Development and quality evaluation of quick cooking *dhal*—A convenience product

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Abstract Owing to rapid urbanization and more women joining the workforce, use of ready-to-eat and ready-to-use convenience foods is gaining increasing popularity. Women require dhal that cooks fast and increases in volume when cooked. In an attempt to prepare quick cooking dhal from pigeon pea, variety UPAS 120 was milled, pre-treated with sodium chloride solution (1%), flaked and dried. The quick cooking dhal was packed in three packaging materials, namely, high molecular weight high density polyethylene (HMHDPE), high density polyethylene (HDPE) and laminated pouches. The quality evaluation of the prepared flakes with respect to the cooking quality attributes, changes in proximate composition, free fatty acid (FFA) and peroxide value (PV) were carried out during storage at ambient temperature (8–36°C) at regular intervals for a period of 10 months. During storage, quick cooking dhal packed in laminated pouches performed better than samples stored in other pouches with respect to the changes in the overall quality and acceptability of the product.

Keywords Pigeon pea · Convenience · Quick cooking *dhal* · Cooking time · Storage · Overall acceptability

Pigeonpea (*Cajanus cajan*) is traditionally processed into consumable forms by methods which can be broadly

divided into two categories: primary processing (or dehulling) to form *dhal* and secondary processing that involves cooking, germination and fermentation. India is the largest producer (81.49%) and consumer of pigeon pea in the world (Ghadge et al. 2008) and almost all pigeonpea is milled to produce *dhal* (Faris and Singh 1990). Out of 14.5 million tons of pulses, nearly 11 million tons are converted to *dhal* in India (Jain and Doharey 2009). *Dhal* is popular because dehulling pigeonpea greatly reduces its cooking time and improves the appearance, texture, palatability, digestibility and bioavailability of nutrients of the grain. The cooking quality of pigeonpea is primarily assessed by its cooking time. With the increased urbanization and number of working-women, there is a need to develop products that need less preparation time in households. Since pigeonpea requires considerable cooking time about 32–68 min (Narasimha and Desikachar 1978), there is a need to have quick cooking pigeonpea *dhal*. These foods are especially suited for operational pack rations of armed forces because of their light weight, easy cooking characteristics and long shelf life. Greater emphasis is being given for marketing the new products of legumes such as quick cooking *dhal* or instant *dhal* of grain legumes which have good market potential (Singh 2007). Because pulses are an important source of proteins, calories and vitamins, they have the potential to alleviate protein-energy malnutrition (Ghadge et al. 2008). However, the consumption of pulses is impaired by two factors. Firstly the naturally occurring antinutritional factors and secondly the hard-to-cook (HTC) defect which develops when they are stored at high temperature and humidity conditions. The cooking process not only improves the palatability of pigeonpea but it destroys or minimizes some antinutritional factors (Salunkhe 1982; Singh 1993). Pulses with hard-to-cook defect require extended time to cook and have decreased

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protein, starch, vitamin availability and poor textural quality which ultimately reduce the consumer preference and acceptability (Phillips et al. 2003). Taking this into consideration present investigation was carried out with the objective to develop quick cooking *dhal* from pigeon pea and to evaluate it for changes in cooking quality and nutritional attributes during storage.

Materials and methods

Procurement of raw material UPAS 120 variety of pigeon-pea was obtained from the Pulse Laboratory, Division of Genetics, Indian Agricultural Research Institute, New Delhi.

Dehulling and pretreatment Whole seed samples of UPAS 120 were processed into *dhal* (decorticated split cotyledons) by using an abrasive type dehulling machine (Satake model). *Dhal* was pretreated by solution of sodium chloride (1.0%) by soaking for 2 h in the salt solution at ambient temperature. After soaking the excess solution was drained and samples were dried in a tray drier at 50°C for an hour (Singh and Rao 1995) till moisture content of 25–30%. The moist pretreated samples were flaked using a hand operated laboratory scale *dhal* flaker consisting of two rollers, rotating in opposite directions that was developed in the Division and again dried to moisture content of $6.0 \pm 0.5\%$ in a dehydrator.

Packaging and storage The prepared quick cooking *dhal* (100 g) was packed in three packaging materials, viz., HDPE 1 (200 gauge), HDPE 2 (150 gauge) and laminated pouches and stored under ambient conditions (8–36°C). The quick cooking *dhal* samples were analyzed after every 2 months for changes in cooking time, physico-chemical and organoleptic attributes till a period of 10 months.

Chemical constituents Moisture content of 10 g of whole *dhal* was determined by hot air method by exposing to 100°C for 72 h (Sahay and Singh 1994). Proximate composition was determined in the finely ground flour obtained from the *dhal*. Ash and nitrogen were determined by AOAC methods (1986). Protein values were obtained by multiplying the nitrogen value with 6.25. Fat was estimated by soxhlet extraction with petroleum ether (60–80°C) for 16 h. The free fatty acid content (as percentage oleic acid) and peroxide value in the stored quick cooking *dhal* was determined by the method described in AOAC (1986).

Cooking time Cooking time was determined by cooking the *dhal* in distilled water until it softened to uniform mass,

when pressed between the thumb and forefinger as described by Singh et al. (1984). *Dhal* sample (10 g) was boiled in 50 mL distilled water. During boiling, samples were removed at 1 min intervals and examined for softness. The time taken to achieve the desirable softness was recorded as the cooking time of the sample.

Solids dispersed The percentage of solids dispersed into the cooking water was determined by the method described by Singh et al. (1984). 5 g *dhal* was boiled for 25 min and the material was passed through a sieve and residue was washed thoroughly with distilled water. After washing, the residue was dried at 100°C for 3 h. The loss in weight of *dhal* after boiling was calculated as per cent solids dispersed into the cooking water.

Water absorption Five gram of *dhal* was taken in a digestion tube and boiled in excess distilled water (35 mL) for 25 min. The excess water, after boiling, was decanted and the *dhal* was weighed. The amount of water taken up by the *dhal* was calculated and the results are expressed as per cent water absorption.

Sensory analysis The freshly boiled quick cooking *dhal* was subjected to sensory analysis for quality attributes such as colour, texture, flavour, taste and overall acceptability by a semi-trained panel of eight members on a 9 point hedonic scale (Amerine et al. 1965). A spice mix constituting of salt 0.9 g, turmeric 0.4 g, red chilli powder 0.2 g, *garam masala* 0.2 g, black pepper 0.4 g, ginger onion garlic powder (1:1:1) 2.0 g and coriander powder 0.5 g per 100 g of prepared *dhal* was also developed to be added to the quick cooking pulse for enhancement of its sensory attributes.

Statistical analysis The values were determined using three replications. Statistical analysis of data was carried out by Analysis of Variance (ANOVA) technique on factorial Completely Randomized Design (CRD) following the standard procedure (Snedecor and Cochran 1995) to determine significance of difference amongst treatments and Duncan's multiple range test for comparing the means to find the effect of treatments on various parameters.

Results and discussion

The values for moisture, protein, fat and ash for raw pigeonpea were 7.64, 27.62, 2.71 and 3.01%, respectively whereas the quick cooking *dhal* was found to have 6.0, 25.13, 1.99 and 1.97%, respectively. Data on changes in moisture and protein is given in Table 1. During storage period of 10 months, the moisture content of the stored samples increased significantly in case of samples packed

Table 1 Chemical changes in quick cooking *dhal* stored under different packaging materials at ambient temperature (8–36°C)

Packaging material (P)	Storage period (months)(S)						
	0	2	4	6	8	10	Mean
Moisture (%)							
HDPE 1	6.0	6.1	6.1	6.4	6.4	6.5	6.26
HDPE 2	6.0	6.2	6.2	6.4	6.7	6.8	6.39
Laminate	6.0	6.0	6.1	6.1	6.2	6.3	6.13
Mean	6.0	6.1	6.1	6.3	6.5	6.5	
CD($P=0.05$)	P		0.02				
	S		0.03				
	P × S		0.05				
Protein (%)							
HDPE 1	23.6	23.6	23.7	23.3	22.3	22.3	23.1
HDPE 2	23.6	23.5	23.6	23.2	22.9	22.3	23.2
Laminate	23.6	23.6	23.6	23.5	23.0	22.6	23.7
Mean	23.6	23.6	23.6	23.5	23.0	22.6	
CD(0.05)	P		0.07				
	S		0.10				
	P × S		0.18				
Fat (%)							
HDPE 1	1.99	1.99	1.97	1.94	1.88	1.88	1.94
HDPE 2	1.99	1.98	1.96	1.94	1.90	1.89	1.94
Laminate	1.99	1.99	1.96	1.94	1.91	1.89	1.95
Mean	1.99	1.99	1.96	1.94	1.89	1.89	
CD(0.05)	P		0.005				
	S		0.74				
	P×S		0.012				
FFA (% oleic acid)							
HDPE 1	0.93	0.93	0.97	1.03	1.12	1.44	1.07
HDPE 2	0.93	0.95	0.97	1.17	1.45	1.57	1.17
Laminate	0.93	0.93	0.95	1.01	1.09	1.40	1.05
Mean	0.93	0.94	0.96	1.07	1.22	1.47	
CD(0.05)	P		0.08				
	S		0.11				
	P × S		0.21				
PV (meq O ₂ /kg)							
HDPE 1	0.9	0.96	10.30	14.9	32.63	82.00	23.61
HDPE 2	0.9	2.03	13.4	23.60	47.56	96.7	30.70
Laminate	0.9	1.00	9.03	15.00	28.06	75.36	21.56
Mean	0.9	1.33	10.9	17.8	36.10	84.69	
CD($P=0.05$)	P		1.53				
	S		2.17				
	P × S		3.76				

($n=3$), FFA Free fatty acids, PV Peroxide value, HDPE 1 = High density polyethylene (200 gauge), HDPE 2 = High density polyethylene (150 gauge)

in all the three packaging materials with minimum increase in laminated pouches. HDPE 2 (150 gauge) packed samples showed maximum increase in moisture from initial of 6.04% to 6.39%. Moisture content of pigeonpea seeds was reported to vary markedly during storage period of 6 months with an overall increase from 8.49% to 9.80% in cloth bags

(Talawar 2005). It was observed that during storage there was a slight reduction in the protein and fat content in case of all the samples. Protein content reduced from initial 23.63% to 22.63% after 10 months of storage. Earlier Pushpamma and Vimla Reddy (1979) also reported a loss of 0.59 to 0.70 g protein per 100 g in rice and 0.51 to 0.74 g

per 100 g in *jowar*. A study on home-level storage of legumes for 9 months was conducted in rural areas in Andhra Pradesh by Pushpamma and Chittemma Rao (1981). They observed a progressive decrease in protein content during storage of all the legumes with a maximum loss in green gram (11%) after 9 months of storage. Leterme (2004) has also reported partial protein hydrolysis during long term storage of legumes at high temperature and humidity. Peace et al. (2006) studied the effect of storage on the protein nutritional quality of grain legume and found out that little change in legume amino acid contents and only slight changes in relative net protein ratio (RNPR) and true crude protein digestibility occurred over the three years.

Pre-cooked and dried pulses have been reported to undergo rapid autooxidation during storage (Patki and Arya 1994; Semwal et al. 1994) leading to disappearance of yellow colour and formation of off flavour. The free fatty acid (FFA) value and peroxide value (PV) are indicators of autooxidation/rancidity. Although there was a non-significant increase in the two parameters during the entire period of storage (Table 1), the quick cooking *dhal* remained acceptable till the end. In the present study, for all the samples, peroxide value increased significantly during storage period of 10 months from an initial value of 0.9 meq O₂/ kg fat to final value of 30.7 meq O₂/ kg fat in HDPE 2 (150 gauge) packed samples. Minimum changes in PV (21.56 meq O₂/ kg fat) were observed in samples packed in laminated pouches. Arya and Rudramma (2000) reported an increase in PV values of the flaked *dhal* from 1.3 meq O₂/ kg fat to 135 meq O₂/ kg fat after a storage period of 10 months at 37°C stored in laminate packs, whereas Nayak et al. (2004) reported an increase from 0 to 100 meq O₂/ kg fat at 25±1°C in polyethylene pouches.

The relevance of free fatty acids (FFA) in monitoring degradation cannot be ignored as the formation of organic acids and free fatty acids is an initial step in fat deterioration, development of rancidity and off flavours in foods. The FFA contents in stored quick cooking *dhal* increased progressively and significantly ($P<0.05$) with the advancement of storage (Table 1). Differences were also observed in the FFA content of samples packed in different packaging materials. Of the three packaging materials used, the highest values of FFA (1.17%) were recorded for samples packed in HDPE 2 (150 gauge) pouches while lowest (1.05%) FFA were found in laminated pouches. Nayak et al. (2004) also reported FFA values to be lowest (4.86%) in laminated pouches at the end of storage period of 105 days. The rate of autooxidation of fats as measured by PV and FFA was highest in samples packed in HDPE 2 (150 gauge) pouches. The lower values recorded for all samples is an

indication of low fat content in the *dhal* and the effectiveness of salt as a preservative acting by excluding unwanted organisms, retarding activities of others and therefore delaying oxidative degradation. Arya and Rudramma (2000) suggested the increase in the lipid autooxidation owing to the high surface area of the flaked *dhal*. Sharma et al. (2000) also reported a significant change in the fatty acid composition of free and bound lipids with respect to processing method and storage temperature of instant red gram *dhal*.

The cooking quality of *dhal* is a function of the duration of cooking i.e., the time required to attain desired softness, amount of water absorbed, solids dispersed and texture of the cooked *dhal*. From consumers point of view, the cooking quality is also judged to some extent on increase in volume after cooking, higher dispersability of solids into cooking media and improved texture after cooking. It was observed that the cooking time of the quick cooking *dhal* increased significantly (Fig. 1) during the storage period in case of all the samples. It was observed that the cooking time initially was 6 min and after 180 days of storage it was 9.5 min and after 300 days of storage it increased to 19 min (more than three fold) which is attributed to the hard-to-cook (HTC) defect leading to the increase in cooking time. Earlier workers (Gracia and Lajolo 1994; Liu 1995) also reported HTC defect in legumes. They reported high temperature (> 25°C), high RH (>65%) and time of storage were the three factors that induce this defect. During the month of July and August which coincides with the monsoon period, humidity was around 59–80% and temperature ranged from 26–36°C. Due to high humidity and temperature, sharp increase in cooking time was observed in 240 days stored samples. The maximum changes were observed in *dhal* samples stored in HDPE 2 (150 gauge) pouches. The variations in cooking time in different packaging materials were almost same. This finding is in agreement with the observations of Singh et al. (2003), Gulati et al. (1997) and Vimla and Pushpamma (1987). Balamaze et al. (2008) studied the influence of variety and storage conditions on development of hard-to-cook defect in beans and found that storage of beans, especially at temperatures higher than 25°C, and relative humidity greater than 65%, led to development of the hard-to-cook (HTC) defect which resulted in increased cooking time, fuel and water use. The increase was highest for beans stored in polypropylene bags and plastic buckets while beans stored in the sisal bags and earthenware had the least increase. Singh et al. (2003) observed maximum change in cooking time in *dhal* samples stored in jute bags as compared to polyethylene bags and polylined bags. Leterme (2004) observed that storage of beans for 6 months at 37°C and 76% RH

Fig. 1 Changes in **a** cooking time, **b** solids dispersed, **c** water absorption and **d** sensory overall acceptability (OAA) of quick cooking *dhal* stored in different packaging materials at 8–36°C. Means with different letters differ significantly ($p < 0.05$) ($n = 3$)

increased the cooking time 5-fold and the hardness of the seed 2.5-fold.

With regard to changes in percentage of solids dispersed in the cooking media and the water absorption parameters, it was found that as storage period progressed there was a significant decrease in the solids dispersed and the water absorption of all the samples (Fig. 1) in conjunction with a progressive increase in the cooking time. The present findings are in agreement to the results obtained by earlier workers Manimekalai et al. (1979) and Singh et al. (1984) wherein the amount of solids dispersed in cooking water and water uptake were negatively correlated with cooking time. In case of *dhals*, it is the water absorbing capacity and solids dispersed (%) that makes the difference in cooking time. The water absorbing capacity depends on cell wall structure, composition of seed and compactness of the cells in the seed (Rosaiah et al. 1993). Owing to the HTC defect occurring during storage, the water absorption and the solids dispersed during cooking decreased in all the samples. Earlier reports also indicate an increase in the cooking time and a simultaneous reduction in water uptake with progressive increase in storage period of green gram, black gram, pigeonpea and chickpea (Pushpamma and Vimala 1984).

Data on overall acceptability of the quick cooking *dhal* is given in Fig. 1. It is evident that even though the cooking time of *dhal* increased, the quick cooking *dhal* was very much acceptable organoleptically till end of storage period of 10 months. Least changes in cooking quality and chemical characteristics were found in the samples packed in laminated pouches. Nayak et al. (2004) also observed polyester-aluminum-polyethylene laminate packaging material to be most suited for maximum stability and best sensory quality of the *dhal*.

Conclusion

On the basis of results obtained it can be concluded that cooking time of the *dhal* can be decreased by giving pretreatment with salt solution followed by flaking. The quick cooking *dhal* thus developed could be stored upto 6 months without any appreciable increase in cooking time as well as loss of nutritional value and organoleptic quality. Although the results are based on the analysis of one pigeonpea cultivar 'UPAS 120', it is evident that treatment with sodium chloride followed by flaking is effective in reducing the cooking time of pigeonpea *dhal*.

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