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The Effect of Processing Treatments on the Shelf Life and Nutritional Quality of Green Chilli (*Capsicum annuum* L.) Powder

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ABSTRACT

An attempt was undertaken to investigate the effect of various common processing treatments, such as (a) without pedicle and cut longitudinally plus treated with 0.01% potassium metabisulphite (KMS), (b) without pedicle and sliced, (c) without pedicle as a whole, and (d) as a normal whole green chilli with pedicle, on the shelf life during storage in high density polyethylene (HDPE) and low density polyethylene (LDPE) packages at room temperature. The nutritional quality in terms of proximate compositions, Vitamin-C, beta-carotene and mineral contents of green chilli powder were also assessed. The chilli powder from the treatment (a) showed the highest stability up to 195 days in the HDPE pouches. In relation to proximate compositions and mineral contents, the processing treatments had a significant effect on them, except for Vitamin-C content at P<.0001. The results showed that the nutritional quality in all the samples of green chilli powder was better than that of the red chilli powder. Vitamin C content was reduced around 50% in all the samples due to the processing, while beta-carotene content was significantly increased as compared to the fresh green chilli. A simple calculation revealed the potential of green chilli powder as a value added and alternative spice.

Keywords: Green chilli powder, spice, shelf life, mineral content, value addition

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INTRODUCTION

Chilli is generally found to be used in three forms, namely, as fresh green chillies, red grind and raw red. Usually, red chillies are dried in the open sun without any pre-treatment in Bangladesh (Elias & Hossain, 1984). It was reported in the FAO Bulletin (FAO, 1995) that as a general rule, chillies are dried as whole pods without cutting or slicing because the whole pods are more attractive to the consumers than the sliced pods. Red chilli drying and its processing in the form of powder are very common all over the world. Many researchers have studied the processing and preservation of red chillies and reported the nutritional compositions in terms of the proximate analysis, Vitamin-C content and mineral contents (Saimbhi *et al.,* 1977; Khadi *et al.,* 1987; Esayas, 2011; Anon., 2002). Notably, there are very limited research reviews on the drying, processing and preservation of green chillies. Mechanical dehydration of green chillies has been performed by Luhadiya and Kulkarni (1978), Hossain and Bala (2000), as well as Srivastava *et al.* (2006). In fact, the processing of green chillies in the form of powder is still a very new technology. Meanwhile, the preservation of green chillies in the form of paste and mixed pickles has been studied by Ahmed *et al.* (2001) and Molla *et al.* (2007), respectively. Recently, the feasibility of green chilli processing and preservation in the form of powder has been reported by Sarker (2008) and Tummala *et al*. (2008).

In Bangladesh, chillies are ranked first in area and second in production among the spices. The cultivated area and production of chillies in 2006-2007 were 68096 hectares and 154000 tons, respectively (BBS, 2007). During the peak to the end of the harvesting season (February-March), the local variety green chillies are found to be wasted at the farm level due to the lack of proper processing and preservation technology in Bangladesh. The price of green chillies at this period falls to Tk5 to 10 (US$0.07 to $0.14) per kg, while the market price rises up to 10 to 20 times higher than this price during the off season. Green chilli growers are deprived from getting the actual price, and thus, its cultivation sometimes becomes non-profitable to them. Therefore, the processing and preservation of green chillies are very important in order to minimize the field losses as well as enhance the value addition, thus, contributing to the national economy of Bangladesh. In economics, the difference between the sale price and the production cost of a product is the value added per unit.

Before the commencement of this research, there was no sufficient information in scientific literature on the chemical compositions including the mineral contents of green chilli powder and its shelf life in poly packages. Since processing treatments influence chemical constituents, therefore, the present study was designed and undertaken to investigate the effect of common processing treatments on the shelf life and nutritional quality of green chilli powder. This study also aimed to identify an easy and low-cost technique for processing and preserving the green chillies. The

findings from this study may also justify the usage of green chilli powder as a potential value added spice as well as nutritional supplement.

MATERIALS AND METHODS

Collection and Preparation of the Samples

Matured but not over-matured green chillies of a local variety named 'DhaniMorich' (Dinajpur, Bangladesh) were collected from the farmer's field for the purpose of this research. The drying shed (bamboo mat), two types of polyethylene pouches [i.e. low-density polyethylene (LDPE) and high-density polyethylene (HDPE)] and KMS (Potassium Meta-bi-sulphite) were obtained from the local market.

The fresh green chillies were cleaned and washed manually in this study. Then four samples as per type of the processing treatments were prepared as follows; Sample-A: without pedicle, cut longitudinally and treated with 0.01% KMS, Sample-B: without pedicle and sliced, Sample-C: without pedicle as a whole, and Sample-D: as a normal whole green chilli with pedicle. A total of 40 kg samples of 10 kg per treatment were simply dried using the sun drying method by scattering them on a bamboo mat. During drying, air temperature and relative humidity were observed in the range from 25 to 32°C and 55 to 65%, respectively. The dried green chillies were ground using a local grinding mill which is normally used for grinding the red chilli powder. The samples were then packed in poly packages and stored at room temperature for the shelf life study and further quality evaluation. All the analyses were done after 180 days of storage of the samples in HDPE.

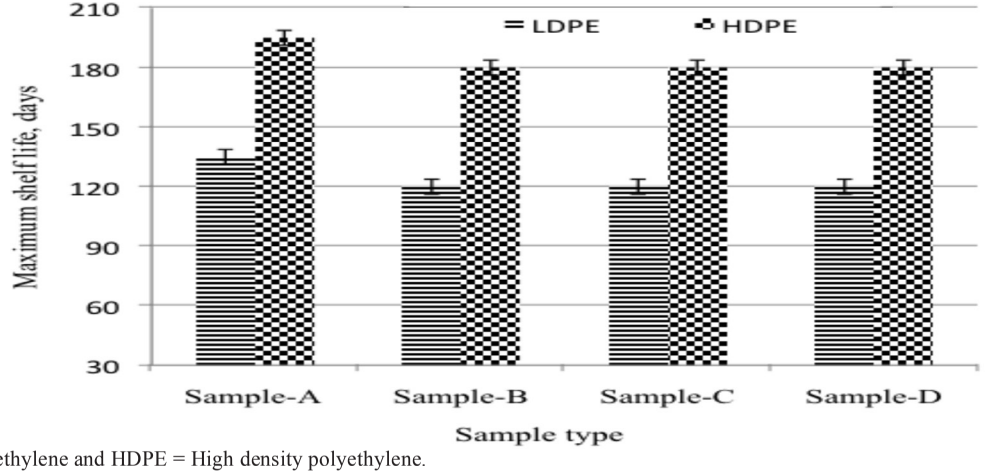
Shelf Life Study of Green Chilli Powder

The samples of chilli powder were manually packed in two types of polyethylene pouches. Chilli powder of 125 g was filled in each package having a dimension of 200 mm x 150 mm. There were 13 packs for each sample, including replications while the total number of pack was 52. All the packages were quickly sealed using an electric-impulsed hand sealer and then stored at room temperature (20 to 30°C) on a shelf at the laboratory. All the pouches were kept under shade to prevent any effect from direct sunlight and other heat sources. Every sample was drawn at each 15-day-interval for monitoring and evaluating of its shelf life simply by the physical observation of its colour, texture, flavour and moisture absorption, as consumers usually test these physical properties before buying any powdery spice. During the observation, the researcher would either tick (√) or cross (×) the evaluation sheet for acceptable and non-acceptable condition of the powder, as presented in Table 1. The maximum storage life of powder was considered as the time of storage having no significant change of its physical properties in terms of colour, texture and moisture absorption.

TABLE 1
Shelf life of green chilli powder in LDPE and HDPE pouches at room temperature

Sample	Storage periods (days)											
	120		135		150		165		180		195	
	LDPE	HDPE	LDPE	HDPE	LDPE	HDPE	LDPE	HDPE	LDPE	HDPE	LDPE	HDPE
Sample-A	√	√	√	√	×	√	×	√	×	√	×	√
Sample-B	√	√	×	√	×	√	×	√	×	√	×	×
Sample-C	√	√	×	√	×	√	×	√	×	√	×	×
Sample-D	√	√	×	√	×	√	×	√	×	√	×	×

'√' and '×' indicate the acceptability and non-acceptability of the sample, respectively in both LDPE and HDPE pouches during the storage period. LDPE=Low density polyethylene and HDPE=High density polyethylene. Sample-A: without pedicle, cut longitudinally and treated with 0.01% KMS, Sample-B: Without pedicle and sliced, Sample-C: Without pedicle as whole and Sample-D: Normal whole green chili with pedicle



(LDPE = Low density polyethylene and HDPE = High density polyethylene.
Sample-A: without pedicle, cut longitudinally and treated with 0.01% KMS,
Sample-B: Without pedicle and sliced,
Sample-C: Without pedicle as whole and Sample-D: Normal whole green chilli with pedicle)

Fig.1: The maximum shelf life of green chilli powder in LDPE and HDPE pouches stored at room temperature

Determination of Compositions of Fresh Green Chilli, Green Chilli Powder (Four Samples) and Red Chilli Powder

The proximate analysis for the fresh green chillies and dried green chilli powder (four samples) and red chilli powder of the same variety was done to determine the moisture, fat, protein and ash contents, as per method recommended by the Association of Official Analytical Chemists (AOAC) and Ranganna (1986). The fat content was determined by the solvent extraction method using the Soxhlet apparatus (Model Acm-54097, India). The percentage of protein (N × 6.25) present in the samples was determined by the Micro-kjeldhalmethod (Esayas, 2011). Meanwhile, the total ash content was determined using the Memmert drying oven (model 40050), whereas carbohydrate was calculated by the difference method. Vitamin C was determined by the titration method while beta-carotenecontent was determined using a spectrophotometer according to the conventional method of Srivastava (1994).

Determination of the Mineral Content of Green Chilli Powder

The most common mineral contents (Ca, Mg, K, P, S, Fe, Mn and Zn) of the different samples packed in HDPE were determined using the Atomic Absorption Spectrophotometer (AAS), VARIAN model AA2407, California, USA.

Quality and Sensory Evaluation of Green Chilli Powder

The colour, taste, flavour and overall acceptability of the green chilli powder were evaluated by a panel of 10 experienced taste panellists (Tummala *et al.,* 2008). The taste panellists gave scores for their preferences of colour, flavour, taste and overall acceptability. The sensory evaluation of the green chilli powder was carried out by preparing these two common items, namely, beef curry and potato mash with other normally used spices. The two items were analyzed for the sensory evaluation by a panel of 10 trained judges, to whom the items were supplied earlier and prepared with the red chilli powder. The panellists evaluated the samples admixed with cooked rice at the beginning and the end after six months of storage of the samples. The scores were noted over a hedonic scale with a maximum score of 9 for "like extremely" and minimum of 1 for "dislike extremely". The hedonic rating test in a scale of 1-9 marking was given as follows: like extremely (9), like very much (8), like moderately (7), like slightly (6), neither like nor dislike (5), dislike slightly (4), dislike moderately (3), dislike very much (2), and dislike extremely (1).

Statistical Analysis

All the means of the triplicate values and standard deviations from the obtained data were calculated and statistically analyzed using SAS version 9.1. Meanwhile, Duncan's multiple range test was employed to determine the differences in the different compositions among the samples.

RESULTS AND DISCUSSION

Shelf Life of Green Chilli Powder

The results of the shelf-life study are presented in Table 1 and Fig.1. All the samples exhibited acceptable shelf life in both types of the packages up to 120 days of storage. Table 1 displays the data startingfrom this period. The powder from Sample-A (i.e. without pedicle, equally cut along the length and potassium meta-bi-sulphite treated) showed the highest stability up to 195 days in the HDPE pouches. This might be due to the packaging material having less permeability and variation of its processing treatment. Besides, potassium meta-bi-sulphite, which is a proven preservative against yeast and moulds in dried products, might enhance the shelf life of the green chilli powder. However, a satisfactory shelf life up to 180 days was observed in HDPE for the other samples. A minimum shelf life up to 120 days was noticed in all the samples when packed in LDPE packages because of the rapid change in physical properties of powder, such as colour, flavour, as well as texture and moisture absorption. An earlier study also reported similar results during the storage of red chilli powder in HDPE (Remya, 2007). Nonetheless, a further study should be carried out to check the shelf life of this powder up to the maximum time by preserving in other packages such as vacuum, metallic and high quality poly packages.

Proximate Analysis, Vitamin-C and Beta-carotene Content ofChilli and Chilli Powder

The fresh green chillies, the green chilli powder of the four samples and the red chilli powder were analyzed in this study. Their chemical compositions are presented in Table 2. Similar proximate results were observed in the fresh green chillies, green chilli powder and red chilli powder of three Ethiopian varieties (Anon, 2002; Esayas *et al*., 2011; Tummala *et al.*, 2008), respectively. However, significant variations in the fat content in comparison with Tummala *et al.*'s (2008) data were noticed, and this was probably due to varietal and methodological differences. However, the results showed that the nutritional quality in an average of all the samples of the green chilli powder was better or similar compared to the red chilli powder. Vitamin-C content was reduced around 50% in all the samples due to drying and processing. On the other hand, beta-carotene content was found to be significantly increased after drying and processing, and this might be due to the increase in its concentration for removing moisture.

Mineral Content of Green Chilli Powder

The common mineral contents in the green chilli powder obtained from the four samples are displayed in Table 3. The results gave interesting information that all the samples of the dry powder contained a very good amount of minerals. It is noted that no published research literature has

TABLE 2
The compositions of fresh green chilli, green chilli powder and red chilli powder

Sample Name and No.		Proximate Analysis					Vitamin-C (mg/100gm)	Beta-Carotene(µgm/gm)
		Moisture Content (%)	Fat (%)	Protein (%)	Ash (%)	Carbohydrate (%)		
Fresh green chilli		85.54± 0.78^{a}	1.05 ± 0.14^{c}	5.42 ± 0.43^{c}	0.582 ± 0.07^{c}	7.41 ± 0.87^{d}	110 ± 2.21^{a}	3.914 ± 0.26^{c}
Green chilli powder	Sample-A	8.47 ± 0.17^{d}	2.67 ± 0.20^{a}	7.93 ± 0.68^{b}	10.64 ± 0.67^{b}	70.29 ± 0.9^{a}	67.6 ± 2.99^{b}	11.89 ± 0.89^{b}
	Sample-B	9.05 ± 0.28^{cd}	2.05 ± 0.15^{b}	8.05 ± 0.45^{b}	9.74 ± 0.73^{b}	71.11± 1.23^{a}	59.08± 0.47^{b}	13.80 ± 1.03^{a}
	Sample-C	8.80 ± 0.30^{cd}	2.58 ± 0.33^{a}	7.87 ± 0.28^{b}	11.06 ± 0.81^{b}	69.68 ± 0.76^{a}	62.48 ± 6.87^{b}	11.90 ± 0.71^{b}
	Sample-D	9.45 ± 0.22^{c}	2.50 ± 0.28^{ab}	9.97 ± 0.46^{a}	13.92 ± 0.93^{a}	64.15 ± 0.70^{c}	66.06 ± 3.68^{b}	14.40 ± 0.65^{a}
Red chilli powder		10.68 ± 0.23^{b}	2.06 ± 0.37^{b}	8.78 ± 0.51^{b}	10.57 ± 0.64^{b}	67.9 ± 0.54^{b}	60.80 ± 6.92^{b}	12.40 ± 0.95^{b}

Values are mean ± SD of three replicates $^{a-d}$The test values along the same column carrying different superscripts foreachcomposition content are significantly different ($p < 0.05$).
Sample-A: without pedicle, cut longitudinally and treated with 0.01% KMS; Sample-B: without pedicle and sliced; Sample-C: without pedicle as a whole; and Sample-D: as normal whole green chilli with pedicle

TABLE 3
Mineral contents in the green chilli powder

Sample No.	Minerals in mg/100gm powder							
	Ca	Mg	K	P	S	Fe	Mn	Zn
Sample-A	500 ± 4.58^{c}	430 ± 5.57^{b}	1810 ± 14^{d}	620 ± 10.0^{c}	450 ± 5.56^{a}	54 ± 4.0^{b}	5.7 ± 0.50^{b}	3.9 ± 0.30^{b}
Sample-B	350 ± 1.0^{d}	320 ± 7.0^{c}	2700 ± 11.13^{a}	680 ± 11.8^{a}	310 ± 5.29^{c}	45 ± 4.58^{c}	3.9 ± 0.40^{c}	4.5 ± 0.26^{ab}
Sample-C	650 ± 2.65^{a}	680 ± 4.36^{a}	2300 ± 13.23^{b}	650 ± 8.89^{b}	350 ± 8^{b}	66 ± 4.0^{a}	8.4 ± 0.50^{a}	5.1 ± 0.56^{a}
Sample-D	560 ± 3.0^{b}	430 ± 2.0^{b}	2100 ± 17.53^{c}	610 ± 11.14^{c}	300 ± 7.8^{c}	54 ± 3.6^{b}	5.7 ± 0.46^{b}	3.9 ± 0.61^{b}

Values are means ± SD of three replicates. $^{a-d}$The test values, along the same column carrying different superscripts foreach mineral content, are significantly different ($p < 0.05$).
Sample-A: without pedicle, cut longitudinally and treated with 0.01% KMS; Sample-B: without pedicle and sliced; Sample-C: without pedicle as a whole; and Sample-D: as normal whole green chilli with pedicle

been found regarding the mineral contents in green chilli powder. It is interesting to note that the mineral contents of the green chilli powder undertaken in this study seemed to be much higher than the results found in the red chilli powder as reported by Saimbhi *et al.* (1977), Khadi *et al.* (1987) and Esayas (2011). These variations may be due to multiple factors, such as the differences in soil conditions where it is grown, variety of chilli, maturity of chilli, growing season, climatic condition, processing treatments and preservation method.

A significant variation in the mineral contents was also observed among the samples. The highest amount of mineral contents in mg/100gm found in samples A, B, C and D were 450 S, 2700 K; 680 P; 4.5 Zn, and 650 Ca; 680 Mg; 5.1 Zn, respectively. In fact, it was difficult to identify which processing treatment was better in terms of mineral contents through the assessment of all these mineral contents. However, a significant effect of the processing treatment on individual mineral content was found at $P<0.0001$.

Sensory Evaluation of Green Chilli Powder

The analysis of variance showed that there was a significance of processing treatment on every sensory attribute at $P<0.0001$. The degree of differences among the samples was evaluated by Duncan's Multiple Range Test (DMRT), as shown in Table 4. From the DMRT result, it was observed that the chilli powder prepared from the chilli pods without pedicle, equally cut along the length and KMS treated revealed the highest scores for colour, flavour, taste and overall acceptability. Due to the longitudinal cut, the surface area for mass transfer during drying had been increased, and hence, Sample-A took a little bit shorter time to dry and it gave better colour and texture after processing. At the same time, KMS might also influence the preservation of colour. Tummala *et al.* (2008) reported similar results when the sample prepared from 1-cm cuts and longitudinal slits was ground without salt and preserved in a metallic polyethylene (MPE) during the storage period of 180 days. However, the powder

TABLE 4
The overall sensory quality of beef curry with green chilli powder at the end of 180 days of storage in HDPE

Sample No.	Sensory Evaluation Test			
	Colour	Flavour	Taste	Overall Acceptability
Sample-A	8.5 ± 0.53^{a}	8.3 ± 0.67^{a}	8.4 ± 0.70^{a}	8.5 ± 0.53^{a}
Sample-B	7.1 ± 0.88^{b}	6.8 ± 0.79^{b}	6.8 ± 0.79^{b}	6.9 ± 0.74^{b}
Sample-C	5.2 ± 0.79^{c}	4.4 ± 0.84^{c}	4.6 ± 0.84^{c}	4.8 ± 0.79^{c}
Sample-D	3.5 ± 0.53^{d}	3.7 ± 0.82^{c}	3.6 ± 0.70^{d}	3.4 ± 0.52^{d}

Values are mean of scores ± SD of 10panellists. [a-d] The test values along the same column carrying different superscripts for each attribute are significantly different ($p < 0.05$).
Sample-A: Without pedicle, cut longitudinally and treated with 0.01% KMS; Sample-B: Without pedicle and sliced; Sample-C: Without pedicle as a whole; and Sample-D: As normal whole green chilli with pedicle.

prepared from the chillies without pedicle slices and without the KMS treatment was found to be moderately favoured by the panellists.

Based on the above results and discussion, it can be summarized that fresh green chillies can easily be dried and processed as powder by slicing into two parts along the length and treated with KMS or without any chemical treatment. This powder can be used as spice and nutritional supplement either in curries for domestic cooking or for processing of commercial products, such as potato wafers, chips, finger fries, extruded products, sandwiches, pizzas, burgers and others. However, it can also be an alternative spice to red chilli powder and fresh green chillies which are more expensive for many practical purposes.

Value Addition by Processing and Preserving of Green Chilli Powder

The total green chilli powder produced from 40kg of fresh green chillies was around 6.25kg at 9% moisture content. The approximate processing cost was US$2.75 per kg of the green chilli powder. Meanwhile, the expected market price of the product was US$4.125/kg, and the cost of red chilli powder was more than US$4.125 per kg. Value addition was 4.125-2.75 = US$1.375/Kg powder. Thus, at least US$208 of value addition was possible by processing and preserving 1 ton of fresh green chillies in the form of powder.

CONCLUSION

Variations in nutritional quality in terms of proximate analysis and mineral contents and shelf life of green chilli powder, due to different processing treatments, were observed in this study. The powder prepared from the chilli pods without pedicle, sliced into two parts along the length and treated with 0.01% KMS was found to be better than that of the other samples in terms of the shelf life and sensory quality with acceptable nutritional values when it was packed in HDPE. Processing of green chillies in the form of powder and preserving it in low-cost poly packages were identified to be potential techniques to minimize field wastage of green chillies, and hence, chilli growers could benefit from these techniques. This powder can be used with many food adjuncts in place of fresh green chillies and red chilli powder. Further research is recommended for standardizing the efficient and sustainable technique for processing and preserving green chilli powder using other mechanical drying methods such as vacuum, oven drying, freeze drying, fluidized bed drying and others, both in domestic and industrial scales.

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