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Research article

Study of physicochemical properties of capsicum powder by different drying techniques

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ABSTRACT

The objective of this study was to analyze the effects of phytochemical parameter, physical parameter, color, and sensory analysis in green capsicum by different drying processes (microwave, freeze, and hot air drying). Results showed an increase in microwave output power (600W), decreased drying time, moisture content, Chroma, and bulk density values. The Freeze drying process significantly improved the lightness of dried capsicum. Due to take less time for the Microwave drying technique, phytochemical parameters are intact in capsicum; on the other side, color degradation has been occurred due to the Maillard reaction (L*=29.34±0.08, a*=6.98±0.09,b*=15.36±0.10). Bulk density (0.335±0.01) and dispersibility (40±2.00%) were highest in Microwave drying powder. The capsaicin content of dried capsicum was higher than the fresh capsicum sample, but compared to the different drying techniques, the Microwave drying sample has higher capsaicin content than the Hot air drying and Freeze drying samples. The lower capsaicin content in fresh capsicum may occur due to the catalytic activity of the peroxidase enzyme. The capsaicin content of all dried capsicum varied between 1.91±0.05 and 3.31±0.16 mg/100 g. In this research, the Microwave drying powder of capsicum was the best product for its highest antioxidant content and other physical properties.

Keywords: Physicochemical Properties, Capsicum Powder, Oven Drying, Freeze Drying, and Microwave Drying, Different Techniques

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INTRODUCTION

Capsicum (Capsicum annum) is a trendy vegetable throughout the world. This highly nutritious vegetable is consumed in dried, cooked, and pickled forms, a good source of vitamin C, pro-vitamin A, carotenoids, capsaicinoids, a derivative of cinnamic acid, flavonoids, and phenolic compounds. Capsaicinoids are responsible for specific taste in capsicum [1].The potent antioxidant compounds in capsicum participate in body defense mechanisms and protect the human body from free radicals [2]. The redox properties of phenols and flavonoids' hydroxyl groups, as well as the structural relationship between various parts of their chemical structure, determine their antioxidant activity [3, 4, 5]. The beneficial effects of antioxidant

Compounds lie in preventing cancer, cardiovascular disease, and neurodegenerative disorders. Since the human body does not form phenolic compounds, they must be consumed via the diet.

Nowadays, capsicum powder is more preferred than raw capsicum because raw capsicum gets deteriorated within a few days after harvesting [6]. Dried capsicum is a spice product widely used as a coloring and flavoring ingredient in food [7, 8]. Dried capsicum quality depends on different parameters such as color, flavor, hotness, ascorbic acid content, etc. [9]. Hot air drying method produces a high-quality product with a uniform, hygienic, and appealing color of dried capsicum [10]. The temperature ranges from 45°C-70°C, reduce drying time to <20h. During heating, chemical oxidation of phenol occurs. The antioxidant capacity of dried capsicum is higher than fresh capsicum [11]. The main drawbacks of hot air drying include low energy efficiency and a long drying time during the dropping rate cycle, which causes severe damage to the dried product's flavor, nutrients, and rehydration ability. Freeze drying is the most effective method for removing water and producing a high-quality finished product without heat. The color quality of dried capsicum is best maintained in the freeze-drying technique [12]. Because of the rise in temperature in the material's middle, microwave drying of capsicum is beneficial because of the fast drying period and appropriate dried product characteristics. Compared to traditional heating and drying equipment, a microwave drying system needs just 20% - 35% of the floor space due to its concentrated energy [13].

MATERIALS AND METHODS

Raw material

The fresh capsicums 1 kg (Capsicum annum) were collected from the local market of Kolkata, India.

Reagents

Ethanol, Sodium Hydroxide, copper sulfate, Aluminum chloride, sodium nitrite, Folin reagent, Sodium carbonate, Acetonitrile, sodium and potassium Tartarate, Gallic acid, Catechin, Beta carotene, Ascorbic acid, Capsaicin, 2-diphenyl-1 picryl hydroxyl radical, Bromine water,2,4-Di Nitro Phenyl Hydrazine, Thiourea.

Methods

Capsicums were washed thoroughly in distilled water. The whole capsicum was blanched for 3 min in hot water at 90°C, then drained on a perforated tray and cooled in cold water before drying. The capsicum was sliced into 2 cm lengths. The material was then dried using three methods: hot air drying (HD), freeze-drying, or microwave drying. HD was conducted by spreading blanched cut capsicum on a tray and placed in a hot air oven at 60 ºC. Freeze drying of capsicum was performed at -40 ºC in a freeze drier. A microwave drier was used for capsicum drying, which is done at 600W. Dried samples were made into the fine powder and store in the refrigerator for further analysis.

Moisture content

5 g of the sample was placed on a metal dish and measured using a digital weighing balance. The sample in the metal dish was then kept in a hot air oven at 105 °C for three hours until it reached a constant weight. The sample in the dish was then put in the desiccators for 10 min to bring the temperature down. The sample's final weight was determined.

Moisture content = [(initial weight - final weight)/ initial weight)] * 100

Rehydration ratio

1g capsicum powder was dissolved in 30 ml of distilled water. Then, it was kept in the hot air oven at 95°C for 20 min. Then, the excess water was filtered out, the residue left was weighed, and the rehydration ratio was calculated.

Oil absorption capacity

1 g of powder with 6 ml of oil in a centrifuge tube and stirring for 30 sec with a vortex mixer, then centrifuging at 5000 rpm for 10 min. The amount of supernatant collected was measured.

The oil absorption capacity = (ml of supernatant)/g of powder

Bulk density [14]

In a measuring cylinder, bulk density (g/ml) was determined by gently adding 2 g of powder, keeping it on a vortex vibrator for 1 min, and recording the volume. The bulk density is determined by the bellow equation.

Bulk density (g/ml) = W/V1. (Where, W = wt of powder; V1 = measured volume)

Dispersibility

10 g sample was weighed-added into 100 ml distilled water, stirred vigorously, and allowed to settle down for 3h. The volume of settled particles was recorded and subtracted from 100. The difference was reported as % dispersibility.

Colour

The Hunter Lab color measurement method (Color Flex 45/ 0, D 65, 10° observer) was used to assess the color profile study. The instrument was calibrated using a 3.5 cm white standard plate (L*=93.49; a* =-1.07; b*=10.6). Optical glass cells measuring 3.5 cm in length and 6 cm in diameter were used to collect samples. L* lightness (0; black to 100; white), a* redness (green to +; red), and b* yellowness (blue to +; yellow) values were used to express the result: Equation and the color measurement.

Chrome (C*) = (a2+b2)1/2. And Hue angle (h*) =1/tan (b*/a*)

Extraction of samples

Weighing 1g of sample and mixed it with 20 ml of 80 % methanol yielded an extract for determining antioxidant activity. To minimize particle size, the mixture was sonicated for 10 minutes in a sonicator. The sample was then centrifuged at 8944g for 10 min at 4 OC. The ready to use extracts had been placed in glass tubes.

Total phenolic content

0.20 ml collected sample was added in 1.80 ml distilled water. Then, 0.20 ml Folin Reagent was applied, and the mixture was thoroughly mixed by handshaking for 5min. Then 2 ml of Folin reagent solution (7%) was applied. Following that, 0.80 ml of distilled water was added. In a spectrophotometer, the mixture's absorbance was measured at 750 nm after 90 min of incubation in the dark. The standard curve of total phenolic content was done by gallic acid.

Total flavonoid content

1 ml isolated sample, 4 ml distilled water, and 0.3 ml NaNO2 were combined in a mixing bottle. Then 2 ml 1(M) NaOH and 0.3 ml AlCl3 were added. The mixture's absorbance was measured in the spectrophotometer at 510 nm after a 25 min light incubation period. A standard curve of total flavonoid content was done with catechins.

Antioxidant activity by scavenging capacity

In a volumetric flask, 0.002 g of DPPH was combined with 50 ml of ethanol. The flask was then held in the dark and at a very low temperature (0 0C). In a test tube, 0.1 ml of sample was mixed with 3.90 ml of the prepared DPPH solution. Then, it was placed in a dark place for 45 min. Absorbance was measured at 515 nm.

Total antioxidant activity = ((Blank- Sample)/ Blank)*100

Capsaicin

1 g powder was mixed with 10 ml of ACN at 65ºC along with 20 min under sonication with a 35 kHz frequency. The extract was evaporated to dryness at 60 ºC re-suspended in 0.50 ml of ACN and filtered through a 0.45 µm membrane filter. The sample was stored at -20 ºC. The absorbance was measured at 280 nm wavelength, and concentration was expressed as mg of capsaicin equivalent per g of the dry weight of the sample.

Beta-carotene

The beta-carotene content of the extracted sample was measured by spectrophotometer at various wavelengths, i.e., 663nm, 645nm, 505nm, and 453nm.

Beta-carotene (mg/100ml) = 0.216 (A663) – 1.22 (A645) – 0.304 (A505) + 0.452 (A453)

Ascorbic acid

0.23 ml of bromine water (3%) was applied to 4.0 ml of the centrifuged sample solution, followed by 0.13 ml of 10% thiourea to eliminate the excess bromine. Then, to make osazone, 1.0 ml of 2, 4-Dinitro Phenyl Hydrazine solution was added. All standard sample and blank solutions were held at 37 °C for three hours in a thermostatic bath. After cooling in an ice bath for 30 min, 5 ml chilled 85 % H_2SO_4 was applied to each sample while stirring constantly. The absorbance of the colored solution was measured at 521 nm. Pure ascorbic acid was used to build a regular curve.

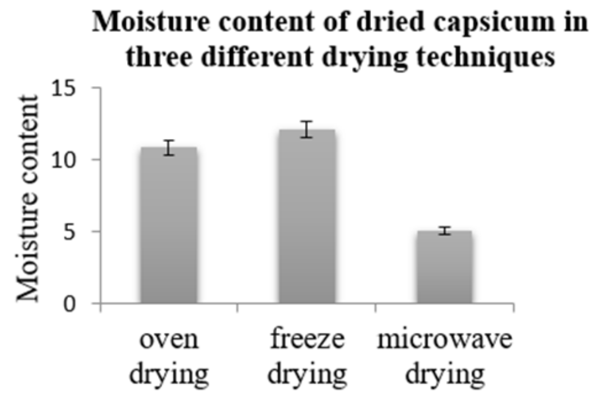
RESULTS AND DISCUSSION

PHYSICAL PROPERTIES

Moisture content

The initial average moisture content of fresh capsicum is 82.08 %, and after drying, the final moisture content of dried capsicum ranges from 11 % to 13 %. Capsicum moisture content is critical because it is linked to the stability of ascorbic acid and pigment and any potential hygiene issues. If the moisture content is lower than 5 %, it could accelerate pigment destruction. If the moisture content is higher, it allows mold growth (aflatoxin production), and moisture content below 4 % causes excessive colour loss. It was observed from fig. 1 that the final moisture content after oven drying, freeze drying, and microwave drying of capsicum powder are 10.79±0.53, 12.06±06, 5.022±0.25 %, respectively. The moisture content of the oven and freeze-dried samples of capsicum are in the desired range.

Figure 1: The moisture content of dried capsicum using three drying methods



Colour

Table 1 shows the impact of various drying methods on the color qualities of capsicum. 1 The samples differed significantly ($p<0.05$) in terms of lightness (L*), redness (a*), and yellowness (b*). Both dried capsicum had L* values ranging from 29.34 to 50.32, a* values ranging from -3.92 to 7.08, and b* values ranging from 14.79 to 27.53. In comparison to the other drying processes, the FD process significantly improved the lightness of dried capsicum. Capsicum greenness was highest in the freeze-drying sample, while yellowness was highest in the oven-drying sample. The low temperature inside a product can be explained by the weak internal heat transfer in the dry layer during the FD method. The nutraceutical value was maintained due to the minimal color deterioration during the FD method. Non-enzymatic browning, on the other hand, was another source of capsicum color degradation in the HD and MWD samples. This was since the method's temperature and time was used to obtain the necessary moisture level in the dried capsicum. Non-enzymatic browning in dried capsicum has been linked to a Maillard reaction involving reducing sugar and amino acid. Browning reactions are predicted to be reduced in the FD method due to the low temperature. As a result, the FD sample lost less color than the HD and MWD samples.

Table1: The effect of the physical parameter in three different drying techniques of capsicum

Sample	Rehydration ratio	Dispersibility (%)	Oil absorption capacity	Bulk density (g/ml)
HD	12.35±0.5175[a]	6±0.3[a]	2.35±0.11[a]	0.325±0.01[a]
FD	10.89±0.619[b]	36±2.8[b]	2.89±0.03[b]	0.22±0.011[b]
MWD	8.78±0.439[c]	40±2.00[c]	1.6±0.08[c]	0.335±0.01[a]

Rehydration capacity

The rehydration capability of the dried product was employed as a quality feature reflected in the rehydration rate. The high rate of moisture removal at high temperatures results in less shrinkage. Microstructural property is improved by rehydrating the sample at 50°C-80°C. The rehydrated product suggests minimizing the damage of cellular structure and improving vitamin C, color, and firmness. The rehydration ratio of the HD powder is the highest, and the MWD powder is the lowest, which is reflected in table 2.

Table 2: Colour parameters of different dried capsicum

DT	L*	a*	b*	Hue (^{0})	Chrome
OD	45.45±0.12^a	-1.19±0.13^a	31.04±0.20^a	87.80±4.39^a	31.06±1.5^a
FD	50.32±0.25^b	-3.92±0.22^b	27.53±0.36^b	81.89±4.09^b	27.80±1.39^b
MWD	29.34±0.08^c	6.98±0.09^c	15.36±0.10^c	65.56±3.27^c	16.87±0.845^c

Oil absorption capacity

The oil absorption capacity is reduced due to the increase in drying temperature. Oil absorption capacity of the MWD, HD, and FD powder is 1.6±0.08 g/g at 700W, 2.35±0.11 g/g at 60 °, 2.89±0.03 g/g at -50°C.

Bulk density

Bulk density is a measurement of a powder sample's heaviness. It indicates the approximate volume of packaging material needed. High bulk density is desirable for the greater ease of dispersion and reduction in thickness of paste. The highest bulk density was found to be 0.335±0.01675g/ml in MWD powder.

Dispersibility

When a powder is dissolved in water with gentle mixing, it can break into individual particles. The ease with which lumps and agglomerates of powder break apart in water are known as dispersibility. As compared to FD and HD powder, MWD capsicum has a higher dispersibility. The wettability of highly distributed particles is excellent

CHEMICAL PROPERTIES

Capsaicin

The capsaicin content of dried capsicum was higher than the fresh capsicum sample, but compared to the different drying techniques, the MWD sample has higher capsaicin content than the HD and FD samples. The lower capsaicin content in fresh capsicum may differ due to the catalytic activity of the peroxidase enzyme. Dried capsicum samples were blanched (90 ºC) before drying for inactivating that enzyme. The capsaicin content of all dried capsicum varied between 1.91±0.05 and 3.31±0.16 mg/100 g. thermally treated (210 °C) capsicum was reported to show an increase in capsaicin content. Dehydration of the food matrix and increased extractability of capsaicin due to cell disruption during thermal treatment were responsible for this.

Carotenoid

Carotenoid content is an essential parameter for determining the final quality of dried capsicum as it is a determining factor of the nutritional quality of the product. The total carotenoid content of HD, FD, and MWD dried capsicum powder are 0.296±0.014 mg/ml, 0.2747±0.013 mg/ml, and 3.5245±0.176 mg/ml, as shown in table 3.

Table 3: Antioxidant content and antioxidant activity in different dried capsicum

Sample	OD	FD	MWD
Phenolic content (mg/g)	17.002±0.51^a	12.86±0.643^b	18.4±0.92^c
Flavonoid (mg/g)	1.055±0.05^a	1.783±0.08^b	1.14±0.05^c
Ascorbic acid (mg/g)	29.18±0.45^a	31.67±1.58^b	24.12±1.1^c
Carotenoid content (mg/ml)	0.296±0.014^a	0.274±0.013^b	3.524±0.176^c
Capsaicin content (mg/g)	1.98±0.09^a	1.91±0.05^b	3.31±0.16^c
DPPH (%)	75±3.75^a	66.90±3.35^b	82.38±4.12^c

Ascorbic acid

The ascorbic acid content varies with different drying conditions. The ascorbic acid content of dried capsicum varied between 24.12±1.1 to 31.67±1.58 mg/100g (Table 3). The ascorbic acid content of the FD sample was higher than that of the HD and MWD samples. Capsicum's ascorbic acid content decreases as it dries. The HD approach had a negative impact on ascorbic acid retention, which was because heated air naturally exposes goods to oxidation, lowering their ascorbic acid content. During drying, light and high temperatures oxidized ascorbic acid, resulting in the formation of L-dehydro ascorbic acid and several carbonyl and other unsaturated compounds.

Antioxidant content and antioxidant activity

The polyphenol and flavonoid contents of the capsicum were determined and presented in Table 3. MWD sample is rich in polyphenol and flavonoid compared to the FD and HD sample. The extreme heat produced by microwaves produces a high vapor pressure and temperature within plant tissue, resulting in the disruption of plant cell wall polymers, explaining the increase in polyphenols and flavonoids in microwave dried powder. As a result, cell wall phenolics or bond phenolics and flavonoids can be released in some instances, resulting in increased phenolic and flavonoid extraction. MWD powder has high antioxidant content and activity compared to the FD, and HD powder is shown in table 3. As antioxidant activity and antioxidant content, both are correlated.

CONCLUSION

In this research study drying temperature affects the capsicum's color, antioxidant compounds, and physical properties. However, freeze-drying was better due to color properties but in respect of antioxidant content (phenolic 18.4±0.92 mg/g), bioactive components (Capsaicin 3.31±0.16 mg/g, carotenoids content 3.524±0.176 mg/ml), and antioxidant activity (82.38±4.119%). Physical parameters such as bulk density (0.335±0.01g/ml) and dispersibility (40±2.00%) were highest in MWD powder. Microwave drying was the best among different drying processes for capsicum. MWD capsicum powder has the best flavor property (8.2±0.02) compared to HD and FD samples. The MWD powder of capsicum was the best product for its highest antioxidant content and other physical properties.

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