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Effect of thermal treatment on milling performance of pigeonpea (*Cajanus cajan*)

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ABSTRACT

Pigeonpea [*Cajanas cajan* (L.) Millsp.] is an important pulse crop of India. It is consumed as dehusked splits commonly, known as *dhal*. The hull of pigeonpea adheres tightly to the cotyledons through a gummy layer that hinders separation of hull during milling. Hence, pre-milling treatment is an essential step before milling for higher *dhal* recovery. Thermal pre-milling treatment was conducted at temperatures (5, 85, 105, 125°C) for varying duration (2, 4, 6, 8 min). The experiment consisting of 16 treatment combinations was conducted as per factorial CRD. Treatment at temperature 85±5°C for 4 min resulted in maximum hulling efficiency of 84.28% and finished product recovery of 53.53%, which was significantly higher than untreated sample. Losses in form of broken was found to be only 2.5%.

Key words: Dehulling efficiency, Optimization, Pre-milling method, Recovery

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is consumed as dehusked splits commonly, known as *dhal*. It is an important dietary constituent, especially for the vegetarian population of India, as a source of protein. The hull of pigeonpea adheres tightly to the cotyledons through a gummy layer that hinders separation of hull during milling. Due to this the pigeon pea has been categorized under difficult-to-mill pulse. The dehusking efficiency in traditional mills is quite low. Moreover, the yield of dehusked and splitted pulses in traditional mills is about 55-70% in comparison to 88-89% maximum potential recovery of splits (Anonymous 2015). Thus, there is excessive loss of pulse cotyledons and embryos in the form of broken and powdered grains (5-15%).To reduce milling losses, several pre-treatments have been reported.

Pre-treatment using oil involves using a large quantity of edible oil, nearly 50–100 g/kg of pigeonpea (Ali 2000). Goyal *et al.* (2008) reported that 0.3% mustard oil pre-milling treatment process could enhance dehulling efficiency to 83.2%. Dehulling, often leads to losses in form of powder and broken seed. Powder and broken seed losses had been found to be as high as 12.8% and 4.4%, respectively (Singh 1995). Wani *et al*. (2011) reported the effect of thermal treatments on milling quality of greengram. The pretreatment showed *dhal* recovery of 71.18-78.12% as against 61.19-65.64% without any pretreatment. Deshpande *et al*. (2007) reported *dhal* recovery of 67.1-70.8% and 69.4-72.5%, respectively, on linseed oil-water and sodium bicarbonate treatments against 63.2-66.3% by conventional milling method. Mangaraj and Singh (2011) reported maximum pulse recovery of 76.36% in pigeonpea, 78.3% in chickpea and 71.25% in greengram.

Kyi *et al.* (1997) proposed to evade using edible oil for pre-milling treatment to enhance availability for consumption of edible oil directly in human diet to mitigate shortage of it. Heat treatment using sand as a medium is common practice in some parts of northern India at rural level but getting consistency in quality product and recovery is a problem. This underlines the need to investigate pre-treatment methods further. The present study was undertaken to standardize pre-milling heat treatment for the farmer having locally available resources.

MATERIALS AND METHODS

The popular variety of pigeonpea, cv.**P**-992 largely grown in Northern India was selected for the study. Raw pigeonpea was procured from the IARI Regional Station, Karnal. The samples were cleaned, graded and stored in gunny bags until further processing.

The average moisture content of seed was 8.5% (w.b.). Cleaned and graded lot of pigeonpea sample was added 5–10% water by weight and kept in heaps for about 16 hr. The sample was dried in shade or using electro-mechanical tray dryer at 40ºC to attain moisture content 10% (w.b.).

The dried lots were subjected for heat treatment by pre-fabricated controlled heating system. The heating system had electrical heater for raising temperature, an electronic thermostat for precise temperature control inside

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the chamber. To accomplish uniform heating to the desired extent and handle the material from feed to outlet, an auger conveyer powered with an electrical motor through an AC drive was provided. The drive had provision to control the speed of motor by adjusting frequency. This arrangement was used for achieving desired exposure time of the pre-treatment. Sample lots were mixed with sand and fed to the pre-heated system at desired temperature and operated for pre-specified speed to attain desired exposure time. Samples of 10 kg with three replications were treated at four levels of temperature (65, 85, 105, 125˚C) and four levels of exposure time (2, 4, 6, 8 min).

The pre-treated dried samples of pigeonpea weighing 500 g were dehulled with small hand operated emery plate chakki. Dehulling fractions (husk, unhulled, brokens, powder, whole dehulled, dal and split, partially hulled) were separated from milled output by hand picking and using set of sieves (BSS 6, BSS 8, BSS 16, BSS 18, BSS 25) and stored in polyethylene bags.

The different separated fractions were weighed and hulling efficiency, finished product recovery, unhulled and brokens percent were calculated using the following formulae (Saxena 1985).

$$\textit{Dehulling efficiency}\ (\%) = \left(1 - \frac{U_n}{T}\right) \times \left(\frac{F_p}{F_p + B_r + P_0}\right) \times 100$$

where, *Un*, Unhulled grain mass (g); *T*, Sample mass (g); *Fp*, Finished product, consisting of splits and whole dehusked grain (g); *B,* Brokens mass (g); *P,* Powder mass (g).

$$\textit{Finished product recovery}\ (\%) = \frac{F_p}{T} \times 100$$

where, F_p, Finished product, consisting of splits and whole dehusked grain (g); *T,* Sample weight (g).

$$\textit{Unhulled (per cent)} = \frac{Un}{T} \times 100$$

$$\textit{Broken (per cent)} = \frac{Br}{T} \times 100$$

Experiment as per factorial CRD consisting of 16 treatment combinations was carried out. Data analysis was done using SAS.

RESULTS AND DISCUSSION

The effect of pre-treatment on milling performance, i.e. dehulling efficiency, finished product recovery, unhulled percentage and brokens percentage was determined (Table 1).Temperature and time had significant effects on milling performance at 5% level of significance.

Dehulling efficiency

The dehulling efficiency varied from 74.3 to 84.3%, which were significantly higher than the control (66.2%). The increase in temperature from 65 to 85°C led to significant increase in the dehulling efficiency, irrespective of exposure time. It might be due to roasting effect which imparts brittleness to the surface of the hull, considerably supporting the dehulling process. Similar effect was observed by Shyeh *et al.* (1980) for dehusking efficiency of soybean. However, further increase of temperature from 85°C to 125°C resulted in decrease in the dehulling efficiency. It was more prominent when exposure time was higher than 4 min. The lower dehulling efficiency at higher temperatures might be due to over roasting, which made the hull stick with grain. Remarkably at 125°C, lower exposure time (up to 4 min.) led to increase in the dehulling efficiency. On contrary, reduction of the dehulling efficiency was observed with higher exposure times (6 and 8 min) at 125°C.There was significant interaction of temperature and residence time for dehulling efficiency. It could be attributed that low temperature-high exposure time and high temperature-short exposure time combinations yielded higher dehulling efficiency. This implied that higher level of heat was not always having a positive effect on dehulling efficiency. After an optimum level of heat supplement, any further increase adversely affects the dehulling process.The dehulling efficiency with 65°C and up to 6 min exposure time were found at par. It might be due to insufficient heat supplement for detaching the hull from grain. The 105°C temperature and up to 6 min exposure time were observed at par with respect to dehulling efficiency. Similar higher heat induction in these pre-treatments might be inducing sticking of hull with grain. Maximum dehulling efficiency of 84.28% was recorded with 85°C and 4 min residence time for the pre-treated lot.

Table 1 Effect of heat treatment on product recovery (%), dehulling efficiency (%), and broken (%)

Treatment		Product recovery (%)	Dehulling efficiency (%)	Broken (%)
Temp (°C)	Time (min)			
65	2	32.8500^{I}	74.043^{E}	2.3833^{I}
65	4	40.8667^{HG}	74.300^{E}	3.7667^{H}
65	6	42.1500^{G}	74.107^{E}	4.6167^{FG}
65	8	48.3667^{D}	77.857^{C}	5.7167^{E}
85	2	46.1000^{F}	81.240^{B}	1.5833^{J}
85	4	53.5333^{A}	84.283^{A}	2.4833^{I}
85	6	51.5667^{B}	81.717^{B}	4.8167^{G}
85	8	48.0000^{E}	78.643^{C}	7.0333^{C}
105	2	39.9833^{H}	78.369^{C}	4.5333^{G}
105	4	49.5333^{DC}	77.950^{C}	6.1000^{DE}
105	6	50.7667^{BC}	78.803^{C}	6.8333^{C}
105	8	50.2000^{BC}	76.797^{CD}	8.3833^{B}
125	2	44.6667^{F}	81.633^{B}	5.3000^{F}
125	4	50.1167^{BC}	81.337^{B}	6.2167^{D}
125	6	50.7167^{BC}	78.193^{C}	8.3333^{B}
125	8	47.6667^{E}	75.787^{ED}	9.1333^{A}
LSD (P=0.0 5)		1.501	2.0499	0.4104
Control		29.3	66.2	2.87

Broken grain

The broken grain mass was observed to be between

1.58 and 9.13%. The pre-treatment at 65ºC for 2 min exposure and 85ºC for 4 min exposure were at par in respect of broken percentage. The effect of pre-treatment temperature and residence time on broken percentage was prominently demonstrated. Elevation of temperature resulted in increase of brokens. Similarly, thermal exposure period also inflated amount of brokens, irrespective of temperature. The maximum broken was witnessed at 125ºC for 8 min exposure. Minimum broken was observed at 85ºC for 2 min exposure to material. It was evident that increase of temperature during pretreatment enhanced broken percentage. Interaction of temperature and exposure time was found significant in terms of brokens. It indicated that higher level of heat made the grain brittle, which might be reflected as higher brokens in milled mass.

Product recovery

Milling of pre-treated pigeonpea resulted into product recovery in the range of 32.8-53.3% as against 29.3% for untreated sample. Maximum product recovery was obtained from the sample pretreated at 85ºC for 4 min and minimum was with 85ºC for 2 min. It clearly indicated that pretreatment (temperature and exposure time) significantly enhanced the product recovery. The product recovery was found positively correlated with pre-treatment thermal exposure time. However, the elevation of temperature expressed beneficial effect on product recovery up to 85ºC. Discolouration of product was seen with treatment which was conducted at higher temperatures for longer durations. Odd colour and stink was found in elevated temperature treated lots. Higher level of heat treatment might be affecting protein content of product considerably as reported by Akande (2010). Elevated temperature treatment also affects cooking quality and taste adversely (Tiwari *et al.* 2010). Reduced product recovery at higher level of heat supplement might be alleviating the brittleness of the grain. It was also reinforced with data of brokens. However, the lower product recovery at lower temperature and lower exposure period might be due to inefficient in breaking the bond of husk with kernel. The interaction plot signifies that treatment at 85°C for 4 minu might be optimum for getting maximum product recovery.

Thermal pre-milling treatment was found efficient for pigeonpea milling yielding higher product recovery and dehulling efficiency as well as minimizing losses in form of brokens and powder. Temperature and residence time were found as critical parameters for the thermal treatment. Higher level of both the parameters induced off-odour and colour, which could be non-acceptable to consumers. For maximum dehulling efficiency and product recovery, pre-treatment of pigeonpea at 85ºC for 4 min was found to be optimum. Pre-treatment at optimum condition led to increase in *dhal* recovery and dehulling efficiency by 24% and 18% over untreated samples and achieved 53%, 86% and 2.45% product recovery, dehulling efficiency and broken percentage, respectively.

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