APHA. 2001. American Public Health Association. Frances PD, and Keith I (Eds). Compendium of Methods for the Microbiological Examination of Foods. Washington, DC.

Adams S M. 1994. Development of low-fat ground beef patties with extended shelf life. MS Thesis, Texas A & M University, College Station, TX.

Al-Sayed H M A and Ahmed A R. 2013. Utilization of watermelon rinds and sharlyn melon peels as a natural source of dietary fiber and antioxidants in cake. *Annals of Agricultural Science* **58**: 83–95.

Balasundram N, Sundram K and Samman S. 2006. Phenolic compounds in plants and agri-industrial by-products: antioxidant activity, occurrence, and potential uses. *Food Chemistry* **99**: 191–203.

Banerjee R, Verma A K and Narkhede H P. 2015. Cauliflower powder in pork meatballs: effects on quality characteristics and oxidative stability. *Fleischwirtschaft International* **1**: 97–102.

Bourne M C. 1978. Texture profile analysis. *Food Technology* **32**: 62–66.

Das A K, Rajkumar Vincet and Verma A K. 2014. Bael pulp residue as a new source of antioxidant dietary fiber in goat meat nuggets. *Journal of Food Processing and Preservation* **39**: 1626–35.

Devatkal S K, Narsaiah K and Borah A. 2010. Anti-oxidant effect of extracts of kinnow rind, pomegranate rind and seed powders in cooked goat meat patties. *Meat Science* **85**:155–59.

Duncan D B. 1995. Multiple range and multiple F- Tests. *Biometrics* **11**: 1–42.

El-Magoli S B, Laroia S and Hansen P M T. 1996. Flavor and texture characteristics of low fat ground beef patties formulated with whey protein concentrate. *Meat Science* **42**: 179–93.

El-Nashi H B, Fattah A F A K A, Abdel Rahman N R and Abd El-Razik M M. 2015. Quality characteristics of beef sausage containing pomegranate peels during refrigerated storage. *Annals of Agriculture Science* **60**: 403–12.

Fernandez-Lopez J, Sendra E, Sayas-Barbera E, Navarro C and Perez-Alvarez J A. 2008. Physico-chemical and microbiological profiles of ''salchichon'' (Spanish dry-fermented sausage) enriched with orange fiber. *Meat Science* **80**: 410–17.

Fung D Y. 2010. Microbial hazards in food: food-borne infections and intoxications. Toldra F. (Ed.) *Handbook of Meat Processing* (pp. 481–500). USA: Blackwell Publishing.

Georgantelis D, Blekas G, Katikou P, Ambrosiadis I and Fletouris D J. 2007. Effect of rosemary extract, chitosan and -tocopherol on lipid oxidation and colour stability during frozen storage of beef burgers. *Meat Science* **75**: 266–74.

Guanghou S and Leong L P. 2004. Analysis of Polyphenolic antioxidant in star fruit using liquid chromatography and mass spectrometry. *Journal of Chromatography* **1022**: 67–75.

Hayrapetyan H, Hazeleger W C and Beumer R R. 2012. Inhibition of *Listeria monocytogenes* by pomegranate (*Punica granatum*) peel extract in meat pateµ at different temperatures. *Food Control* **23**: 66–72.

Ho L H and Dahri N C. 2016. Effect of watermelon rind powder on physico-chemical, textural and sensory properties of wet yellow noodles. *Cyta Journal of Food* **14**: 465–72.

Huda A B, Parveen S, Rather S A, Akhter R and Hassan M. 2014. Effect of incorporation of apple pomace on the physico-chemical, sensory and textural properties of mutton nuggets. *International Journal of Advance Research* **2**: 974–83.

Kamath J V, Nair R, Kumar C K and Mohana Lakshmi S. 2008. *Psidium guajava* L: A review. *International Journal of Green Pharmacy* **2**: 9–12.

Kondaiah N, Anjaneyulu A S R, Rao V K, Sharma N and Joshi H B. 1985. Effect of salt and phosphate on the quality of buffalo and goat meat. *Meat Science* **15**: 183–92.

Kruskal W H and Wallis W A. 1952. Use of ranks in one-criterion variance analysis. *Journal of the American Statistical Association* **47**: 583–621.

Kumar M. 2001. Efficacy of different fat replacers on the processing quality and storage stability of low fat pork patties. Ph.D. thesis submitted to IVRI, Deemed University, Izatnagar, UP.

Kumar V, Biswas A K, Sahoo J, Chatli M K and Sivakumar S. 2013. Quality and storability of chicken nuggets formulated with green banana and soybean hull flours. *Journal of Food Science and Technology* **50**: 1058–68.

Leong L P and Shui G. 2002. An investigation of antioxidant capacity of fruits in Singapore markets. *Food Chemistry* **76**: 69–75.

Lewinsohn E, Sitrit Y, Bar E, Azulay Y, Ibdah M, Meir A, Yosef E, Zamir D and Tadmor Y. 2005. Not just colors carotenoid degradation as a link between pigmentation and aroma in tomato and watermelon fruit. *Trends in Food Science and Technology* **16**: 407–15.

Lim Y S and Lee S T. 2013. *In vitro* antioxidant capacities of star fruit (*Averrhoa carambola*), an underutilized tropical fruit. *Research Journal of Biology* **3**: 21–24.

Malav O P, Sharma B D, Kumar R R and Talukder S.2015. Antioxidant potential and quality characteristics of functional mutton patties incorporated with cabbage powder. *Nutrition and Food Science* **45**: 542–63.

Martiµnez-Cervera S, Salvador A, Muguerza B, Moulay L and Fiszman S M. 2011. Cocoa fiber and its application as a fat replacer in chocolate muffins. *LWT – Food Science and Technology* **44**: 729–36.

Murphy E W, Criner P E and Grey B C. 1975. Comparison of methods for calculating retentions of nutrients in cooked foods. *Journal of Agricultural and Food Chemistry* **23**: 1153–57.

Miean K H and Mohamed S. 2001. Flavonoid (myricetin, quercetin, kaempferol, luteolin, and apigenin) content of edible tropical plants. *Journal of Agricultural and Food Chemistry* **49**: 3106–12.

Misra K and Seshadri T R.1968. Chemical components of the fruits of *Psidium guajava*. *Phytochemistry* **7**: 641–45.

Naknaen P, Itthisoponkul T, Sondee A and Angsombat N. 2016. Utilization of watermelon rind waste as a potential source of dietary fiber to improve health promoting properties and reduce glycemic index for cookie making. *Food Science and Biotechnology* **25**: 415–24.

Payal G, Pankti K, Manodeep G and Jagadish K. 2012. Phytochemical and pharmacological profile of *Averrhoa carambola*—An overview. *International Research Journal of Pharmacy* **3**: 88–92.

Saµnchez-Zapata E, Munisoz C M, Fuentes E, Fernaµndez-Loµpez J, Sendra E and Sayas E. 2010. Effect of tiger nut fibre on quality characteristics of pork burger. *Meat Science* **85**: 70–76.

Sendra E, Fayos P, Lario Y, Ferna µndez-Loµpez J, Sayas-Barbera µE and Peµrez-Alvarez J A. 2008. Incorporation of citrus fibers in fermented milk containing probiotic bacteria. *Food Microbiology* **25**: 13–21.

Serdaroglu M and Degýrmencioglu O. 2004. Effects of fat level (5%, 10%, 20%) and corn flour (0%, 2%, 4%) on some properties of Turkish type meatballs (koefte). *Meat Science* **68**: 291–96.

Tarladgis B G, Watts B M, Younathan M T and Dugan L R. 1960. A distillation method for the quantitative determination of malonaldehyde in rancid foods. *Journal of American Oil Chemistry Society* **37**: 44–48.

Temple N J. 2000. Antioxidants and disease: more questions than answers. *Nutrition Research* **20**: 449–59.

Thomas R, Jebin N, Saha R and Sarma D K. 2016. Antioxidant and antimicrobial effects of kordoi (*Averrhoa carambola*) fruit juice and bamboo (*Bambusa polymorpha*) shoot extract in pork nuggets. *Food Chemistry* **190**: 41–49.

Tiwari B K, Valdramidis V P, O'Donnell C P, Muthukumarappan K, Bourke P and Cullen P. 2009. Application of natural antimicrobials for food preservation. *Journal of Agricultural and Food Chemistry* **57**: 5987–6000.

Troutt E S, Hunt M C, Johnson D E, Claus J R, Kastner C L and Kropf D H. 1992. Characteristics of low-fat ground beef containing texture-modifying ingredients. *Journal of Food Science* **57**: 19–24.

Verma A K, Rajkumar V, Banerjee R, Biswas S and Das A K. 2013. Guava (*Psidium guajava* L.) powder as an antioxidant dietary fibre in sheep meat nuggets. *Asian Australasian Journal of Animal Science* **26**: 886–95.

Verma S N and Sahoo J. 2000. Improvement in the quality of ground chevon during refrigerated storage by tocopherol acetate preblending. *Meat Science* **56**: 403–13.

Vivar-Vera M A, Pérez-Silva A, Ruiz-López I I, Herna µndez-Ca µzares A S, Solano-Barrera S, Ruiz-Espinosa H, Bernardino-Nicano A and Gonzaµlez-Cruz, L. 2018. Chemical, physical and sensory properties of Vienna sausages formulated with a starfruit dietary fiber concentrate. *Journal of Food Science and Technology* **55**: 3303–13.