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Research Article

Preparation and Storage Quality of Green Chilli (*Capsicum Annuum* L.) Powder and Paste

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Abstract

A study was conducted at the Laboratory, Department of Food Engineering and Technology, Hajee Mohammad Danesh Science and Technology University, Dinajpur during April to June, 2018 with the green chilli fruits of the variety Bogra Local for developing a technique to preserve green chilli as powder and paste, to assess the quality of those powder and paste during storage, and also to find suitable techniques for maintaining their storage quality. The six treatments compared in the Completely Randomized Design with four replication, those were: T1- green chilli with pedicel, cut longitudinally, treated with 0.01% KMS solution, rinsed, sundried and made into powder;T2- green chilli with pedicel, cut longitudinally, sliced, treated with 0.01% KMS solution, rinsed, sundried and made into powder; T3- green chilli without pedicel, cut longitudinally, treated with 0.01% KMS solution, rinsed, sundried and made into powder; T4- green chilli without pedicel, cut longitudinally, sliced, treated with 0.01% KMS solution, rinsed, sun-dried and made into powder; T5- green chilli with pedicel, treated with 0.01% KMS solution, slight water was added and made into paste, and T6- green chilli without pedicel, treated with 0.01% KMS solution, slight water was added and made into paste. The noted traits were ratio of the green chilli fruits to the powder, ratio of the green chilli fruits to the paste, moisture content, vitamin C content, recovery of the powder and the paste from the fruits, storage quality of the products for: color, flavor, texture, and overall acceptability. After getting the powder (T1 - T4) and the paste (T5 - T6), those were stored for 0, 30 and 60 days for their storage quality and also for the moisture and vitamin C contents. But their sensory traits noted on the 0 and the 60th day of storage. The results clarified that the chilli had initially 86.6% moisture and115.71mg/100g vitamin C. The moisture contents in all the six products increased little up to the 60th day as their values were from 4.08 - 5.25 to 4.33 - 6.68 and 87.08 - 87.35 to92.39 - 93.39%, in T3 - T4 and T5 - T6, respectively. But the vitamin C contents decreased much up to the 60th day. Still, the highest amount was noted in T4 (38.19) and T6 (17.32mg/100g) among the powder and the paste, respectively. Moreover, all the six treatments had notable statuses in terms of sensory evaluation test (6.50 - 7.70 for the color, 6.10 - 7.40 for the flavor, 6.50 - 7.70 for the texture and 6.47 - 7.60 for the overall acceptability) in case of both the powder and the paste forms) up to the 60th day of storage. So, overall, the treatment T4 was the best one. The study further paved the ways to work with other varieties, other treatments (whole fruit with pedicel and whole fruit without pedicel), long storage, by using various type bagging materials etc. and also to develop new and more sustainable technologies to preserve the green chilli powder and the paste with their adequate nutritional quality, hygiene and value addition too.

Keywords: Potassium Meta-Bisulphate; Ascorbic Acid; Vitamin C; Storage Quality; Chilli

Abbreviations

Ca: Calcium; Et. Al: And Others; Fe: Iron; HPO_3: Phosphoric Acid; I. E.: That Is; KMS: Potassium Meta-Bisulphate; P: Phosphorus

Introduction

Chilli (*Capsicum* spp. L., family Solanaceae) is a diploid species with mostly 2n = 2x = 24 chromosomes but wild ones with 2n = 2x = 26 are also noted [1]. It is usually called hot peppers, red peppers, pod peppers, cayenne peppers, paprika, pimento and capsicum in different countries. Pungent fruits of all the species of *Capsicum* are jointly called chilli [2]. India, Mexico, Japan, Ethiopia, Uganda, Nigeria, Thailand, Turkey, Indonesia, China, Pakistan and Bangladesh are its major growers. But India is the largest producer and consumers of chilli in the orb [3]. It is one of the five major spices in Bangladesh ranking 2nd in the area but 4th in the production. Here, its area and production in 2015 - 2016 were 251872 acres and 130260 tons, respectively [4]. And most of its varieties grown here are pungent varying from very high to mild one. Its pungency is due to the alkaloid Capsaicin, which has high medicinal values. Capsaicin is an amide derivative of vanilly lamine and 8 methyl-non-trans-6-enoic acid [5]. Besides adding pungency and red colour i.e. capsanthin to dishes, it is rich in vitamins A, B, C and E, and minerals Ca, P, Fe etc. Consumption of chilli is increasing day by day.

And those are used in fresh, processed, whole dried, frozen, canned and as value added products like powder, oleoresin, paste and chilli oil which are in vogue in the present global market. In food and beverage industries, it is used in the form of oleoresin which permits better distribution of color and flavor. Chilli is exported in different forms: fresh green fruits, whole ripe fruits, dried fruits, chilli powder and chilli oleoresin to South Asian countries, the USA and Canada [6]. Its powder is widely used for food flavoring and coloring meat food, snack food and sauces. Chilli powder has many useful properties making it vital in ayurvedic medicine to fight against many diseases, destroys harmful toxins and stimulates gastric juices helping in digesting food. It also helps in clearing nasal congestion, relieves throat infection and acts as a pain killer in muscle. Chilli is generally found in three forms: fresh green, raw red and red grind. Usually, red chilli is dried in the open sun without any pre-treatment in Bangladesh [7]. It was noted [8] that chilli is usually dried as whole fruits without slicing as the whole fruit is more attractive to consume than the sliced one. But the green chilli fruit has short shelf-life (about 7days) under ambient storage conditions. So, during the peak to the end of the harvesting season (February - April), microbes cause its severe damage due to lack of proper processing and preservation techniques. Thus, in the off season, its price becomes high manifolds. Quality drop in spices and spice products pose a major threat during storage as those are hygroscopic and highly sensitive to moisture causing caking, discoloration, hydrolytic rancidity, mold growth and insect attack. Carcinogenic metabolites, flatoxins etc. are major issues in stored spices. Harvesting is done as the fruits are well ripe with amoisture content of 65 - 75%, which must be brought down to 8 - 10% to prepare the dried spices and their powder. Many researchers studied the processing and preservation of red chilli and noted the nutritional compositions in terms of the proximate analyses, ascorbic acid and mineral contents [9-12]. Even, processing treatments influence its chemical constituents affecting the storage life too.

Unfortunately, there are very limited research works on the drying, processing and preservation of green chilli. In fact, the processing of green chilli in the form of powder is still a very new technology. Meanwhile, the preservation of green chilli as paste and mixed pickles has been studied by Ahmed., *et al.* [13] and Molla., *et al.* [14].

Recently, the feasibility of green chilli processing and preservation in the form of powder has also been reported by Sarker [15] and Tummala., *et al.* [16]. Oppositely, during the peak to the end of the harvesting season, green chilli is found wasted at the farm level due to the lack of proper processing and preservation technologies in Bangladesh. Hence, the processing and preservation of green chilli are vital to minimize the postharvest losses as well as enhance the value addition, thus, contributing to the national economy of the country. It may also save time in cooking, particularly for office-going ladies by providing ready-to-use green chilli powder and paste. Again, it may pave the way for industrialization, export earnings and employment opportunities. So, the present piece of work was designed to study the green chilli fruits of the variety Bogra Local with these three specific objectives:

- To develop techniques for preserving green chilli in the forms of powder and paste.
- To assess the quality of green chilli powder and paste during their storage, and.
- To find suitable preservation techniques for quality powder and paste of green chilli.

Material and Methods

The research work was conducted at the Laboratory, Department of Food Engineering and Technology, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, Bangladesh, during April to June, 2018.The study was a laboratory work with a single factor conducted in the completely randomized design (CRD) with six treatments and four replications. The variety Bogra Local was chosen for the study and the mature and fresh green chilli fruits were purchased in April 2018 from the local Bahadur Bazar, Dinajpur town, Dinajpur. Only fresh fruits were selected and washed by using tap water and kept under fan to dry-up the surface water of washing before using in the study

The six treatments that used in the present study:

- T1 (Fruits with intact pedicel, cut longitudinally (Plate 3.2), dipped in 0.01% KMS solution, rinsed and sundried on a silver tray and blended to make the powder).
- T2 (Fruits with intact pedicel, cut longitudinally sliced transversely, dipped in0.01% KMS solution, rinsed and sundried on a silver tray and blended to make the powder).
- T3 (Fruits without pedicel, cut longitudinally dipped in 0.01%KMS solution, rinsed and sundried on a silver tray and blended to make the powder).
- T4 (Fruits without pedicel, cut longitudinally, sliced transversely dipped in0.01% KMS solution, rinsed and sundried on a silver tray and blended to make the powder).
- T5 (Fruits with intact pedicel, fresh fruits dipped in 0.01%KMS solution and blended with 100 ml water to make the paste).
- T6 (Fruits without pedicel, fresh fruits dipped in 0.01% KMS solution and blended with 100 ml water to make the paste).

For the treatments T1 to T4, sun-dried fruits were uses to have the powder. So, for each replication, 2.5kg of green chilli fruits were dried and used. In contrast, for T5 and T6, only 0.5kg of green fruits for each replication was used. Besides that, 100ml of plain water was added during the blending for ease of blending to have the two paste products. Then, after getting the paste, the paste was spread on trays and the trays were kept at the 30^0 slanting manner for 10minutes to drain out the excess water from the paste.

Storing the powder/paste for quality study

Then the powder/paste was divided into three parts (for analyses at 0, 30^{th} and 60^{th} day of storing), packed in the high density polyethylene bags, heat sealed and stored at the room temperature ($25\text{-}30^0$C) up to 60 days (15^{th} April to 15^{th} June) to study the shelf-life and the storage quality of the six types of products developed.

Data recorded

To achieve the aforesaid objectives of the study, in total, the following nine parameters were recorded.

- Ratio of the green chilli fruits to the powder.
- Ratio of the green chilli fruits to the paste.
- Moisture content (%, wet weight basis).
- Ascorbic acid content (mg/100g).
- Recovery of the powder and paste from the chilli fruits (%, wet weight basis).

Storage quality/shelf life:

- Color of the stored product.
- Flavor of the stored product.
- Texture of the stored product, and.
- Overall acceptability of the stored product.

For the storage quality, data were collected at 0, 30th and 60th day after storing for moisture and vitamin C contents. But for the sensory evaluation, data were collected at two stages, at 0 and 60th day after storing.

Ratio of the green chilli fruits to the powder

The ratio of the green chilli fruits to the powder was assessed with the following formula.

$$\text{Ratio of the green chilli fruits to the powder} = \frac{\text{Weight of green chilli fruit used}}{\text{Weight of the powdered obtained}}$$

Ratio of the green chilli fruits to the paste

The ratio of the green chilli fruits to the paste was determined using the following formula.

$$\text{Ratio of the green chilli fruits to the paste} = \frac{\text{Weight of green chilli fruit used}}{\text{Weight of the paste obtained}}$$

Moisture contents in% (wet weight basis)

The moisture contents were assessed at the following two circumstances.

For the fresh chilli fruits (to have the bench mark information)

It was done just after buying the fresh chilli fruits to have the benchmark information about the fresh chilli fruits.

For the stored products (to have the comparative information)

This was done at the 0, the 30th and the 60th day of storing to get the comparative information about the six treatments used.

Procedure

In both the circumstances, the procedure of Ranganna [17] was used. For that, 5g of the sample was taken in the moisture dish and weighed with an electric balance. Then the moisture dish with the sample was placed in an electric oven and dried at the 1050C for 24 hours. After drying, the moisture dish with the sample was removed from the oven and cooled down in a desiccator. After cooling, the weight of the moisture dish with the sample was recorded. From that weight, the moisture content of the sample was calculated using the following formula.

Let,

Weight of the empty moisture dish = W_1 (g)

Weight of the sample + moisture dish = W_2 (g)

Weight of the sample (dry) + moisture dish = W_3 (g)

Now,

$$\% \text{ Moisture content (wet weight basis)} = \frac{W_2 - W_3}{W_2 - W_1}$$

Then the mean value of such four observations for each treatment was expressed in%.

Ascorbic acid/vitamin C contents in mg/100g

Like the moisture contents, the ascorbic acid contents were also assessed at the following two contexts.

- **For the fresh chilli fruits (to have the bench mark information):** It was done just after buying the fresh chilli fruits to have the benchmark information about the fresh chilli fruits.
- **For the stored products (to have the comparative information):** This was done at the 0, the 30th and the 60th day of storing to get the comparative information about the six treatments assessed.
- **Reagent used:** For both the cases, the following reagents were used for the same.
- **6% Metaphosphoric acid (HPO_3):** It was prepared by dissolving 60g of HPO_3 and 80ml of glacial acetic acid in distilled water and volumed up to 1litre.
- **Standard ascorbic acid solution:** For that, 10% of L-ascorbic acid solution was prepared by dissolving ascorbic acid in 6% metaphosphoric acid solution.
- **Dye solution:** It was prepared by dissolving 260 mg of the sodium salt of 2, 6- dichloro-phenol indophenol in one litre of distilled water containing 210 mg/litre of sodium bicarbonate.

Procedure

In both the circumstances, the procedure of Plummer (1971) was used. And the flowing steps were followed.

Standardization of the dye solution

Five ml of the standard ascorbic acid solution was taken. A micro burette was filled in with the dye solution. Then the mixture was titrated with the dye using the phenolphthalein indicator solution to a pink colored end point, which persisted at least for 15 seconds. Then the dye factor was calculated using the following formula.

Dye factor = 0.5/titre.

Preparation of the sample

Five gram of the sample was taken in a 100 ml beaker with 50 ml 6% meta-phosphoric acid and then that was transferred to a blender and homogenized with the same concentration of meta-phosphoric acid. After blending, that was filtered and centrifuged @ 2000 rpm for 5 minutes. The supernatant homogenized liquid was transferred to a 100ml volumetric flask and was made up to the mark with 6% metaphosphoric acid.

Titration: Five ml of the aliquot was taken in a conical flask and titrated with the dye solution which persisted at least for 15 seconds. The ascorbic acid contents of the samples were calculated using the following formula.

$$\text{Ascorbic acid (mg/100g of the sample used)} = \frac{(T \times D \times V1)}{(V2 \times W)} \times 100$$

Where,

T = Titre

D = Dye factor

V_1 = Volume made up

V_2 = Volume of the extract taken for the estimation, and

W = Weight of the sample taken for the estimation.

Sensory evaluation test of the products

The sensory evaluation test of the six treatments i.e. the six products produced from the green chilli fruits was conducted through a testing panel using the nine-point hedonic scale. And the hedonic scale used was as follows:

9 = like extremely	6 = like slightly	3 = dislike moderately
8 = like very much	5 = neither like or dislike	2 = dislike very much
7 = like moderately	4 = dislike slightly	1 = dislike extremely

Table

And the panelists were selected from the students and employees, Department of Food Engineering and Technology, HSTU who frequently took part in such evaluation tests. The panelists were asked to assign the appropriate numerical score to each sample for these four characteristics: color, flavor, taste and overall acceptability of the given six products developed in the study.

Statistical analyses

The results expressed as the mean ± standard deviation were analyzed for the variances (ANOVA) and the means were separated using Duncan's Multiple Range Test (DMRT) for the level of significance with the IBM SPSS statistical package, version 20 (SPSS Inc., Chicago, IL).

Result and Discussions

Initial moisture content of the fresh green chilli fruits (bench mark value)

The initial moisture content of the fresh green chilli fruits was 86.6% (Table 1). This value is almost similar to that of the report of Sarker., *et al.* [18] who found 85.54%. But Wade., *et al.* [19] reported the value as 70 - 80% at the time of harvest, which was slightly lower than the present finding. This variation could probably be due to varietal and cultural differences, e.g. irrigation/rain-fed condition as irrigation increases succulence in chilli fruits andvice-versa.

Initial ascorbic acid content of the fresh green chilli fruits (Bench mark value)

The initial ascorbic acid content of the fresh green chilli fruits was 115.71mg/100g (Table 1). This value is also almost similar to that one of Igbokwe., *et al.* [20] who claimed that fresh green chilli fruits had the ascorbic acid content of 116.08 mg/100g. Oppositely, the present value is great erasargued by Sarker., *et al.* [18] who found less, i.e.110 mg/100g of fresh green chilli fruits. Such disparity may also occur possibly on account of the varietal difference, freshness of the fruits etc.

Fresh green chilli fruits	Moisture content (%)	Ascorbic acid content (mg/100g)
	86.6 ± 0.61	115.71 ± 0.67
The values are Means ± Standard Deviations.		

Table 1: Moisture and ascorbic acid contents of the fresh green chilli fruits of the variety Bogra Local (bench mark value).

Yield/recovery of the dried green chilli powder

The% yield of the green chilli powder from the sundried green chilli fruits is given in the table 2 which has variation among the six treatments. The% powder obtained from the sundried samples ranged from 8.4 - 11. The% yield of the green chilli powder was slightly less than the result obtained by Jyothirmayi., *et al.* [21] who got 12.4% green chilli powder. The variation in the% yield of powder from the raw chilli fruits maybe attributed to the varieties used, stages of maturities of the fruits, the methods of the drying and the extent of drying used in those two separate studies. Nonetheless, the higher yield is a good sign of more% dry matter in the green fruits. And such fruits are cherished for the chilli powder production on the commercial basis for higher yield and fiscal profit as well. Again, in case of the yield, the higher values were noted with both T3 and T4 with the intact pedicels with the fruits but the lower values were obtained with both T1 and T2 without the pedicels. This may happen due to the fact that the pedicels had more dry matter% than the respective green fruits.

Treatments	% Yield
T1	8.8 ± 0.66
T2	8.4 ± 0.72
T3	11.0 ± 0.59
T4	10.0 ± 0.61
T5	140.0 ± 0.85
T6	135.0 ± 0.77

Table 2: Yield of the powder and the paste from the green chilli fruits of the variety Bogra Local

Values are Means ± Standard Deviations.

Yield/recovery of the paste of the green chilli

In contrast to the yield of the green chilli powder, the% yield of the green chilli paste was as high as 135 – 140% as shown in Table 2 which was much higher than chili powder. The higher yield (more than 100%) was found because of three reasons: (a) The fruits used in making the paste were at the fresh green stage i.e. succulent, (b) During making the paste for the ease of pasting 100ml water was added, and (c) The small amount of the water which was present in the treating solution of the KMS used.

Changes in the moisture% of the powder and the paste during their storage

The table 3 presents the changes in the moisture contents of the dried green chilli powder and the paste during their storage up to 60days.

Treatments	Moisture contents (%) at the three storage periods(day)		
	0th	30th	60th
T1	4.78 ± 0.12^{bc}	5.37 ± 0.33^{b}	5.89 ± 0.20^{d}
T2	4.18 ± 0.19^{cd}	4.54 ± 0.27^{c}	4.89 ± 0.23^{e}
T3	4.08 ± 0.09^{d}	4.16 ± 0.07^{c}	4.33 ± 0.19^{f}
T4	5.25 ± 0.13^{b}	5.54 ± 0.17^{b}	6.68 ± 0.15^{c}
T5	87.08 ± 0.75^{a}	90.67 ± 0.42^{a}	93.05 ± 0.28^{a}
T6	87.35 ± 0.89^{a}	90.52 ± 0.51^{a}	92.39 ± 0.47^{b}

Table 3: Changes in the moisture contents of the powder and the paste of the green chilli fruits variety Bogra Local during their storage up to 60days.

Values are Means ± Standard Deviations.

a-eThe means bearing the different letters in each column are significantly different (P < 0.05).

On the 0 day, the moisture content varied notably (P < 0.05). The range was as low as4.08 (T3) to as high as 87.35 (T6). But it fluctuated from 4.08 (T3) to 5.25 (T4) among the four treatments with powder while 87.08 (T5) to 87.35 (T6) between the two paste treatments.

On the 30th day, the moisture content varied significantly too (P < 0.05) among the six treatments. The range was from as low as 4.08 (T3) to as high as 87.35 (T6). However, it ranged from 4.16 (T3) to 5.54 (T4) among the four treatments with powder but 90.52 (T6) to 90.67 (T5) between the two paste treatments. So, there was a gradual as well as almost parallel rise in the moisture contents in all the six treatments irrespective of the powder or the paste forms. That was quite natural as at the 30th day of storage, i.e. the time of the year was 15th April to 15th May. At that time% atmospheric humidity was in the rising direction and so, the products had also absorbed some moisture from the atmosphere to have equilibrium in the conditions.

Finally, at the 60th day, the moisture content varied significantly as well (P < 0.05) among the six treatments. The range was from as low as 4.33 (T3) to as high as 93.05 (T5). However, it fluctuated from 4.33 (T3) to 6.68 (T4) among the four treatments with powder while 92.39 (T6) to 93.05 (T5) between the two paste treatments. So, there was a gradual as well as almost parallel rise in moisture contents in all the six treatments compared irrespective of the powder or the paste forms. That was quite natural as at the 60th day of storage, the time of the year was 15th May to 15th June; at that time% atmospheric humidity was high and so, the products had absorbed some moisture from the atmosphere.

Again, at the 60th day of storage, the moisture contents of green chilli powder ranged between 4.33 (T3) to 6.68% (T4), which was within the range of 2.9 - 9.7% as reported by Wade., *et al*. [19]. Tummala., *et al.* [16] claimed a moisture content of 7.20% in 1cm cut dried green chilli powder. This is a good sign of the shelf-life of green chilli powder against the oxidative and microbial deterioration as well [22]. Mahadevaih., *et al.* [23] found that the moisture content was higher than 15% in chilli powder which was critical with respect to the mold growth and unfit for consumption.

The results of the present study revealed that the moisture contents of the green chilli powder ranged within the acceptable limit as specified by previous researchers. Oppositely, at the same storage period (60th day) of green chilli paste, moisture contents were found to have ranged within 92.39 (T6) to 93.05% (T5). That may be attributed to the absorption of some moisture from the atmospheric humidity through the polyethylene bags as the storage time was 15th April to 15th June, i.e. humid months of the year polyethylene bags were not 100% moisture proof.

Changes in the ascorbic acid contents during the storage periods

The changes in the ascorbic acid contents during the storage of green chilli powder and the paste are shown in the table 4.

Treatments	Storage periods (Day)		
	0 th	30th	60th
T1	49.43 ± 0.74^{c}	42.41 ± 0.31^{c}	33.39 ± 0.28^{c}
T2	49.56 ± 0.27^{c}	42.27 ± 0.34^{c}	32.66 ± 0.30^{d}
T3	50.92 ± 0.45^{b}	44.45 ± 0.44^{b}	35.56 ± 0.39^{b}
T4	53.46 ± 0.89^{a}	46.35 ± 0.46^{a}	38.19 ± 0.38^{a}
T5	30.36 ± 0.25^{d}	24.23 ± 0.60^{e}	15.88 ± 0.33^{f}
T6	31.17 ± 0.44^{d}	25.81 ± 0.43^{d}	17.32 ± 0.17^{e}

Table 4: Changes in the ascorbic acid contents (in mg/100g) of the powder and the paste of the green chilli fruits variety Bogra Local during their storage up to 60 days.

Values are Means ± Standard Deviations.

a-fThe means bearing the different letters in each column are significantly different (P < 0.05).

The vitamin C content got reduced because of the processing (Tables 1 and 4). The comparative analysis revealed that the vitamin C contents were found to be got reduced further during the storage periods in the cases of all the six treatments and the values were lower than the bench mark value obtained from the present study i.e. 115.71mg/100g.

On the 0 day of storage, there was notable disparities (P < 0.05) among the six treatments (Table 4). The variation was as low as 30.36 (T5) to as high as 53.46mg/100g (T4). Such a wide range was probably due to the fact that the two treatments viz. T5 and T6 had lots of moisture on account of the three reasons as noted in the section 4.5 earlier. Oppositely, the four treatments i.e. T1 to T4 had the high values ranging from 49.43 to only 53.46mg/ 100g and such high values with the minimum range was probably due to the fact that in those four cases, only dry fruits were used to have

the powder. Again, there was the least variation between T5 and T6 (30.36 - 31.17mg/100g) where fresh fruits with water was used to have the paste.

On the 30th day of storage, there was significant difference ($P < 0.05$) among the six treatments. The variation was as low as 24.23 (T5) to as high as 46.35mg/100g (T4). There was low vitamin C content than the case of 0 day of storage. In addition, there was also a similar and gradual fall in the vitamin C contents in all the six treatments than their 0 day of storage.

On the 60th day of storage, there was also notable disparities ($P < 0.05$) among the six treatments judged. The variation was as low as 15.88 (T5) to as high as 38.19mg/100g (T4). So, the treatment T4 was best in terms of the retention of the highest amount of vitamin C. There were also low vitamin C contents than both the cases of 0 and 30th day of storages. In addition, there was also further identical and gradual fall in the vitamin C contents in all the treatments.

The fall in the vitamin C contents was quite expected as a number of studies strongly support that ascorbic acid is highly sensitive to heat [18,24,25]. The loss of scorbic acid in this study may be due to the prolong exposure of the chilli fruits for sun-drying (T1 - T4). The variation in vitamin C contents among the treatments may further occur due to difference in oxidation, container, storage environment etc.

Furthermore, the vitamin C contents of green chilli powder ranged from 49.43 - 53.46, 42.27-46.34 and 33.39-38.19mg/100g on the 0 day, the 30th and the 60th day after storage, respectively. The values of those findings are lower than the results obtained by Sharma., *et al.* [26] (47.75mg/100g), Toontom., *et al.* [22] (53.19mg/100gm) and Sarkar., *et al*. [19] who obtained 59 - 67mg/100gm of dried green chilli powder. Such variations could be due to drying methods, varietal traits, oxidation etc.

Another vital observation is that the three treatments having pedicels intact with the fruits (T1, T2 and T5) had low vitamin C contents than their corresponding treatments where pedicels were detached from the fruits (T3, T4 and T6). This may happen due to the fact that fruits were rich in vitamin C, not the pedicels.

Sensory evaluation of the powder and the paste stored up to 60days

Evaluation for the color

On the 0 day of storage, there was significant difference ($P < 0.05$) among the six treatments (Table 5). The variation was from 7.30 (T1) to 8.30 (T2). However, T2, T3 and T6 were statistically identical (8.30, 8.10 and 8.10) while T1, T4 and T5 were also statistically parallel to one another (7.30, 7.50 and 7.70). In contrast, T2 had the top score among the four powder treatments while T6 between the two paste treatments as well.

On the 60th day of storage, there was also notable disparities ($P < 0.05$) among the six treatments. The variation was from 6.50 (T1) to 7.70 (T2). However, T2, T3 and T6 were statistically identical (7.70, 7.50 and 7.20) while T3, T4, T5 and T6 were statistically parallel to one another (7.50, 7.10, 7.10 and 7.20). In addition, there was also further identical and gradual fall in the score from the 0 day to the 60th day. Oppositely, T2 topped the list among the four powder treatments while T6 between the two paste treatments.

The fall in the score for the colour from the 0 to the 60th day may be a common event as colour usually becomes dull due to oxidation and other chemical reactions, storage environment etc.

Evaluation for the flavour

On the 0 day of storage, there was significant difference ($P < 0.05$) among the six treatments (Table 5). The variation was between 7.10 (T1) to 8.20 (T2). However, T2, T3 and T6 were statistically identical (8.20, 7.90 and 7.90) while T1, T4 and T5 were statistically parallel to one another (7.10, 7.40 and 7.50). Oppositely, T2 had the highest score among the four powder treatments while T6 between the two paste treatments.

On the 60th day of storage, there was notable disparities too ($P < 0.05$) among the six treatments. The variation was 6.10 (T5) to 7.40 (T2). But T2 and T3 were statistically at per (7.40 and 7.10) while T1, T4, T5 and T6 were statistically parallel to one another (6.40, 6.30, 6.10 and 6.50). In addition, there was also further somewhat identical and gradual fall in the score for the sensory evaluation of the flavour of the products from the 0 day to the 60th day. Again, T2 had the highest score among the four powder treatments while T6 between the two paste treatments.

The fall in the score for the flavour of the products from the 0 day to the 60th day may be a usual phenomenon as flavour commonly disappears and becomes less due to the volatilization of some essential oils followed by various reactions etc.

Evaluation for the texture

On the 0 day of storage, there was remarkable difference ($P < 0.05$) among the six treatments (Table 5). The variation was 7.10 (T1) to 8.20 (T2). None the less, T2, T3 and T6 were statistically identical (8.20, 7.80 and 7.90) while T1, T4 and T5 were statistically parallel to one another (7.10, 7.20 and 7.50). But T2 had the highest value among the four powder treatments while T6 between the two paste treatments compared.

On the 60th day of the storage, there was also notable disparities ($P < 0.05$) among the six treatments. The variation was 6.50 (T1) to 7.70 (T2). Nevertheless, T2 and T6 were statistically comparable (7.70 and 7.20) while T3, T4 and T5 were statistically parallel to one another (7.10, 6.60 and 6.90). Again, there was also further identical and gradual fall in the score from the 0 day to the 60th day. Once again, T2 had the top most value among the four powder treatments while T6 between the two paste treatments.

The fall in the value of the sensory evaluation of the texture from the 0 day to the 60th day may be a typical event due to chemical reactions, storage environment etc.

Treatment	Colour Storage period (Day)		Flavour Storage period (Day)		Texture Storage period (Day)		Overall acceptability Storage period (Day)	
	0^{th}	60^{th}	0^{th}	60^{th}	0^{th}	60^{th}	0^{th}	60^{th}
T1	7.30 ± 0.48^{c}	6.50 ± 0.70^{c}	7.10 ± 0.56^{c}	6.40 ± 0.52^{b}	7.10 ± 0.56^{c}	6.50 ± 0.70^{c}	7.17 ± 0.36^{d}	6.47 ± 0.39^{d}
T2	8.30 ± 0.48^{a}	7.70 ± 0.67^{a}	8.20 ± 0.42^{a}	7.40 ± 0.52^{a}	8.20 ± 0.42^{a}	7.70 ± 0.67^{a}	8.23 ± 0.16^{a}	7.60 ± 0.38^{a}
T3	8.10 ± 0.56^{ab}	7.50 ± 0.70^{ab}	7.90 ± 0.56^{ab}	7.10 ± 0.57^{a}	7.80 ± 0.68^{ab}	7.10 ± 0.57^{abc}	7.93 ± 0.44^{b}	7.23 ± 0.50^{b}
T4	7.50 ± 0.52^{c}	7.10 ± 0.57^{b}	7.40 ± 0.51^{bc}	6.30 ± 0.48^{b}	7.20 ± 0.63^{c}	6.60 ± 0.69^{bc}	7.37 ± 0.24^{cd}	6.67 ± 0.42^{cd}
T5	7.70 ± 0.67^{bc}	7.10 ± 0.32^{b}	7.50 ± 0.70^{bc}	6.10 ± 0.32^{b}	7.50 ± 0.70^{bc}	6.90 ± 0.74^{bc}	7.57 ± 0.22^{c}	6.70 ± 0.25^{cd}
T6	8.10 ± 0.56^{ab}	7.20 ± 0.42^{ab}	7.90 ± 0.56^{ab}	6.50 ± 0.53^{b}	7.90 ± 0.56^{ab}	7.20 ± 0.42^{ab}	7.97 ± 0.29^{ab}	6.97 ± 0.19^{ab}

Table 5: Changes in the sensory attributes of the powder and the paste of the green chilli fruits variety Bogra Local during their storage up to 60 days.

Values are Means ± Standard Deviations.

a-dThe means bearing the different letters in each column are significantly different ($P < 0.05$).

Evaluation for the overall acceptability

On the 0 day of the storage, there was significant variance ($P < 0.05$) among the six treatments (Table 5). The variation was 7.17 (T1) to 8.23 (T2). But T2 and T6 were statistically comparable (8.23 and 7.97) while T1 and T4 were statistically parallel to one another (7.17 and 7.37). Like other cases, T2 scored the top among the four powder treatments while T6 between the two paste treatments.

On the 60^{th} day of the storage, there were also notable disparities ($P < 0.05$) among the six treatments. The variation was 6.47 (T1) to 7.60 (T2). However, T2 and T6 were statistically similar (7.60 and 6.97) while T1, T4 and T5 were statistically parallel to one another (6.47, 6.67 and 6.70). In addition to those, there was also further identical and gradual fall in the score from the 0 day to the 60^{th} day. Moreover, T2 had the top score among the four powder treatments while T6 between the two paste treatments. The fall in the sensory evaluation of the overall acceptability of the products from the 0 day to the 60th day may be a usual issue as occurred due to chemical reactions, storage environment etc.

Summary and Conclusions

An investigation was carried to know they effects of pretreatments on yield and quality of green chili powder and paste at the Laboratory, Department of Food Engineering and Technology, Hajee Mohammad Danesh Science and Technology University, Dinajpur from April to June, 2018 with the green chilli fruits of the variety Bogra Local having three objectives: (i) to develop techniques for preserving green chilli in the forms of powder and paste, (ii) to assess the quality of those powder and paste during their storage, and finally (iii) to find out suitable techniques to preserve their quality in store. The six treatments (first four for making powder and last two for preparing paste) compared in the completely randomized design replicated four times were: T1- green chilli fruits with intact pedicels, cut longitudinally, treated with 0.01% KMS solution, rinsed, sundried and made into powder; T2- green chilli fruits with intact pedicels, cut longitudinally, sliced, treated with 0.01% KMS solution, rinsed, sundried and made into powder; T3- green chilli fruits without pedicels, cut longitudinally, treated with 0.01% KMS solution, rinsed, sundried and made into powder; T4- green chilli fruits without pedicels, cut longitudinally, sliced, treated with 0.01% KMS solution, rinsed, sundried and made into powder; T5- green chilli fruits with intact pedicels, treated with 0.01% KMS solution, slight water was added and made into paste, and T6- green chilli fruits without pedicels, treated with 0.01% KMS solution, slight water was added and made into paste.

Data for these nine traits were taken: (i) ratio of the green chilli fruits to the powder, (ii) ratio of the green chilli fruits to the paste, (iii) moisture content, (iv) vitamin C content, (v) recovery of the powder and paste from the chilli fruits, (vi) storage quality of the stored products for: (a) colour, (b) flavour (c) texture, and (d) overall acceptability.

After preparing powder and paste, those were divided into three parts and stored for 0, 30 and the 60days to study their storage quality for both the moisture and vitamin C contents. But the four sensory traits studied on the 0 and the 60th day of storage were: colour, flavour, texture and overall acceptability.

The results clarified that the green chilli fruits had initially 86.6% moisture and 115.71mg/100g vitamin C contents. The% higher recovery of powder was found from T3 (11.0) compare to the rest three treatments (as T1, T2 and T4 yielded 8.8, 8.4 and 10.0%, respectively) while the recovery of paste was much higher from135-140%.

The moisture contents of all the products increased little bit from the 0 day up to the final/ 60th day as the ranges were from 4.08 - 5.25 to 4.33 - 6.68 and 87.08 - 87.35to 92.39 - 93.39%, in T3 - T4 and T5 - T6, respectively.

But in all the cases, the vitamin C contents decreased much from the 0 day of processing up to the 60th day. Still, the highest amount was noted in T4 (38.19) and T6 (17.32mg/100g) among the powder and the paste forms, respectively.

Finally, the sensory test indicated a fairly good physical appearance in terms of all the four traits: colour (6.50 - 7.70), flavour (6.40 - 7.40), texture (6.50 - 7.70) and overall acceptability (6.47 - 7.60) up to the 60^{th} under ordinary temperature just with the use of the

very well-known safe preservative i.e. KMS at a very low level of 0.01% solution.

Hence, from the present findings, the following conclusions can be highlighted:

- The maximum powder and the paste yields were in T3 (11.0) and T5 (140.0) for the powder and the paste, respectively.
- All the four treatments (T1 to T4) of powder had the moisture contents < 10%, indicating that their shelf-life was stable up to the storage of 60 days in HDPB.
- The maximum amount of vitamin C was retained in T4 (38.19) among the powder while T6 (17.32mg/100g) among the paste, and finally
- All the six treatments had notable statuses in terms of sensory evaluation test (6.50 - 7.70 for the colour, 6.10 - 7.40 for the flavour, 6.50 - 7.70 for the texture and 6.47 - 7.60 for the overall acceptability) in case of both the powder and the paste forms).

However, the study paved further ways to work with other varieties, other forms of treatments (whole fruits with pedicel and whole fruits without pedicel), storage period up to one year, various bagging materials including oxygen and moisture free conditions, microbial conditions for hygienic purposes, several packing sizes for small, medium and large families as well as large scale uses (i.e. social functions) etc. to develop new and more sustainable technologies to preserve green chilli powder and paste with adequate nutritional quality and value addition too.

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