Product formulation from black gram and its evaluation for nutritional and sensory quality

Anjali Kanth, Kanchan Goswami and Pushpa Shukla

Anjali Kanth
Department of Foods and Nutrition, College of Home Science, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

Kanchan Goswami
Department of Foods and Nutrition, College of Home Science, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

Pushpa Shukla
Department of Foods and Nutrition, College of Home Science, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

Abstract
Black gram is cultivated in India and is the essential legume crops. It is used as whole, split beans and dehusked split beans (*dhal*). Due to better nutrient content and availability, new improved varieties of black gram are being evolved and there is little information available on them. So, the purpose of the study is to develop product using whole black gram and dehusked black gram of same variety (Pant U-31) and to assess the nutritional properties, shelf life and consumer acceptability of the developed product. *Badi* was prepared using whole black gram (Pant U-31) and was compared with dehusked black gram of same variety and was evaluated for sensory characteristics, nutrient composition and storage study for the period of 60 days. Results showed that during storage, obtained values were found to be in acceptable range for total plate count and it was observed that the *badi* packed in polyethylene pouches could be stored up to 2 months at room temperature safely. For sensory evaluation, the prepared *badis* were cooked in a vegetable curry preparation and was done using Nine Point Hedonic Scale and Score card method. Results of Nine Point Hedonic Scale showed that control *badi* curry was liked very much by 33.33% of panel members and *badi* curry prepared by whole black gram was liked very much by 46.66%. Statistical analysis of data obtained by score card method showed that there was non-significant difference in overall acceptability between *badi* curry prepared with dehusked black gram (control) and whole black gram. Nutrient composition of whole black gram (Pant U-31) *badi* curry revealed that it contained higher amount of fibre (3.31g), calcium (60.87 mg/100g) and iron (3.41 mg/100g) content than that of control (Dehusked black gram) *badi* curry of same variety.

Keywords: Black gram, shelf life, consumer acceptability, nutritional properties, nine point hedonic scale, score card method

Introduction

India is a major legume producing country in the world. Legumes serve as an economical source of complimentary proteins and also add variety to diet for human population. They contribute as high protein constituent in India (Sood *et al.*, 2002) [22]. Legumes are valued for their low glycemic index and high protein content so they are generally included in the diets of Indian subcontinent (Khandelwal *et al.*, 2010) [13]. Animal and plant proteins are commonly the two main sources of protein. Since animal proteins are costly, there is a need for alternative supplementation of protein by plant protein. Pulses contain protein of 220-250 g per kg whereas dry fish contain protein of 335g per kg. Thus pulses are considered as a "poor man's meat" (Nunes *et al.* 2006) [18]. The production and inclination of legumes vary in different countries (Ofuya and Akhidue, 2005) [19]. In India legumes are cultivated over an area of 24.8 million hectares with 17.2 million tonnes produced annually (DAC, New Delhi, 2015) [5]. Consumption of legume is higher in those parts of the world, where animal proteins are limited and costly. Being an inexpensive protein source, legumes can be replaced to meat and play an important role in eradicating protein-energy malnutrition. They are also a good source of vitamins, minerals and dietary fibre (Tharanathan and Mahadevamma, 2003) [24].
Pulses belonging to the family of leguminosae are the eatable portions of pod bearing plants are cultivated globally. Seeds of whole legume plant are of major concern to human as they are a rich source of protein ranging from 20-50% (Singh *et al.* 2004) [21]. Pulses are an excellent source of protein and amino acids and certain micronutrients such as iron and zinc. They also have low glycemic index and no cholesterol (Food and Agriculture Organization, 2016) [7]. Legumes reduce the risk of cardiovascular disease and diabetes (Jacobs & Gallaher, 2004) [11] mostly by the presence of phenolics and soluble dietary fiber (Enujiugha, 2010) [6].

Corresponding Author:
Kanchan Goswami
Department of Foods and Nutrition, College of Home Science, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

Pulses enhance the soil fertility and also used for green manure as fodder for livestock (Aggarwal *et al.,* 2004) [1]. Among all the legumes, black gram (*Vigna mungo* L.) is an essential legume crop.

It is consumed in Indian diet and Western diet since it is a very rich source of protein and performs an essential role in the diet of human nutrition. Proteins of black gram are digested in an easy manner and consist of satisfactory amount of sulfur containing amino acids. They are rich in vitamins and phosphoric acid. It is generally used as whole, split beans and dehusked split beans (dal) (Gowda, 2006) [9].

Black gram (*Vigna Mungo* L.), is one of the important pulses crop, grown throughout the country. The crop is resistant to adverse climatic conditions and improve the soil fertility by fixing atmospheric nitrogen in the soil. It has been reported that the crop produces equivalent to 22.10 kg of N/ha., which has been estimated to be supplement of 59 thousand tonnes of urea annually. The pulse 'Black gram' plays an important role in Indian diet, as it contains vegetable protein and supplement to cereal based diet. It contains about 26% protein, which is almost three times that of cereals and other minerals and vitamins. Besides, it is also used as nutritive fodder, specially for milch animals. Madhya Pradesh, Uttar Pradesh and Andhra Pradesh are major black gram growing states area-wise. The highest yield was recorded by the state of Bihar (898 kg/ha) followed by Sikkim (895 kg/ha) and Jharkhand (890 kg/ha). The National yield average is 585 kg/ha. The lowest yield was recorded in the state of Chhattisgarh (309 kg/ha) followed by Odisha (326 kg/ha) and J&K (385 kg/ha)

(https://vikaspedia.in/agriculture/crop-production/package-of-practices/pulses/blackgram-and-greengram).

According to Manay and Shadaksharaswamy (1987) [16], black gram contains mucilaginous arabinoglactins which is an essential constituent in *dosa, badi, idli* and several other food preparations. It helps in making sweet dishes like *imarti* and vada. It is also eaten as snacks in fried and salted form.

Papads, thin wafer like products prepared from black gram or combination of black gram with other pulses with and without spices are made in small scale industries or at homes (Srivatsava, 2015) [23]. Black gram flour was incorporated in buffalo meat burgers and it was stated to enhance burger quality (Modi *et al.*, 2004). Flour of black gram was added to biscuits to enhance its nutritional quality (Patel and Venkateswara, 1995) [20]. To increase productivity and enhance its utilization, new improved varieties of black gram are being evolved. Due to less information regarding their utilization in food present study was done to prepare product from whole and dehusked black gram.

Materials and Methods
Procurement of Raw Materials: The improved varieties (Pant U-8, Pant U-9, Pant U-31 and Pant U-35) of Black gram (*Phaseolus mungo* or *Vigna mungo*) were obtained from CRC (Crop Research Centre), G.B. Pant University of Agriculture and Technology, Pantnagar. The description of four black gram varieties under study is presented in Table I. Other ingredients used for *badi* curry preparations were purchased from local market of Pantnagar.

Table 1: Description of black gram varieties

Varieties of black gram	Origin	Pod		Seeds			Agronomic traits		
		Color of immature pod	Color of mature pod	Color	Shape	Size	Plant ht. (cm)	No. of pods/ plant	No. of seeds/ pod
Pant U-8	Pantnagar	Green	Black	Black	Oblong	Large	Mean: 43.1 Range: 37-66	34-44	5-7
Pant U-9	Pantnagar	Green	Black	Black	Oblong	Large	Mean: 44.6 Range: 31-64	31-49	5-7
Pant U-31	Pantnagar	Green	Black	Black	Oblong	Large	Mean: 71.4 Range: 54.2 – 90.2	34-45	5-7
Pant U-35	Pantnagar	Green	Black	Black	Oblong	Large	100	-	-

Product formulation
Nutritional evaluation of four varieties was carried out. The variety (Pant U-31) with the highest protein content was selected for product formulation. *Badi* was prepared using whole black gram (Pant U-31) and was compared with dehusked black gram of same variety and was analyzed for nutrient composition and storage study.

Preparation of *Badi*
Whole Black gram was washed thoroughly and soaked in double the amount of water for 12-13h. After draining and washing, the whole black gram was ground to paste by using household grinder while the control black gram was rubbed with hands to remove the seed coat and then was ground to paste.

The thick wet paste was made light and fluffy by incorporating air by wiping continuously with hand. The fluffy batter was divided with the help of hand into small balls and kept on the greased drying tray followed by drying in a cabinet tray drier at a temperature of 60±5 °C for 14-16 h till no further water loss occurred. The dried samples were stored in polyethylene bags for further analysis which included storage study and organoleptic evaluation (Kaur and Aggarwal, 2015) [12].

Storage study of *Badi*
Total Viable Count (APHA 1984) [4]: Total bacterial count of the samples was determined using Standard Plate Count (SPC) technique as given in compendium of methods for microbiological examination of foods (APHA, 1984) [4]. This technique gives total number of viable cells of bacteria present in the sample, therefore also called as total viable cell count (TVC) technique or serial dilution technique.

Moisture: Moisture content was determined using the procedure given by AOAC (1995) [3].

Preparation of *Badi* curry
For sensory evaluation, curry preparation was made using prepared baris from whole black gram and dehusked black gram. They were pressure cooked for 15 minutes and then, served hot to the panelists.

The ingredients used were

Ingredients	Quantity
Badi	50g
Onion	75g
Garlic paste	10g
Water	400ml
Oil	15ml
Salt	3g
Spices (red chilli powder, Garam masala, coriander powder)	7g

Method
- *Badi*s were roasted in oil till light brown in colour and kept aside.
- The oil was heated in a container and onion was added and roasted till golden brown.
- To this onion paste was added and fried for another 3 min. then spices and salt were added.
- Fried *badi*s were added the last followed by addition of 400ml water and cooking it for 15-20 min.

Sensory evaluation of *Badi* curry made from dehusked black gram and whole black gram
The prepared *badi* curry were evaluated for sensory characteristics using nine point hedonic scale and sensory score card (Amerine *et al*., 1965) [2] by semi trained panel consisting of 15 members from the Department of Foods and Nutrition.

Nutritional evaluation of developed product
The nutritive value of *badi* curry was calculated by using the data available in Indian Food Composition Tables by Longvah *et al.* (2017) [15]. The nutritive value of whole black gram was used from the result obtained in the present study. Energy, crude protein, crude fat, crude fibre, carbohydrates, physiological energy, calcium and Iron were calculated.

Statistical analysis
The statistical tools used for the analysis of the above data were Mean ± S.D and One-way ANOVA (Analysis of variance) Snedecor and Cochran (1980). Storage stability of

product were analyzed using these procedures. The aim of the analysis was to identify the significant difference in storage stability used in the present study.

Results and Discussion
Product development and evaluation
200gm of whole black gram were soaked in double the amount of water. The weight of black gram after soaking for 12 h was 388g. Total 334gm of *badi* was prepared from whole black gram.

Storage study of *Badi*
Black gram *badi* of improved variety (Pant U-31) which contained highest amount of protein were packed in High density polyethylene bags (HDPE) and were stored for two months at room temperature (17℃- 24℃). The stored sample was evaluated for 60 days at 15 day interval. The shelf life was evaluated on the basis of moisture content and total viable count. The results obtained are presented in Table 2 and Table 3.

Total viable count
There were less than 30 colonies in *badi* on 0 day of storage period. Microbial load increased with increasing time of storage. Microbial load reaches up to 1.71×10^3 cfu/g after 60 days of storage at room temperature. The obtained values were found to be in acceptable range for total plate count. Statistical analysis of data showed that there is significant difference during the storage period for 60 days. In general, the total viable count for papad is reported as 9.15×10^2 cfu/g (Veena, 2012) [25].

Table 2: Total Plate Count of *Badi* during the Storage Period

Total plate count (TPC) (cfu/g)	Storage period						
Product	0 Days	15 Days	30 Days	45 Days	60 Days	S.Em.±	CD at 5%
Badi	<30 [a]	0.94×10^{3} [b]	1.13×10^{3} [c]	1.47×10^{3} [d]	1.71×10^{3} [e]	0.401	0.126

All results are mean± standard deviation for three individual determinations.
Means in each row by different letters (a, b, c, d, e) are significantly different ($P \leq 0.05$)

Moisture Content
The moisture content of *badi* increased with increasing time of storage at room temperature. The moisture content increased from 6.93 per cent on the starting day of study to 7.3 per cent after 60 days. There was significant difference in *badi* on zero day, 30 days, 45 days and 60 days in moisture content but there was non-significant difference between 0

day and 15 days. It was observed that the *badi* packed in polyethylene pouches could be stored up to 2 months at room temperature safely. In deciding the storage stability of *badi,* moisture plays an essential factor and should be less than 11 per cent to prevent them from microbes and fungus (Kulkarni *et al.,* 1997) [14].

Table 3: Moisture Content of *Badi*

Moisture content (%) Storage period							
Product	0 Day	15 Days	30 Days	45 Days	60 Days	S.Em.±	CD at 5%
Badi	6.93±0.10 [a]	7.00±0.05 [a]	7.10±0.05 [b]	7.18±0.08 [c]	7.30±0.10 [d]	0.459	0.144

All results are mean± standard deviation for three individual determinations.
Means in each row by different letters (a, b, c, d) are significantly different ($P \leq 0.05$)

Sensory evaluation of *badi* curry
The sensory evaluation of *badi* curry prepared whole black gram and dehusked black gram (control) was conducted using nine point hedonic scale and score card method by 15 semi trained panels from the Department of Foods and Nutrition.

Sensory evaluation using Nine Point Hedonic Scale
The results of sensory evaluation of *badi* curry using Nine Point Hedonic Scale have been presented in Table 4. Sensory evaluation of *badi* curry by Nine Point Hedonic Scale taking black gram of one improved variety (Pant U-31) which is

highest in protein showed that *badi* curry prepared from whole black gram was liked very much by 46.66 per cent of the panel members, 26.66 per cent of the panel members liked it moderately, 20 per cent of the evaluators liked it slightly and 6.66 per cent of the panel members neither liked it nor disliked it. Control *badi* curry from dehusked black gram was liked very much by 33.33 per cent of the panel members, 46.67 per cent of the panel members liked it moderately, 13.33 per cent of the panel members liked it slightly and 6.67 per cent of the members disliked it.

Table 4: Sensory Score of *Badi* Curry of Selected Variety (Pant U-31) of Whole Black Gram and Dehusked Black Gram (control) Using Nine Point Hedonic Scale

Scale Product	Liked extremely	Liked very much	Liked moderately	Liked slightly	Neither like nor dislike	Disliked slightly
A (Pant U-31) (Control)	-	33.33%	46.66%	13.33%	-	6.66%
B (Pant U-31)	-	46.66%	26.66%	20%	6.66%	-

Sensory score of *badi* curry prepared from improved variety (Pant U-31) of dehusked black gram (Control) and whole black gram using score card method

The prepared *badi* curry were further evaluated for their sensory quality using Score Card method for five parameters namely; taste, color, appearance, sponginess, flavour and overall acceptability. The data have been presented in Table5.

Taste

Mean sensory score for taste of control *badi* curry prepared with improved variety of dehusked black gram (Pant U-31) ranged from 7.67 to 8.85, whereas for the *badi* curry made from improved variety of whole black gram (Pant U-31) ranged from 8.67 to 8.49. Control *badi* curry obtained a mean score of 7.66 whereas curry prepared from whole black gram obtained a mean score of 7.66. Statistically non-significant difference was found in the taste of curry prepared with dehusked black gram (control) and whole black gram *badi*.

Colour

Mean sensory score for colour of control curry prepared with improved variety of dehusked black gram *badi* (Pant U-31) ranged from 8.07 to 8.87, whereas for the curry made from improved variety of whole black gram *badi* (Pant U-31) ranged from 7.27 to 8.55. Control curry obtained a mean score of 8.06 whereas curry prepared from whole black gram *badi* obtained a mean score of 7.26. Statistical analysis of data showed that dehusked black gram curry (control) differed significantly in colour from whole black gram *badi* curry.

Appearance

Mean sensory score for appearance of control *badi* curry prepared with improved variety of dehusked black gram (Pant U-31) ranged from 7.93 to 8.16, whereas for the curry made from improved variety of whole black gram (Pant U-31) ranged from 7.07 to 8.23. Control *badi* curry obtained a mean score of 7.93 whereas *badi* curry prepared from whole black gram obtained a mean score of 7.06. Statistical analysis of data showed that dehusked black gram *badi* curry (control) differed significantly in appearance from whole black gram *badi* curry.

Sponginess

Mean sensory score for sponginess of control *badi* curry prepared with improved variety of dehusked black gram (Pant U-31) ranged from 7.53 to 8.27, whereas for the *badi* curry made from improved variety of whole black gram (Pant U-31) ranged from 6.13 to 7.49. Control *badi* curry obtained a mean score of 7.53 whereas *badi* curry prepared from whole black gram obtained a mean score of 6.13. Statistical analysis of data showed that dehusked black gram *badi* curry (control) differed significantly in sponginess from whole black gram *badi* curry.

Flavour

Mean sensory score for flavour of control *badi* curry prepared with improved variety of dehusked black gram (Pant U-31) ranged from 7.07 to 8.56, whereas for the curry made from improved variety of whole black gram (Pant U-31) ranged from 7.20 to 8.06. Control *badi* curry obtained a mean score of 7.06 whereas curry prepared from whole black gram obtained a mean score of 7.2. Statistically non-significant difference was found in the flavour of curry prepared with dehusked black gram (control) and whole black gram *badi*.

Overall acceptability

Mean sensory score for overall acceptability of control *badi* curry prepared with improved variety of dehusked black gram (Pant U-31) ranged from 7.47 to 8.53, whereas for the *badi* curry made from improved variety of whole black gram (Pant U-31) ranged from 7.37 to 8.34. Control *badi* curry obtained a mean score of 7.46 whereas curry prepared from whole black gram obtained a mean score of 7.36. Statistically non-significant difference was found in the overall acceptability of *badi* curry prepared with dehusked black gram (control) and whole black gram.

Table 5: Sensory score of *Badi* curry of selected variety (Pant U-31) of whole black gram and dehusked black gram (control) using score card method

Product Attributes	Dehusked black gram (Control) Pant U-31	Whole black gram Pant U-31	S.Em±	CD at 5%
Taste	7.67±1.18 [a]	7.67±0.82 [a]	0.261	0.756
Colour	8.07±0.80 [a]	7.27±1.28 [b]	0.275	0.797
Appearance	7.93±0.23 [a]	7.07±1.16 [b]	0.266	0.772
Sponginess	7.53±0.74 [a]	6.13±1.36 [b]	0.282	0.817
Flavour	7.07±1.49 [a]	7.20±0.86 [a]	0.313	0.908
Overall Acceptability	7.47±1.06 [a]	7.37±0.97 [a]	0.262	0.760

All results are mean± standard deviation for three individual determinations.
Means in each row by different letters are significantly different (*P*≤ 0.05)

Nutritive value of improved variety (pant u-31) of whole black gram and dehusked black gram *Badi* Curry (Control)

Nutritive value of improved variety (Pant U-31) whole black gram *badi* curry and dehusked black gram *badi* curry (control) per 100g was calculated by using the data available in Indian Food Composition Tables by Longvah *et al.* (2017) [15] whereas fibre content was calculated by using the data available in Nutritive value of Indian Foods by Gopalan *et al.* (2011) [8]. Results of nutritive value of dehusked (control) and whole black gram *badi* curry have been presented in Table 6. Nutritive value of *badi* curry prepared from dehusked black

gram i.e. control and whole black gram showed that fibre, calcium and iron content of whole black gram *badi* curry were higher than that of *badi* curry prepared from dehusked black gram while protein, fat, carbohydrate and energy content were higher in *badi* curry prepared from dehusked black gram.

Table 6: Nutritive value of selected variety (Pant U-31) of whole black gram *Badi* curry and dehusked black gram *Badi* curry (Control) per 100g

Products	Protein (g)	Fat (g)	Fibre (g)	Carbohydrates (g)	Energy (kcal)	Calcium (mg)	Iron(mg)
Dehusked black gram (Control)	13.34	1.04	1.13	34.86	880.55	45.61	2.76
Whole Black gram	12.80	0.98	3.31	31.35	812.05	60.86	3.41

Conclusion

In the present study results of shelf life of *badi* stored at room temperature revealed that total plate count increased from <30 to 1.76×10^3 cfu/g. Moisture content increased from 6.93% to 7.3%. However, the values obtained in the present study fall within the acceptable limit. For sensory evaluation, the prepared *badis* were cooked in a vegetable curry preparation and was done using Nine Point Hedonic Scale and Score card method. Results of Nine Point Hedonic Scale showed that control *badi* curry was liked very much by 33.33% of panel members and *badi* curry prepared by whole black gram was liked very much by 46.66%. Statistical analysis of data obtained by score card method showed that there was non-significant difference in overall acceptability between *badi* curry prepared with dehusked black gram (control) and whole black gram. Nutrient composition of Pant U-31 *badi* curry revealed that it contained higher amount of fibre (3.31g), calcium (60.87 mg/100g) and iron (3.41 mg/100g) content than that of control *badi* curry. To maximize its utilization more products can be formulated from black gram.

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