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Process optimization for instant pigeonpea (*Cajanus cajan* L.) dal using $NaHCO_3$ (Sodium bi-carbonate) pretreatment

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ABSTRACT

$NaHCO_3$ (sodium bicarbonate) was used in the soaking treatment for preparation of instant pigeonpea dal. The combination of three factors, salt concentration (0.5 – 1.0%), cooking time (8–12 minutes) and flaking thickness (0.5mm – 1.0 mm) were used for the product development. Four sensory parameters; colour, odour, taste and overall acceptability and two instantisation parameters namely reconstitution time and rehydration ratio were evaluated. A combination of salt concentration of 0.80%, cooking time of 10 minute and flaking thickness of 1.0 mm was found to be the optimum combination for the developed product.

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Key words : Reconstitution time, Rehydration ratio, Flaking, Pigeonpea, Instant dal

INTRODUCTION

Pulses occupy an indispensable place in our daily diet as a source of protein. It serves as the cheapest source of proteins and rich in lysine for which the lysine deficient cereal diets are supplemented with that of pulses (Bongirwar and Srinivasan, 1971). Black gram, pigeonpea, green gram, pea etc. are the main legume crops grown in India. After chickpea, pigeonpea (*Cajanus cajan* L.) is the second largest legume crop grown in India. It is mainly consumed in dehusked split form, commonly called as dal or dhal. Dal takes a longer cooking time to come to the desirable gruel form which is an essential part of the Indian palate (Bhuibhar, 1991). People, especially in the urban areas, cannot devote their precious time and full attention to this lengthy cooking procedure. Hence, preparation of ready to eat "Instant Pigeonpea Dhal" is the need of the hour.

Some efforts have been made to develop the quick cooking pulses by understanding the influence of various processing parameters on the cooking time of the pulses. Dehusking and splitting of pulses is widely used to reduce the cooking time of pulses and being commercially exploited (Kon *et al.,* 1973; Desikachar and Subramanya, 1961 and Eduardo Beuno Carro *et al.,* 1980). Cooking time of the kidney beans reduced considerably by soaking the beans for the duration of 8 hours and pressure cooking at 13 psi for the duration of 20 minutes of freezing and dehydrating (Charles *et al*., 1956). Coating of precooked beans with that of sugar solution followed by the dehydration was used to reduce the cooking time by Steinkraus *et al.* (1964). The beans were ready for the consumption after boiling for 30 minutes and had smooth uniform texture. Bhuibar *et al.* (1991) studied on the instantization process of redgram dhal. They dried the redgram sample in a laboratory scale fluidized bed dryer at three different temperatures *i.e.* 60, 70 and 80^{0}C. They found that, time of dehydration of the precooked dhal decreased as the drying temperature increased. The percentage reduction in the cooking time (35 minute), was 80 – 84 % when cooking in the boiling water as compared to 34 – 42 % and 57 – 64 % in normal water at 35^{0}C and hot water at 70^{0}C, respectively.

Patki and Arya (1994) prepared both spiced and unspiced bengal gram (*Cicer arietinum* L.) , Black gram (*Phaseolus mungo* L.) and redgram (*Cajanus cajan* L.) dhal flakes by soaking the split dhal in sodium chloride and sodium carbonate solution. The raw material cooked under 15psi steam pressure, conditioned to 32% – 35 % moisture content, flaked to different thickness and then dried to a moisture content of 5 % at 100^{0}C. The flaked dhals reconstituted within 3 minute when mixed with hot water (90-95^{0}C). Singh and Rao (1995) experimented on the influence of salt solution as pretreatments on the preparation of quick cooking dhal. Salt solution (1% w/v) used individually were those of sodium chloride, sodium bicarbonate and sodium tripoly phosphate. The salt mix

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solution used was of 2.5 % sodium chloride, 1.0 % sodium tripoly phosphate and 0.75 % sodium bicarbonate. Sodium carbonate solution was the most effective in reducing the cooking time and that was followed by salt mix and the sodium bicarbonate solution. The objective of the present research work was to find-out the optimum combination of process variables to get the desired product.

MATERIALS AND METHODS

Milling of pigeonpea:

The experiments were conducted on a hybrid variety of pigeonpea (Pusa –33) procured from the Pulse Research Laboratory, IARI, New Delhi so as to ensure the genetic purity. The milling of the pulses was carriedout in a mini dhal mill developed in the Division of Agril. Engg., I.A.R.I. New Delhi. Different fractions such as split dhal, dehusked full pulses, unhusked pulses, husk, chuni etc. were collected in separate outlets.

Experimental plan:

A second order Box-Behnken design in three variables at three levels was used to optimize the products. The independent variables were salt concentration, cooking time and flaking thickness. The coding of the variables was done using the following equation

$$X_1 = \frac{\text{Salt concentration} - 0.75}{0.25}$$

$$X_2 = \frac{\text{Cooking time} - 10.00}{2.00}$$

$$X_3 = \frac{\text{Flaking thickness} - 0.75}{0.25}$$

The coded and the uncoded values of the independed process variables and their levels are given in Table 1.

Table 1 : Coded and uncoded process variables

Independent variables	Symbol		Levels	
	Coded	Uncoded	Coded	Uncoded
Salt concentration			-1	0.5
(%)	X_1	C	0	0.75
			+1	1.0
Cooking time			- 1	8.0
(minute)	X_2	T	0	10.0
			+1	12.0
Flaking thickness			-1	0.5
(mm)	X_3	T	0	0.75
			+1	1.0

Preparation of instant pigeonpea Dhal:

The process of making instant dal from split pulses (obtained from mini dal mill) consisted of unit operations *viz.,* soaking, cooking, initial drying, flaking and final drying

Measurement of response:

For optimization of the process, of making instant pigeonpea dhal, six different responses were studied. Out of these six different responses, four are sensory in nature and other two namely reconstitution time and rehydration ratio are instantisation parameters.

Sensory evaluation:

To evaluate the sensory parameters, 5 g of sample of flaked dhal was added to 10 ml of hot water (90 – 95^{0}C) in a beaker kept over the water bath. After two minute, the flakes were stirred with a spoon. The consistency of the slurry was maintained to such a degree that it is acceptable to the consumers. This reconstituted samples were evaluated for colour, odour, taste and overall acceptability on a nine point hedonic scale by a panel of 10 members, with score 9 for excellent and 1 for highly disliked.

Reconstitution time:

5g flaked dhal sample was put into 100 ml of distilled water kept in the beaker at a temperature of 90 – 95^{0}C. After 3 minute, flakes were drawn from the beaker with the help of a spoon at every 0.5 minute interval. Then it was pressed in between two glass plates, until no hard materials was found. This time was recorded as the reconstituted time of the sample.

Rehydration ratio:

To determine the rehydration ratio 1g of sample was put into the boiling water (90 – 95^{0}C) by keeping the beaker over the water bath. After 3 minute, the contents was filtered through the filter paper. The rehydrated sample was then weighed, and the recorded weight called the rehydrated weight (R_w). The rehydration ratio was computed using the following equation

Rehydration ratio = wt. of rehydrated sample / wt. of dehydrated weight

Data analysis and optimization:

The data of the six different responses studied, were fitted into the second order polynomial model of the following form using SAS software package.

RESULTS AND DISCUSSION

The results of the present study alongwith relevant discussion have been presented as under:

Model fitting:

Experimental values were obtained for six responses at the design points (Table 2).

The colour score varied in the range of 6.00-7.62. The highest score was obtained at the combination levels for Expt. No 2 *i.e.* salt concentration, cooking time and flaking thickness values of 1.00%, 8 minute and 0.75 mm, respectively. Whereas, minimum values obtained at the combination level of 0.5%, 8 minute and 0.75 mm (Expt.No. 4).

The odour score varied from 5.62 (Expt.No. 4) to 7.75 (Expt.No 2). The combinations for these experimental runs were same as that for colour *i.e.* 0.5%, 8 minute and 0.75 mm and 1.00%, 8 minute and 0.75 mm, respectively.

The highest taste score of 7.19 was obtained for the experimental run combinations in Expt. No.16, *i.e.* 0.75%, 10 minute and 0.75 mm. The minimum value, 6.00 (Expt.No. 1) was obtained at 1.00%, 12 minute and 0.75mm flaking thickness, respectively.

The overall acceptability score ranged from 5.72 (Expt.No. 4) to 7.50 (Expt.No.2). The combination of levels were 0.50%, 8 minute and 0.75 mm and 1.00%, 8 minute and 0.75 mm, respectively.

It was observed that the sensory scores obtained in all combinations were in the acceptable range (>5) with the confirmation of earlier findings of Patki and Arya (1994) and Singh and Rao (1995).

The reconstitution time for all 16 combination of levels varied from 4.33 (Expt. No. 8) – 9.83 (Expt. No. 5); whereas, the rehydration ratio ranged from 1.70 ((Expt. No. 14) to 2.76 (Expt. No. 9)

Analysis of variance (ANOVA) for response variables (Table 3) indicated that, models were effective at 5% level of significance ($p<0.05$) for the responses odour and taste and at 10% level of significance ($p<0.10$) for overall acceptability and rehydration ratio. Model fitting showed that the linear effect was significant only in the case of instantisation responses *i.e.* reconstitution time and rehydration ratio. Quadratic effect of models was significant only in the case of taste, whereas, the interaction/cross product effect was significant for colour, odour and overall acceptability.

All models showed no lack of fit to the responses. The coefficient of determination (R^2) of the regression models varied from 77.1% to 90.9% indicating that models developed for all six response variables were adequate.

Optimization:

Optimum levels of the process variables were calculated by using SAS package. The criteria applied for optimization was to find the combination of the variable levels to obtain the product of maximum overall acceptability score with all other responses values in the acceptable range.

Further experiments were conducted keeping the

Table 2 : Box-Behnken design arrangement and responses values

Expt. No.	Coded variables			Sensory parameter				Instantisation parameters	
	X_1	X_2	X_3	Colour	Odour	Taste	Overall acceptability	Reconstitution time	Rehydration ratio
1	1	1	0	6.25	6.44	6.00	6.20	7.83	2.50
2	1	-1	0	7.62	7.75	6.12	7.50	6.83	1.89
3	-1	1	0	7.15	7.22	6.50	6.85	5.83	2.46
4	-1	-1	0	6.00	5.62	6.11	5.72	6.35	1.87
5	1	0	1	7.33	6.62	6.61	6.66	9.83	2.08
6	1	0	-1	6.75	7.14	6.87	6.93	5.51	2.53
7	-1	0	1	7.00	7.12	7.00	7.00	9.33	1.96
8	-1	0	-1	7.35	6.38	6.85	6.55	4.33	1.94
9	0	1	1	6.75	6.85	6.62	6.87	8.16	2.76
10	0	1	-1	6.75	6.16	6.90	6.70	6.16	2.39
11	0	-1	1	6.12	6.00	6.12	6.37	7.00	1.80
12	0	-1	-1	7.37	6.92	6.75	7.12	6.16	1.80
13	0	0	0	6.75	6.50	6.75	6.61	5.16	1.99
14	0	0	0	6.66	6.62	6.77	6.75	5.83	1.70
15	0	0	0	6.97	7.09	6.94	6.75	7.33	1.90
16	0	0	0	7.48	6.81	7.19	7.20	5.16	2.17

Table 3 : ANOVA and model fitting for response variables

Source	Df	Sum of square					
		Colour	Odour	Taste	acceptability	Reconstitution time	Rehydration ratio
Regression/Model	9	2.720	3.771**	1.754**	2.169***	26.089	1.269***
Linear	3	0.160	0.342	0.328	0.192	21.002**	1.019**
Quadratic	3	0.365	0.267	1.288*	0.160	4.060	0.160
Cross product	3	2.194**	3.161*	0.137	1.817**	1.026	0.089
Error/Residual	6	0.807	0.377	0.224	0.426	8.546	0.269
Lack of fit	3	0.402	0.178	0.099	0.228	5.404	0.148
Pure Error	3	0.404	0.198	0.124	0.198	3.141	0.114
Coefficient of determination (R^2)	%	77.1	90.9	88.7	83.6	75.3	82.9

*, ** and *** indicate significance of values at P=0.01, 0.05 and 0.10, respectively

Table 4 : Optimum levels of process variables and response values at optimum combination

Symbol	Coded	Uncoded	Colour	Odour	Taste	Overall acceptability	Reconstitution time	Rehydration ratio
Salt concentration (%)	0.2045	0.8011						
Cooking time (minute)	-0.0107	9.978	7.66	7.91	8.16	7.83	7.33	2.76
Flaking thickness (mm)	0.5761	0.894						

variable values at their optimum level. The product thus obtained was subjected to both sensory and instantanized parameter evaluation.

The values of the variables at optimum level (both in coded and uncoded form) and the response values obtained at the optimum combination point are shown in Table 4. The colour, odour, taste and overall acceptability score obtained at optimum combination levels were 7.66, 7.91, 8.16 and 7.83; thus showing the values well above the score of 5. Hence, the product is highly acceptable at optimum combination points. The reconstitution time was less than 8 minute and the final product was with a rehydration ratio of 2.76. Hence, at optimum level combination the product is highly acceptable with desired instantaisation parameter values. The results confirms with the findings of Patki and Arya (1994) and Singh and Rao (1995).

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