Studies on *dhal* recovery from pre-treated pigeon pea (*Cajanus cajan* L.) cultivars

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Abstract *Dhal* recovery from three popular varieties of North Karnataka was studied using CFTRI mini *dhal* mill with five different treatments at three different levels. It was observed that Gulyal variety treated with mustard oil recorded maximum hulling efficiency (79.4%) and finished product (68.8%) when compared to a Maruti and Asha variety. However, acetic acid treatment recorded higher hulling efficiency (76.5%) for Maruti followed by Asha (56.9%). The plant growth promoting rhizobacteria (PGPR) treatment yielded minimum hulling efficiency and finished product recovery for all the varieties.

Keywords Pigeonpea · Treatments · Milling · Hulling efficiency · *Dhal* recovery

Introduction

Pigeonpea (*Cajanus cajan* L.) is an economically and nutritionally important legume as major source of protein in several communities of many tropical and subtropical regions of the World (Singh et al. 1984). Legume proteins are rich in lysine and complement the proteins in cereals & oil seeds, which are deficient in this amino acid. In addition to be the good source of nutrients, pulses reduce the risk of suffering cardiovascular diseases, diabetes and some types of cancer (Pastor-Cavada et al. 2011). India is the world's largest producer of pulses and the average productivity lies between 637 and 799 kg/ha (Anonymous 2008). *Cajanus* (Tribe: Phaseolae, Subfamily: Papilionaceae and Family: Fabaceae) includes only one species *Cajanus cajan* (L.) Mill Sp., commonly known as red gram, pigeonpea, *arhar* or *tur*. Pigeonpea contains 21.7 g protein, 1.5 g fat, carbohydrate 62.8 g, dietary fibre 15.0 g, energy 343 kcal and 130 mg calcium per 100 g of edible portion. It is cultivated for grain purpose and consumed as *dhal*. It has estimated that the total production of legumes provide almost as much protein (20–30%) to the World as wheat and over 50% more than rice or corn (Rockland and Radke 1981; Gopalan et al. 1985). In addition, legumes supply significant amount of energy through carbohydrates (60–70%), lipids (1–7%), dietary fibers and minerals (2–5%), also the legume oilseeds contains reasonable levels of thiamine, riboflavin and niacin (Bressani and Elias 1974; Arora 1977).

Pulse milling is an important agro-based industry. The milling is originated at the village level using a stone mill (chakki), which operated at a low pressure to split the grain, which was later developed into a large scale industry (Kurien and Parpia 1968). In India, pulse milling is next to

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rice and wheat milling operation. There are about 10,000 milling units of varying capacity for processing of about 2 million tonnes produced annually in India (Kulkarni 1989), whereas north Karnataka alone contributes more than 150 milling units (Anonymous 2008). Further in most cases traders also operate as millers and farmers are at a serious disadvantage as they are compelled to sell their produce to them. The processing centres are located far away from actual pulse producing centres resulting in unavoidable transportation and storage costs (Khan 2007).

Several previous studies reported that the husk of grain adhered to the cotyledons due to the presence of calactomonus disaccharide, glucoronai acid and glycol protein (Kurien and Parpia 1968). For adherence of husk to the cotyledons, arabinogalactan type polysaccharide was found responsible, which is gummy and hygroscopic in nature (Swamy et al. 1991). The presence of these complex carbohydrates makes the dehulling of pigeonpea a difficult process. Therefore, milling of pulses without pretreatment results in low *dhal* recovery. Pre-milling treatments play an important role in improving *dhal* recovery by loosening husk from cotyledons (Saxena 1999). Different pre-treatments viz., water soaking, water spray with oil treatment, sodium bicarbonate treatment and enzyme treatment except sodium bicarbonate treatment caused significant loss in protein content of cotyledons over untreated samples (Phirke and Bhole 2000). The effects of chemical treatment on husk removal of pigeonpea grain using aqueous solutions of calcium hydroxide, sodium hydroxide and sodium bicarbonate was observed and among them sodium bicarbonate solution was the most effective for *dhal* recovery (Saxena 1981).

Keeping in view of small processing farmers and very commonly available varieties in Northern districts of Karnataka, India, ICPL 87119 (Asha), ICP-8863 (Maruthi) and Gulyal are selected for the present study with an objective to standardize the different pre-milling treatments to increase the *dhal* recovery using Central Food Technological Research Institute (CFTRI) mini *dhal* mill.

Material and methods

Materials

Pigeonpea (*Cajanus cajan* L.) varieties viz., Asha (ICPL-87119), Maruthi (ICP-8863) and Gulyal were procured from the Agricultural Produce Marketing Committee (APMC), Gulbarga, Karnataka, India and Regional Research Station (RRS), Raichur, Karnataka, India. The samples were then cleaned using manually operated air screen cleaner (TNAU model), graded as per the standard specification using a standard seed grader (Indosaw lab

Table 1 Details of treatments and their levels

Treatments	Levels (%)		
	Level I	Level II	Level III
T ₀ : Control	–	–	–
T ₁ : Water spray	6.0	7.0	8.0
T ₂ : Mustard oil	0.3	0.4	0.5
T ₃ : Sodium bicarbonate	4.0	5.0	6.0
T ₄ : Acetic acid	15.0	20.0	25.0
T ₅ : PGPR	0.5	1.0	1.5

model) and stored in a perforated lined jute bags in ambient condition until further processing.

Pre-milling treatments

Five different pre-milling treatments with three different levels taken for studying the *dhal* recovery of pigeonpea. The treatments and their levels were selected on the basis of the preliminary experiments (Goyal et al. 2008; Deshpande et al. 2007). The details of treatments and their levels are presented in Table 1.

CFTRI mini *dhal* mill

The schematic diagram of CFTRI (Central Food Technology and Research Institute, Mysore, Karnataka, India) mini *dhal* mill is shown in Fig. 1, which performs all the three functions required in the milling of pulses, viz., dehulling, splitting the cotyledons into two halves and separation of husk and broken from the *dhal*. It works on the principle of abrasion. Asha, Gulyal and Maruti varieties of pigeonpea

Fig. 1 Schematic diagram of CFTRI mini *dhal* mill

Table 2 Milling responses (%) of pigeonpea varieties as influenced by different levels of water treatment

Varieties	Milling responses					Finished product recovery,%				
	Hulling efficiency,%									
	L ₀	L ₁	L ₂	L ₃	Mean	L ₀	L ₁	L ₂	L ₃	Mean
V ₁	39.2	51.3	44.4	42.7	44.4	33.9	42.9	36.4	34.3	36.9
V ₂	42.6	73.3	73.6	72.3	65.5	36.5	62.0	62.0	61.1	55.4
V ₃	48.1	71.5	69.9	69.9	64.9	42.2	60.1	59.3	59.4	55.3
Mean	43.3	65.3	62.6	61.6	58.2	37.5	55.0	52.6	51.6	49.2
	RMSE ±			CD at 1%		RMSE ±			CD at 1%	
Varieties (V)	0.6			1.4		0.6			1.1	
Levels (L)	0.7			1.7		0.6			1.4	
Interaction	0.9			2.9		0.8			2.4	

V₁—Asha, V₂—Maruti and V₃—Gulyal; L₀—Control, L₁—6%, L₂—7% and L₃—8%
The experiment was replicated thrice

(m.c.–10%db), which are popularly grown in the Northern part of Karnataka were selected for the present study. The grains were cleaned from dust, chaff, grits etc., and graded according to size by a rotating sieve type cleaner. The cleaned grains were passed through the *dhal* mill for dehulling and splitting. The respective pre-milling treatments were applied according to the sets of the experiments. The conditioning of the grains was done by alternate wetting and drying. After sun drying for a certain period, 3–5% moisture was added to the grains and tempered for about 8 h and again dried in the sun. The grain samples were dried to about 10±0.5% m.c (d.b.) after the conditioning. The dried samples were milled using CFTRI *dhal* mill.

Milling efficiency

The samples were prepared and milled using CFTRI mini *dhal* mill. Prior to milling, different process parameters such as, feed rate, concave clearance were adjusted and optimized. The different fractions were separated using

suitable sieves and manually picking. Hulling efficiency and finished product recovery was calculated using following formulae (Saxena, 1981).

$$\text{Hulling Efficiency (\%)} = \left(1 - \frac{U_n}{T}\right) \times \left(\frac{F_p}{F_p + B_r + P_o}\right) \times 100 \quad (1)$$

where,

U_n Unhulled grain, g
 T Total sample, g
 F_p Finished product, consisting of splits and whole dehulled grain, g
 B_r Broken, g
 P_o Powder, g

$$\text{Finished Product Recovery (\%)} = \frac{F_p}{T} \times 100 \quad (2)$$

Table 3 Milling responses (%) of pigeonpea varieties as influenced by different levels of mustard oil treatment

Varieties	Milling responses					Finished product recovery,%				
	Hulling efficiency,%									
	L ₀	L ₁	L ₂	L ₃	Mean	L ₀	L ₁	L ₂	L ₃	Mean
V ₁	39.2	51.1	50.3	50.9	47.9	33.9	43.8	43.2	42.9	41.0
V ₂	42.6	74.1	70.7	70.2	64.4	36.5	64.4	64.3	63.8	57.3
V ₃	48.1	79.4	78.8	77.4	70.9	42.2	68.8	68.7	66.7	61.6
Mean	43.3	68.2	66.6	66.2	61.1	37.5	59.0	58.7	57.8	53.3
	RMSE ±			CD at 1%		RMSE ±			CD at 1%	
Varieties (V)	0.5			1.0		0.5			1.0	
Levels (L)	0.6			1.2		0.5			1.2	
Interaction	0.7			2.1		0.7			2.0	

V₁—Asha, V₂—Maruti and V₃—Gulyal; L₀—Control, L₁—0.3%, L₂—0.4% and L₃—0.5%
The experiment was replicated thrice

Table 4 Milling responses (%) of pigeonpea varieties as influenced by different levels of sodium bicarbonate treatment

Varieties	Milling responses									
	Hulling efficiency, %					Finished product recovery, %				
	L ₀	L ₁	L ₂	L ₃	Mean	L ₀	L ₁	L ₂	L ₃	Mean
V ₁	39.2	53.4	53.8	54.5	50.2	33.9	46.7	46.5	46.4	43.4
V ₂	42.6	74.4	70.6	74.0	65.4	36.5	62.3	59.6	61.7	55.0
V ₃	48.1	77.0	76.8	77.2	69.8	42.2	66.3	64.8	65.5	59.7
Mean	43.3	68.3	67.1	68.6	61.8	37.5	58.4	57.0	57.9	52.7
	RMSE ±			CD at 1%		RMSE ±			CD at 1%	
Varieties (V)	0.5			1.1		0.5			0.8	
Levels (L)	0.6			1.3		0.5			1.0	
Interaction	0.7			2.2		0.7			1.7	

V₁—Asha, V₂—Maruti and V₃—Gulyal; L₀—Control, L₁—4%, L₂—5% and L₃—6%
The experiment was replicated thrice

Statistical analysis

The experiment was carried out in two factorial Complete Randomised Block (CRD) design with three replications (protocol for sun drying and conditioning). The milling responses of different pretreated samples were analysed using two way analysis of variance (ANOVA) method. Statistical software Stat-soft 6.0 was used for statistical analysis and Microsoft office excel (2007) were used to plot the graph.

Results and discussion

The selected pigeonpea varieties viz., Maruti, Gulyal and *Arhar* were subjected to different pre-treatments before milling in CFTRI mini *dhal* mill. The pre-treatments viz., water treatment, mustard oil treatment, acetic acid treatment, sodium bicarbonate treatment, PGPR treatment and control were considered to study the effect and quality of *dhal* recovery on milling.

Water spray treatment

The milling responses of pigeonpea as influenced by different levels of water treatment and different varieties are presented in Table 2. There was a significant difference among the varieties at different levels of water treatment. Among the varieties, significantly higher hulling efficiency was recorded in Maruthi which was on par with Gulyal. The finished product recovery was high in Maruthi which was on par with Gulyal and superior to Asha. Among the three varieties the hulling efficiency (65.3%) was recorded more at Level I. However, Level II and Level III were on par with each other and higher than the control. However, the same trend was observed with finished product recovery for hulling efficiency at different levels. The interaction effect of different varieties and different levels of water on hulling efficiency and finished product recovery was found to be significant. Variations in milling responses obtained with the three varieties were possibly the result of varying extent of loosening of husk from the cotyledons after pre-milling treatments reducing the influence of gums. Similar

Table 5 Milling responses (%) of pigeonpea varieties as influenced by different levels of acetic acid treatment

Varieties	Milling responses									
	Hulling efficiency, %					Finished product recovery, %				
	L ₀	L ₁	L ₂	L ₃	Mean	L ₀	L ₁	L ₂	L ₃	Mean
V ₁	39.2	49.5	51.1	56.9	49.2	33.9	42.7	43.3	47.6	41.9
V ₂	42.6	75.8	74.1	76.5	67.3	36.5	63.6	63.4	66.0	57.4
V ₃	48.1	72.2	69.3	67.3	64.2	42.2	60.9	60.1	58.5	55.4
Mean	43.3	65.8	64.8	66.9	60.2	37.5	55.7	55.6	57.4	51.6
	RMSE ±			CD at 1%		RMSE ±			CD at 1%	
Varieties (V)	0.6			1.2		0.5			1.0	
Levels (L)	0.6			1.4		0.5			1.1	
Interaction	0.8			2.5		0.7			2.0	

V₁—Asha, V₂—Maruti and V₃—Gulyal; L₀—Control, L₁—15%, L₂—20% and L₃—25%
The experiment was replicated thrice

Table 6 Milling responses (%) of pigeonpea varieties as influenced by different levels of PGPR

Varieties	Milling responses									
	Hulling efficiency, %					Finished product recovery, %				
	L ₀	L ₁	L ₂	L ₃	Mean	L ₀	L ₁	L ₂	L ₃	Mean
V ₁	39.2	47.6	48.6	50.8	46.6	33.9	41.1	42.8	44.0	40.5
V ₂	42.6	55.1	55.9	57.3	52.7	36.5	46.9	48.3	50.8	45.6
V ₃	48.1	62.2	63.3	63.6	59.3	42.2	54.1	55.2	55.4	51.7
Mean	43.3	55.0	55.9	57.2	52.9	37.5	47.4	48.8	50.1	45.9
	RMSE ±			CD at 1%		RMSE ±			CD at 1%	
Varieties (V)	0.5			0.9		0.5			1.0	
Levels (L)	0.1			1.0		0.5			1.1	
Interaction	0.7			1.8		0.7			1.9	

V₁—Asha, V₂—Maruthi and V₃—Gulyal; L₀—Control, L₁—0.5%, L₂—1.0% and L₃—1.5%
The experiment was replicated thrice

observations have been reported by Waghule and Kanawade (1998) for different pigeonpea varieties.

Mustard oil treatment

The Table 3 shows that, the higher hulling efficiency was recorded in Gulyal (70.9%) as compared to Maruthi and Asha variety. Also, a maximum finished product recovery was recorded in Gulyal followed by Maruthi which was superior to Asha. The interaction effect on hulling efficiency and finished product recovery was found to be significant. It was also observed that, an increase in the levels of treatment resulted in the decreased hulling efficiency and finished product recovery. The results were in accordance with Goyal et al. (2008), who reported that oil treatment at 0.3% increased dehulling efficiency up to 83.2%. The commercial processing units generally follow the application of oil as pretreatment for dehulling of pigeonpea. This is due to penetration of the oil through the husk of cotyledons that helps in release of its binding. The loosening process may be slow, but the husk can be totally loosened (Deshpande et al. 2007).

Sodium bicarbonate treatment

The data in Table 4 shows that higher hulling efficiency was noticed in Gulyal variety followed by Maruthi, which significantly differed over Asha. The maximum finished product recovery was recorded in Gulyal (59.7%) followed by Maruthi (55.0%), which significantly differed over Asha (43.4%). The significant difference was observed on milling responses of pigeonpea grain due to influence of different concentrations of sodium bicarbonate. The results on effect of different levels of sodium bicarbonate treatment on hulling efficiency indicated that high hulling efficiency was recorded at Level III (68.6%) which was on par with Level I (68.3%) and significantly differed over Level II (67.1%) and control (43.3%). Since hulling efficiency of 68.6 and 67.1% are not significantly different as control which is 43.3%. Similar results were observed with the finished product recovery. The interaction effect was found to be significant. The sodium bicarbonate solution replaces Ca, K and P ions present in the lipid bi-layer of seed membrane and makes it porous thereby increasing finished product recovery and hulling efficiency (Srivastava et al.

Fig. 2 Optimization of different treatment for milling responses of selected pigeonpea varieties (n=3)

1998). Higher hulling efficiency was recorded in sodium bicarbonate treated pigeonpea (4 to 6%). The use of sodium bicarbonate as pre treatment to loosen the seed coat of pulses and to improve the *dhal* yield have also been suggested by Singh et al. (2004) and Deshpande et al. (2007).

Acetic acid treatment

The data is clearly indicated in Table 5 that, higher hulling efficiency was recorded in Maruthi (67.3%), which significantly differed over rest of the varieties. The interaction effect of different varieties and levels on hulling efficiency and finished product recovery of pigeonpea was found to be significant. The reason for the maximum hulling efficiency and finished product recovery at different levels for different varieties may be due to the behaviour of pigeonpea varieties at different levels of acetic acid. Similar trend was reported by Singh and Sokhansanj (1984) with average hulling efficiency of 74.5%.

Plant Growth Promoting Rhizobacteria (PGPR) treatment

The data obtained for milling responses on treated with PGPR are presented in Table 6. The higher hulling efficiency was noticed in Gulyal (59.3%) followed by Maruthi (52.7%) which were superior to Asha (46.6%). Similar results were observed with finished product recovery. The increase in both Hulling efficiency and finished product recovery is shown in Table 6 for milling responses on pigeonpea treated with PGPR. The interaction effect was found to be significant. It was also observed that Gulyal was having good milling response over the other two varieties. There were no earlier reports on these aspects for comparison on milling response of different varieties at different levels of PGPR treatment.

Optimized pretreatments for hulling of pigeonpea varieties

Figure 2 illustrates the effect of different treatments on milling responses of the three varieties over control. It is evident that Gulyal recorded maximum hulling efficiency (79.4%) and finished product recovery (68.8%) from mustard oil treatment followed by sodium bicarbonate treatment which was superior over the control. However, in Maruthi, maximum hulling efficiency (76.5%) and finished product recovery (66.0%) was recorded from acetic acid treatment followed by mustard oil and sodium bicarbonate treatments. In case of Asha variety, higher hulling efficiency (56.9%) and finished product recovery (47.6%) was recorded from acetic acid treatment followed by sodium bicarbonate treatment with 54.5% hulling efficiency and 46.7% finished product recovery. This might

be due to the different mechanisms of different treatments involved in loosening the husk from the cotyledons and distinct varietal characteristics of pigeonpea.

Conclusion

The three different pigeonpea varieties were selected for study using CFTRI mini *dhal* mill to estimate the hulling efficiency and product recovery with different treatments. All the pretreatments have shown significant variation in hulling efficiency and finished product recovery among the three varieties. Therefore, it was concluded that in mustard oil (0.3%) treatment, the hulling efficiency of 79.4% (RMSE is 0.7 at 1% CD is 1.0) and finished product recovery of 68.8% (RMSE is 0.7 at 1% CD is 1.0) was significantly higher for Gulyal, which was superior over other treatments and varieties. While the PGPR treatment gave minimum values of hulling efficiency and finished product recovery for all the three varieties viz. Asha (50.8% and 44.0%), Maruthi (62.1% and 51.6%) and Gulyal (62.9% and 52.9%), respectively. Hence, mini *dhal* mill is appropriate for processing of pulses, among three varieties with different treatments. The gulyal variety found maximum *dhal* recovery as compared to Maruthi and Asha variety.

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