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Physico-chemical and sensory quality of fluidized bed dried green chilli flakes

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Abstract

The present study aimed to evaluate the effect of drying temperature, cutting style, and NaCl pretreatment on the quality of green chilli flakes during storage. Fresh green chillies were pretreated with NaCl, prepared in two forms (slit and chopped), and dried at three different temperatures (40 °C, 50 °C, and 60 °C) using a fluidized bed dryer. This drying system, known for its efficient heat and mass transfer, suspends food particles in a hot air stream to ensure uniform and rapid moisture removal. Dried samples were analyzed at 0, 30, 60, and 90 days for physicochemical parameters such as moisture content, ash content, ascorbic acid, capsaicin content, and rehydration coefficient. Instrumental color values (L*, a*, b*, hue angle, chroma, and ΔE) were recorded to assess visual quality. Sensory evaluation was conducted to assess colour, flavour, taste, texture, and overall acceptability. Results revealed that chopped samples, pretreated with NaCl and dried at 50 °C, retained more nutrients, had less color degradation, higher rehydration capacity, and better sensory scores. NaCl pretreatment improved drying efficiency by increasing cell wall permeability. However, higher temperatures (60 °C) caused greater nutrient loss, while lower temperatures (40 °C) slowed drying and posed microbial risks. This study confirms fluidized bed drying, combined with pretreatment, enhances the quality and shelf stability of green chilli flakes.

Keywords: Green chilli flakes, fluidized bed drying, NaCl pretreatment, storage stability

Introduction

Green chillies are a common vegetable used in Indian kitchens for their spicy taste. Green chillies are scientifically known as *Capsicum annum* L. The spiciness of green chillies comes from a chemical called capsaicin. Apart from providing a hot and spicy taste, capsaicin is responsible for numerous other health effects on the heart, stomach, and pain relief. Green chilli is one of the most widely used spice worldwide. Green chillies originated in America and are widely grown in Africa, Asia and the Mediterranean region [1]. In India, chilli occupies an area of 7.50 lakh hectares with an annual production of 11.67 lakh tonnes. Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu are major chilli growing states in India which together contributes about 75% of the total cultivated area. Karnataka stands second in area (1.23 lakh hectares) and production (1.42 lakh tonnes), while in productivity it ranks 8thin position with an average yield of 1150 kg of dry chilli per hectare [2].

In Asian cuisines, dried chilli is the most commonly used spice product for flavouring and colouring [3]. Numerous factors, including colour, hotness, ascorbic acid concentration, and volatile taste components, are used to evaluate the quality of dried chillies [4, 5, 6, 7, 8, 9]. In actuality, chilli may be kept for a long time as dried chilli, mostly by employing various drying techniques. In essence, drying is the act of removing moisture by the simultaneous movement of mass and heat.

The use of an expensive or limited supply of drying gas implies a beneficial application for a fluidized bed dryer. The above is especially true for corrosive and erosive particles. Because of its small size and light weight, it is a device that may be built in corrosion-resistant alloy materials without incurring significant costs. The selection of optimal fluidizing conditions is an important component in the dryer's design and functioning. This is best determined empirically for the specific material in a pilot plant. Drying is an essential procedure in many food sectors and agricultural countries like China, India.

Large quantities of food are dried to extend shelf life, reduce packaging costs, minimise transportation weights, improve appearance, encapsulate natural flavour, and preserve nutritional value. Drying process research in the food industry has three basic goals: economic considerations, environmental issues, and product quality. The large market for dehydrated fruits and vegetables highlights the relevance of drying for the majority of countries globally.

Drying is one of the many solid handling methods that make extensive use of fluidized bed technology. Generally speaking, fluid bed drying is used in situations requiring delicate handling conditions, careful control, or the application of tiny driving forces. Green chilli flakes, onion slices, garlic granules, ginger powder, turmeric pieces, tea leaves, grains such as rice and wheat, pulses, herbs, and dehydrated fruit slices are among the materials that can be dried by fluidized bed drying. Even though fluidization is a very flexible process, its full potential can only be realised with a thorough comprehension of its fundamentals and an awareness of its limitations. Very intriguing findings arise when the mechanisms of fluidization and drying are combined. The solid particles are moving in the fluidized bed with almost no restraint. Any particle is not defined in space other than as a function of time and has unrestricted access to every area of the fluidized bed at any given time. Instead of being a line, the upper level of the bed is a region. The fluidized regime is generally characterized by fast mass and heat movement. The fluidized bed of solids is a very effective solids mixer, as has been shown numerous times. Wet feed is immediately distributed across the bed, as is easily visible. In general, the fluidized beds' properties are unaffected by the feed state [10].

Material and Methods

Experiments were carried out to develop a green chilli flakes, in the laboratories established under the RKVY funded project "Establishment of Agro Processing centre" at the Department of Processing and Food Engineering, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut. Experiments were also carried out to evaluate the physico-chemical properties (moisture content, ash content, ascorbic acid, capsaicin content), and sensory evaluation (overall acceptability) of green chilli flakes. The samples were kept for storage for further study after 30, 60, and 90 days. The present study was carried out to prepare green chilli flakes using fluidized bed dryer. The drying of NaCl treated samples was done at three temperatures i.e., (40℃, 50℃, 60℃) in slit and chopped form.

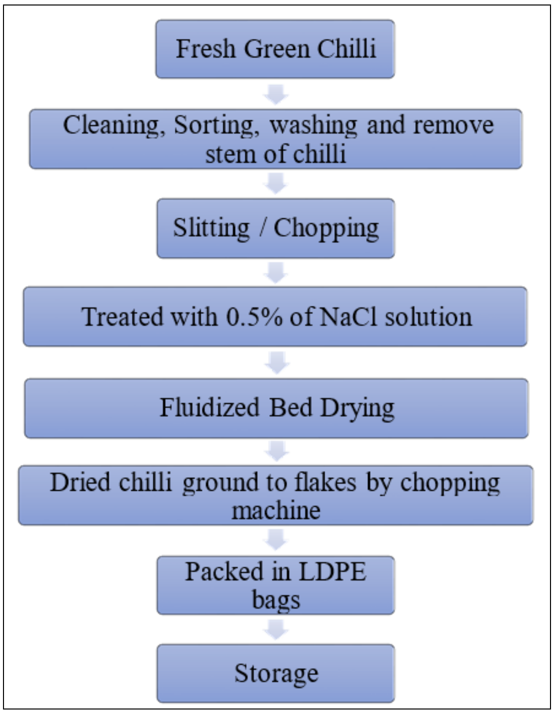

Fig 1: Preparation of Green Chilli Flakes Ash Content

The ash content of the flakes was determined by using oven method [11]

Moisture Content

Moisture content of all the samples was determined using standard method [11].

Instrumental Colour quality

The color values of the sample were measured in terms of L*, a*, and b* using a Hunter color meter under Illuminant D65 lighting conditions. In the CIELAB color space, L* values indicate the lightness of the sample, where higher values correspond to a brighter or whiter appearance. The a* values represent the red-green chromaticity, with positive values indicating redness and negative values indicating greenness. Similarly, b* values correspond to the yellow-blue chromaticity, where positive values signify yellowness and negative values indicate blueness. Hue angle and C* (chroma) were computed using a specific formula.

Total colour difference (ΔE)

The measure of change in visual perception of two given colors. ΔE a metric for understanding how the human eye perceives color difference.

$$\sqrt{(L_0 - L)^2 + (a_0 - a)^2 + (b_0 - b)^2}$$

Where, refer to the Hunter colour parameters of fresh chilli sample. L, a, b refer to the Hunter colour parameter of dried chilli sample.

Chroma

The chroma or saturation of a color is a measurement tool for determining level of its intense or the degree of saturation of colour and is proportional to the strength of colour.

$$C = \sqrt{a^2 + b^2}$$

Hue Angle

The Hue angle is another parameter frequently used to characterize the colour in food products. As drying proceeded, the hue angle value corresponds to whether the subject is red, orange, yellow, green, blue or violet, especially if hue angle between of 0° or 360° represent red hue, while 90°, 180° and 270° represents yellow, green and blue hue respectively.

H = tan-1 (b/a)

Extraction and determination of capsaicin content

Capsaicin content in the samples was estimated by spectrophotometric measurement of the blue coloured component formed as a result of reduction of phosphomolybdic acid to lower acids of molybdenum following [12].

Extraction and determination of ascorbic acid content

Ascorbic acid content of dried green chilli flakes was estimated by volumetric method [13].

Rehydration ratio

The rehydration ratio of the dried green chilli flakes was determined as the ratio of rehydrated mass to the initial dehydrated mass, which gives a measure of the ability of dried green chilli flakes to reabsorb water. A sample of 5g of the dried green chilli flakes was placed in a 250ml beaker containing 100ml of boiling distilled water. The contents were boiled for 20 min to allow the flakes to rehydrate. After rehydration, the free surface water on the flakes was removed before assessing the rehydrated mass. Rehydration ratio can be calculated by the formula;

$$\text{Rehydration Ratio (RR)} = \frac{Wr}{Wd}$$

Where,
Wr = Rehydrated sample mass (g)
Wd = Initial mass of the sample before rehydration (g)

Storage Studies

Shelf- life studies were conducted on green chilli flakes using LDPE bags. The study lasted for 3 months at room temperature. 100 grams of dried slit and chopped samples were packed and stored. Samples were analyzed at regular intervals (0, 30, 60, 90 days) to asses moisture content and overall acceptability based on by sensory evaluation.

Sensory Evaluation

Green Chilli flakes were tested by a panel of ten judges. A semi trained panel consisting of both genders more than 10 judges of different age group having different eating habits was constituted to evaluate the quality. The judges was selected from the faculty staff and the students of Department of Agricultural Engineering SVPUA&T. Samples shall be served to the panelists and they were asked to rate the acceptability of the product through sense organ. The products were evaluated organoleptically for color, flavor, texture, and overall acceptability. The test panelists were asked to rate the sample for color, flavor, texture, and overall acceptability on 1- 9-point scale.

In this study, the comparison between general feelings and pungency feelings was used to obtain a clearer understanding of consumer perception of green chilli flakes. The general hedonic scale measures overall acceptability through terms such as “Like Extremely” or “Dislike Moderately,” without reference to any specific attribute. Since pungency is the defining characteristic of chilli products, the scale was modified into a pungency-specific form, ranging from “Extremely Pleasant Pungency” to “Extremely Unpleasant Pungency.” This modification allowed the evaluation to focus directly on the acceptability of pungency intensity, providing more accurate insights into consumer preference than the general hedonic scale alone.

Table 1: 9 Point hedonic scale for sensory evaluation

S. No.	Feelings	Rating	Pungency Feeling
1	Like Extremely	9	Extremely Pleasant Pungency
2	Like Very Much	8	Very Much Pleasant Pungency
3	Like Moderately	7	Moderately Pleasant Pungency
4	Like Slightly	6	Slightly Pleasant Pungency
5	Neither Like or Dislike	5	Neither Pleasant nor Unpleasant Pungency
6	Dislike Slightly	4	Slightly Unpleasant Pungency
7	Dislike Moderately	3	Moderately Unpleasant Pungency
8	Dislike Very Much	2	Very Much Unpleasant Pungency
9	Dislike Extremely	1	Extremely Unpleasant Pungency

Result and Discussion

The purpose of this study was to investigate the effect of different temperatures on nutritional quality of green chilli flakes in a fluidized bed dryer during storage. Investigations were also conducted to investigate drying behaviour under fluidized bed drying optimisation of process parameters in terms of drying features of dried green chilli flakes and nutritional properties over a 90-days storage period. In the experiment, dried green chilli flakes were categorised as slit and chopped and allowed to dry at varied temperatures (40, 50, and 60 ºC) for different exposure time, with observations made accordingly.

Effect of drying temperatures, cutting style and storage period on the quality attributes of green chilli flakes

Moisture Content

The moisture content of dried slit green chilli flakes at 40, 50, and 60 ºC was 4.86%, 5.45% and 3.52% at the beginning of storage (0 day). It is evident from Fig 2. that when the temperature rose, the moisture content dropped. Regardless of the fluidized bed drying temperature, the study found that over the storage time. Following 30 days of storage, the moisture content was found to be 10.65%, 12.02% and 10.65% (w.b.), followed by 12.53%, 13.32% and 11.64% (w.b.) after 60 days, and 15.89%, 15.50% and 12.68% after 90 days for the dried samples at 40 ºC, 50 ºC, and 60 ºC drying temperatures, respectively.

The moisture content of chopped green chilli flakes was determined to be 7.34%, 5.96% and 6.16%; 7.90%, 6.12% and 7.47%; 9.23%, 7.14% and 10.97%; 11.83%, 8.00% and 11.23% (w.b.) after 0, 30, 60, and 90 days of storage period respectively. Fig 2. clearly shows that the moisture content of slit at 40 ºC dried samples was higher than that of chopped at 60 ºC samples after 30, 60, and 90 days of storage period. clearly shows the influence of storage period on moisture content in relation to various drying procedures. In any case, the moisture content increases storage term. The observed increase in moisture content during storage is primarily due to the hygroscopic nature of the dried green chilli flakes, packaging inefficiencies, and ambient storage conditions.

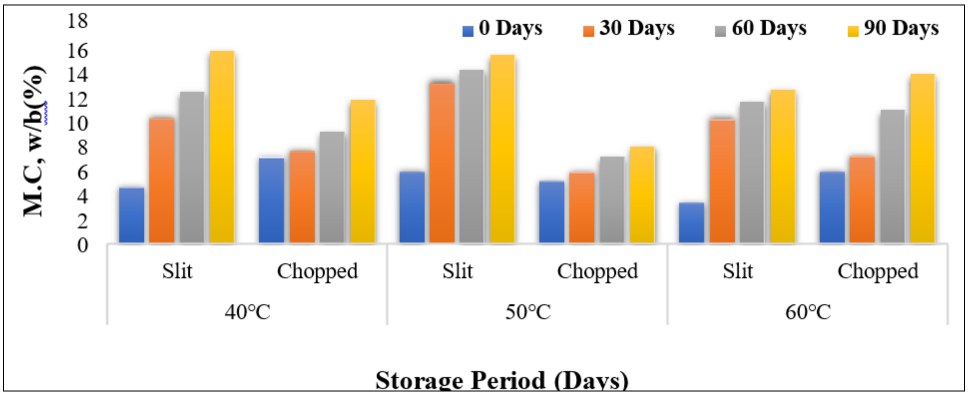

Fig 2: Changes in Moisture Content of Green Chilli Flakes

Ash Content

Fig 3. showed the experimental data on variations in the ash content of green chilli flakes over storage. Fig. displays a bar chart for three distinct temperatures of chopped and slit green chilli flakes (40 ºC, 50 ºC, and 60 ºC). The ash level of dried slit green chilli flakes at 40, 50, and 60 ºC was 7.06%, 6.79% and 6.9% at the beginning of storage (0 day). The ash content was recorded as 5.7%, 6.7% and 5.38% (w.b.) after 30 days of storage and as 4.59%, 5.8% and 5.27% (w.b.) after 60 days. After 90 days, the dried samples at 40 ºC, 50 ºC, and 60 ºC drying temperatures had ash contents of 4.14%, 5.39% and 4.94% (w.b.). In case of chopped green chilli flakes, the ash content were obtained as 6.79%, 6.62% and 5.95%; 4.22%, 5.37%, and 4.29%; 3.98%, 4.71% and 4.25%; 3.6%, 3.7% and 3.8% (w.b.) during storage of 0 day, 30 day, 60 days and 90 days, respectively.

The decline in ash content observed over 90 days of storage in both slit and chopped green chilli flakes dried at different temperatures can be attributed to multiple factors such as mineral loss due to oxidation or leaching, increased enzymatic activity in high moisture conditions, and physical form of the product. These results are in line with previous studies by [14, 15]**,** which reported similar reductions in mineral content in dried vegetables over storage under ambient conditions.

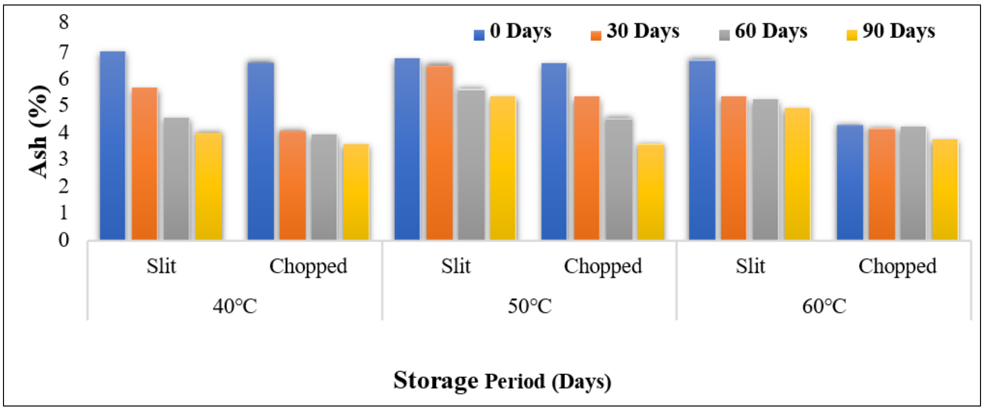

Fig 3: Changes in Ash Content of Green Chilli Flakes

Ascorbic Acid

Fig 4. showed the experimental data on variations in the ascorbic acid content of green chilli flakes over time. Fig. displays a bar chart for three distinct temperatures of chopped and slit green chilli flakes (40 ºC, 50 ºC, and 60 ºC). The ascorbic acid of dried slit green chilli flakes at 40, 50, and 60 ºC was 68.8mg/100gm, 67.28mg/100gm and 61.928mg/100gm at the beginning of storage (0 day). The study discovered that during the storage term, regardless of the fluidized bed drying temperature. After 30 days of storage, the ascorbic acid was observed as 588mg/100gm, 60.88mg/100gm and 548mg/100gm, after 60 days, the ascorbic acid was observed as 528mg/100gm, 55.78mg/100gm and 48.28mg/100gm, and after 90 days the ascorbic acid was observed as 48.168mg/100gm, 50.128mg/100gm and 41.288mg/100gm for the dried samples at 40 ºC, 50 ºC, and 60 ºC, respectively. The ascorbic acid content of chopped green chilli flakes was found to be 37.848mg/100gm, 37.848mg/100gm, and 45.04mg/100gm; 30.40mg/100gm, 28.50mg/100gm, and 42.20mg/100gm; 24.80mg/100gm, 24.30mg/100gm and 35.88mg/100gm; 180mg/100gm, 17.40mg/100gm and 25.50mg/100gm after 0, 30, 60, and 90 days of storage period. The ascorbic acid content of green chilli flakes significantly decreased during storage due to oxidative degradation, with higher losses in chopped samples and those dried at higher temperatures. These findings are consistent with previous studies [16, 17] highlighting ascorbic acid's instability during thermal processing and storage. The results emphasize the importance of temperature control, minimal processing, and protective packaging to preserve nutrient quality during storage.

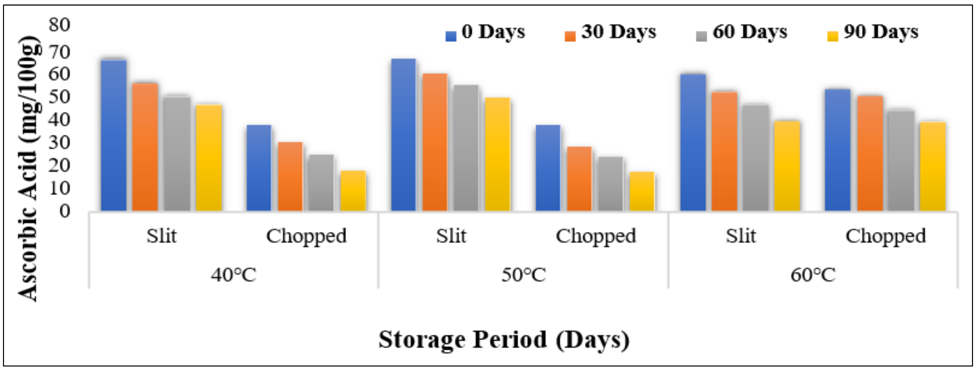

Fig 4: Changes in Ascorbic acid of Green Chilli Flakes

Rehydration ratio

To recover the original samples, the rehydration ratio of dried green chilli flakes was examined. Fig 5. showed the experimental data for variations in the green chilli flakes' rehydration ratio over storage. The rehydration ratio and moisture content of the rehydrated sample were used to express this feature. The rehydration ratio of dried slit green chilli flakes (40 ºC, 50 ºC, 60 ºC temperature) was determined at the beginning of storage (0 day). Fig 5. clearly shows that the rehydration ratio decreases with increasing temperature. The study discovered that during the storage term, regardless of the fluidized bed drying temperature. After 30 days of storage, the rehydration ratio was observed as 6.04, 6.93 and 3.95 (w.b.), after 60 days, the rehydration ratio was observed as 5.96, 6.6, and 3.54 (w.b.), and after 90 days the rehydration ratio was observed as 3.28, 6.32, and 3.43 for the dried samples at 40, 50, and 60 ºC, respectively. The rehydration ratio for chopped green chilli flakes was 9.01, 6.53 and 7.18; 6.08, 6.18 and 6.9; 5.27, 6.6 and 5.23; 2.49, 6.32 and 3.69 (w.b.) after 0 days, 30 days, 60 days, and 90 days of storage, respectively. The rehydration ratio of green chilli flakes declined with increasing drying temperature and prolonged storage, due to structural damage and aging effects on cellular components. Chopped samples, despite having initially higher rehydration, experienced faster degradation. The results align with previous literature [18, 19] on how drying and storage conditions affect reconstitution properties of dehydrated plant products.

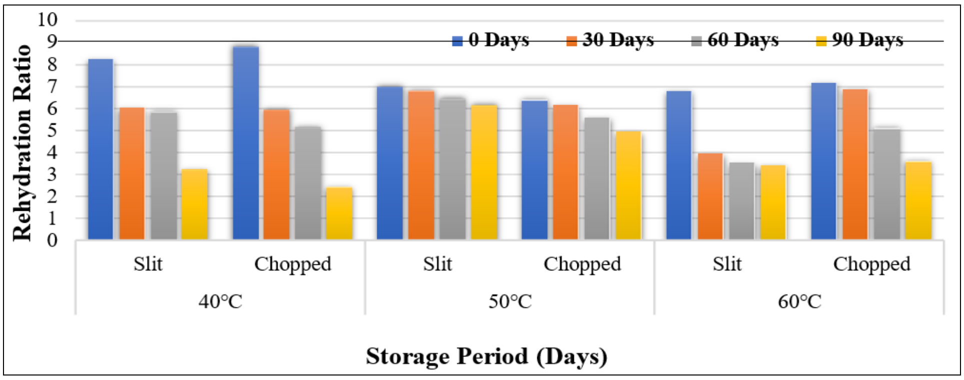

Fig 5: Changes in Rehydration ratio of Green Chilli Flakes

Coefficient of rehydration

The coefficient of rehydration (CoR) is a crucial parameter used to assess the ability of dried food products to regain moisture and restore texture upon rehydration. In the present study, the CoR of green chilli flakes (slit and chopped) was evaluated at three drying temperatures (40 °C, 50 °C, and 60 °C) over a 90-day storage period. The results revealed a noticeable decline in the CoR with increased storage time across all drying conditions. At 0 days, slit green chillies dried at 40 °C exhibited the highest CoR (0.9), indicating excellent rehydration potential due to minimal structural damage during drying. Chopped samples at the same temperature showed a slightly lower value (0.8), likely due to higher surface exposure and cell wall breakage during preparation. As storage progressed, a consistent decrease in CoR was observed. By the 90th day, the CoR had reduced significantly in both forms, with slit samples at 40 °C showing the lowest value (0.3). Interestingly, chopped samples dried at 50 °C demonstrated relatively better rehydration retention (0.5) than those at 40 °C and 60 °C, suggesting that moderate drying temperature may preserve microstructure more effectively during long-term storage. These findings are in agreement with [20], who emphasized that optimal drying conditions minimize cellular collapse, preserving rehydration efficiency. Throughout the study, chopped green chillies generally retained higher CoR values than slit ones, particularly during extended storage. The observed decrease in CoR over time can be linked to oxidative reactions, hardening of tissues, and irreversible changes in cellular matrix during storage. This degradation ultimately limits the product's ability to absorb moisture and regain its original texture. Similar trends were reported by [21] in rehydrated chilli puree, reinforcing the correlation between thermal processing, storage duration, and rehydration behaviour.

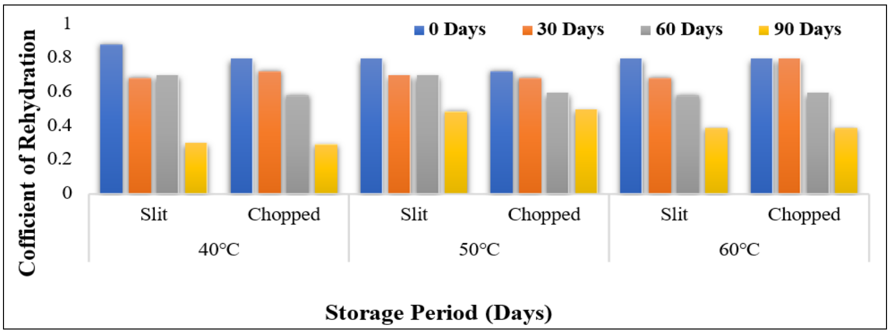

Fig 6: Changes in Coefficient of rehydration of Green Chilli Flakes

Capsaicin Content

Capsaicin content, which contributes to the pungency of green chillies, showed a decreasing trend with increasing storage time across all drying temperatures and forms. At day 0, slit samples dried at 50 °C exhibited the highest capsaicin content (0.91 mg/g), followed closely by chopped samples at the same temperature (0.89 mg/g). This suggests that moderate drying temperature (50 °C) is optimal for retaining pungency due to minimal thermal degradation compared to 60 °C, and reduced enzymatic activity compared to 40 °C. By 90 days, a significant decline was observed across all samples. Slit samples at 40 °C dropped to as low as 0.08 mg/g, while slit at 50 °C retained relatively higher capsaicin (0.65 mg/g). Chopped samples, in general, showed faster degradation than slit, likely due to more surface exposure and cellular rupture, increasing the susceptibility to enzymatic breakdown and oxidation. The degradation of capsaicin with prolonged storage is consistent with earlier studies by, [22] who noted thermal and oxidative sensitivity of capsaicinoids. Similarly, [23] emphasized the impact of drying conditions and storage on bioactive compound retention.

The results underline that 50 °C is an optimal temperature for maintaining capsaicin during drying and storage.

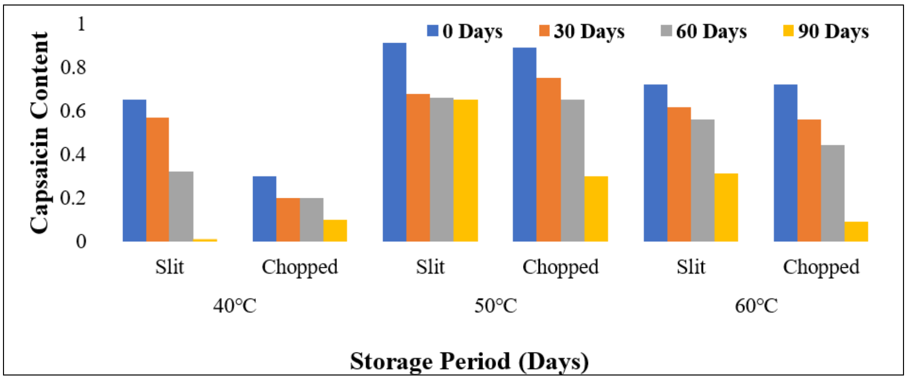

Fig 7: Changes in Capsaicin Content of Green Chilli Flakes

Colour values (L*)

The L* values, indicating lightness of green chilli flakes, increased progressively with storage duration for all drying temperatures and forms. Initially, chopped samples at 40 °C showed the highest lightness (L* = 42.74), while slit samples at 60 °C recorded the lowest (L* = 25.88), reflecting deeper color retention due to minimal oxidation at the start. As storage progressed, L* values increased significantly, especially for chopped samples, with a maximum of 69.19 at 90 days for chopped flakes at 40 °C, indicating pronounced discoloration.

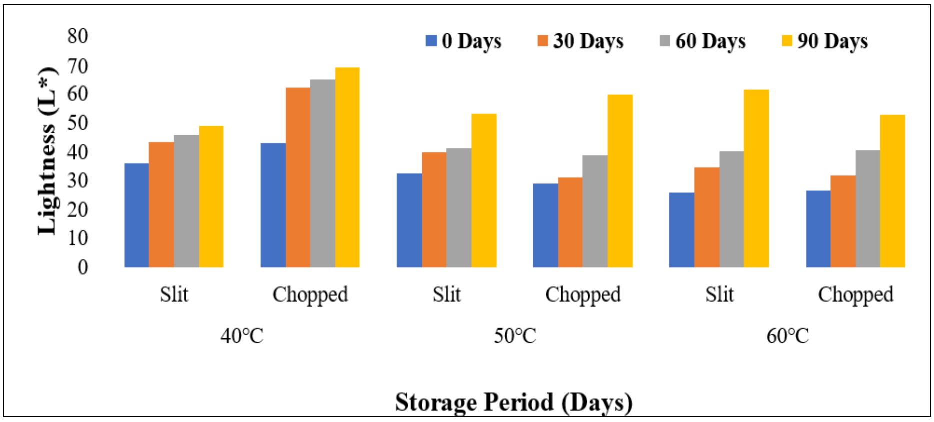

Fig 8: Changes in Colour values (L*) of Green Chilli Flakes

This rise in L* values suggests the breakdown of pigments such as chlorophyll during storage, leading to color fading. Chopped samples showed more color degradation than slit ones, likely due to increased surface area exposure. The drying temperature of 60 °C showed higher L* values at later storage stages, particularly for slit samples (61.36), possibly due to higher thermal degradation of pigments.

Colour values (a*)

The a* value in the CIELAB color space signifies the red-green axis, where positive values indicate redness and negative values indicate greenness. Initially, all samples especially slit ones dried at 50 °C exhibited higher positive a* values, such as 12.64 for 50 °C slit and 8.42 for 50 °C chopped at day 0. This indicates the strong retention of red pigmentation like carotenoids and anthocyanins immediately after drying. However, a clear decreasing trend in a* values was observed during storage up to 90 days, across all drying temperatures and chilli forms. For example, the a value of slit chilli at 50 °C decreased from 12.64 to -2.3, while chopped chilli at 40 °C dropped drastically from 2.03 to -11.18, indicating substantial pigment loss and the dominance of greenish tones. This shift from red to green tones during storage is a strong indicator of color degradation, primarily due to oxidation of carotenoids and chlorophyll degradation. Chopped samples showed more negative a* values than slit forms at all time intervals, which may be due to their increased surface area exposure, higher enzyme activity, and faster moisture loss, accelerating pigment degradation. Likewise, higher temperatures such as 60 °C showed more color instability over time compared to moderate drying at 50 °C. This behaviour is supported by [24]**,** who reported a decrease in redness due to carotenoid breakdown during drying and storage of peppers. Similarly, [25] found that air-drying at higher temperatures could negatively affect the color parameters, including a* values, over time.

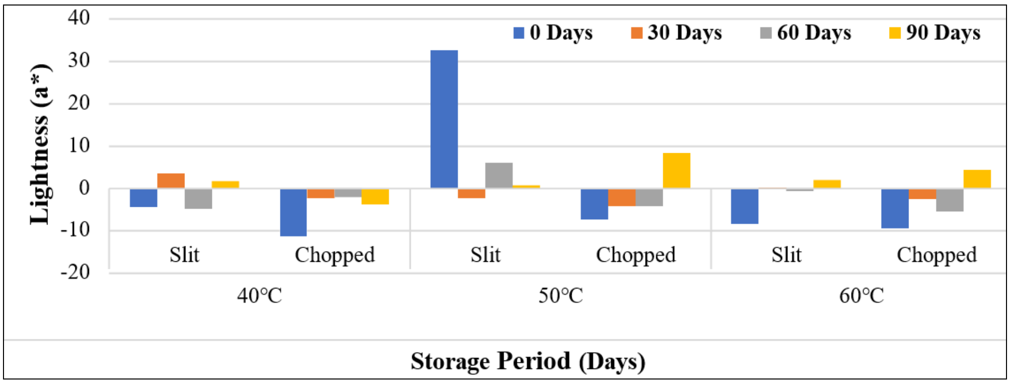

Fig 9: Changes in Colour values (a*) of GreSen Chilli Flakes

Colour values (b*)

The b* value in the CIELAB color space reflects the yellow-blue spectrum, with positive values indicating yellowness. Initially, all dried green chilli samples exhibited high b* values, with the highest recorded in 50 °C chopped samples (51.37) and 49.67 in 50 °C slit form, indicating strong yellow pigmentation immediately after drying.

Over time, a progressive decline in b*values was observed across all treatments during storage, reflecting loss of yellow pigmentation due to oxidative degradation of carotenoids and Maillard browning reactions. The most significant drop was recorded in the 60 °C slit samples, where the b* value declined from 48.38 to 21.22 by day 90. This suggests that higher drying temperatures, such as 60 °C, may accelerate degradation of yellow pigments like lutein and zeaxanthin. In contrast, chopped samples dried at lower temperatures (40 °C and 50 °C) retained higher b* values even after 90 days, e.g., 33.98 and 30.28, respectively, which implies better color stability. The slower rate of decline in chopped samples can be attributed to uniform heat penetration and possibly less intense surface-level degradation due to shorter drying time needed for smaller pieces.

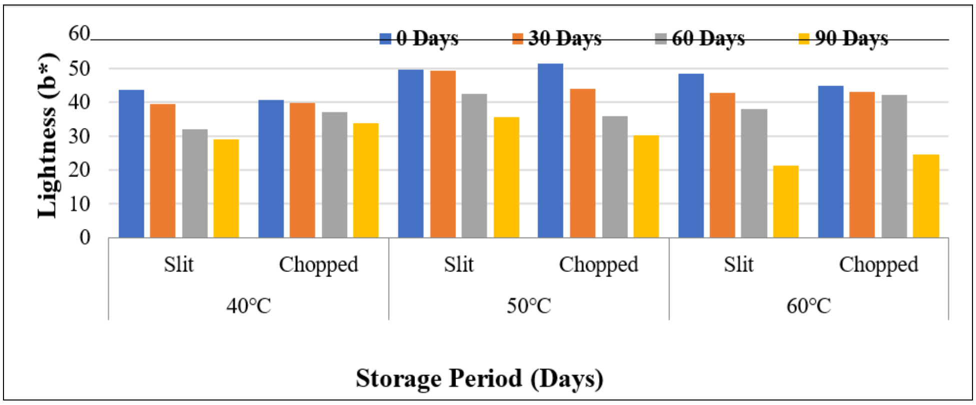

Fig 10: Changes in Colour values (b*) of Green Chilli Flakes

Total Colour Difference (ΔE)

The total colour difference (ΔE) is a key parameter used to evaluate the extent of deviation from the original fresh product colour during processing and storage. In this study, ΔE values were observed to increase with both storage duration and drying temperature, indicating progressive discoloration over time. At the initial stage (0 day), lowest ΔE was observed in slit samples at 50 °C (18.71), suggesting that drying at this temperature helped in maintaining colour integrity. However, chopped samples across all temperatures showed relatively higher ΔE, especially at 40 °C and 60 °C, likely due to greater exposure to oxidation and enzymatic browning caused by increased surface area.With time, a gradual increase in ΔE was seen across all treatments. By the end of 90 days, maximum ΔE was recorded in chopped samples at 40 °C (69.22) and 60 °C (62.13),indicating severe degradation in visual quality. This may be attributed to insufficient drying at low temperatures and thermal degradation at higher temperatures, especially in chopped samples where cellular structure is more disrupted.

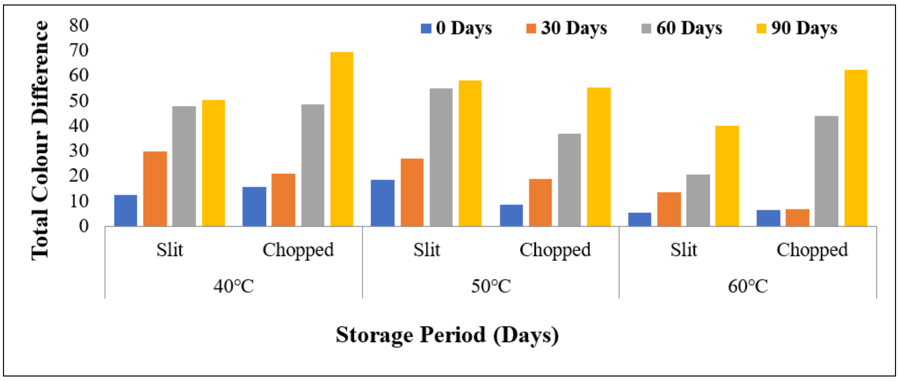

Fig 11: Changes in Total Colour Difference of Green Chilli Flakes

Chroma

Chroma, an indicator of color saturation and intensity, gradually decreased over storage time across all treatments, indicating the loss of vividness and color stability in dried green chilli flakes. At 0 days, the highest chroma was recorded in chopped samples dried at 50 °C (52.05) and slit samples at 50 °C (50.31), indicating that this temperature maintained the color vibrancy effectively in both forms. However, the chroma values declined steadily over 90 days, with the lowest chroma seen in slit samples dried at 60 °C (22.81), suggesting that high temperature in combination with a slit form may accelerate pigment degradation due to increased surface exposure and thermal breakdown. In general, chopped samples retained better chroma than slit samples at all temperatures. This may be due to the lower surface area exposed in chopped samples, reducing oxidation and preserving pigments. The slit form, having more exposed surface area, is more vulnerable to oxidation and enzymatic browning, particularly at elevated drying temperatures. By 90 days, the reduction in chroma was most significant at higher temperatures, especially in slit samples. For instance, a reduction from 48.41 to 22.81 was observed in slit samples at 60 °C, indicating a more than 50% decline. On the other hand, chopped samples dried at 50 °C showed a relatively better chroma retention (from 52.05 to 36.72), highlighting that moderate temperature drying (50 °C) in chopped form is more effective for maintaining color quality over time.

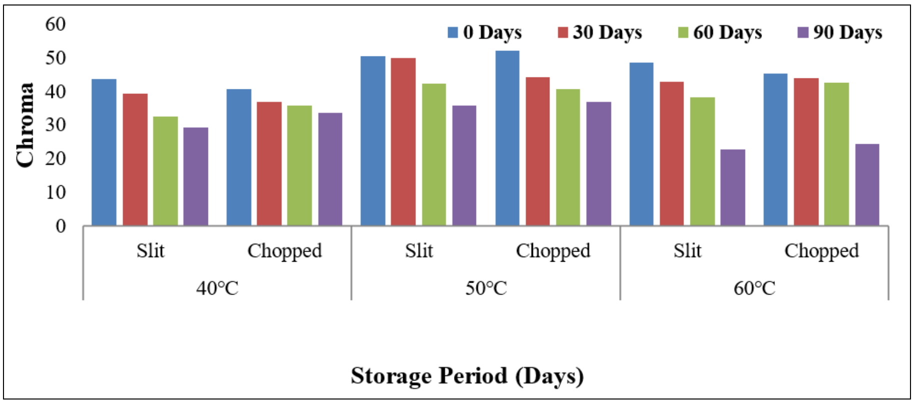

Fig 12: Changes in Chroma of Green Chilli Flakes

Hue Angle

The hue angle of green chilli flakes showed a decreasing trend during storage across all temperatures and both cutting methods, indicating a gradual shift from green to yellowish or brownish hues, which is a common result of chlorophyll degradation and Maillard browning during drying and storage. Initially, all treatments exhibited high hue values (above 84°), consistent with a fresh green appearance. Over 90 days, the slit samples at 60 °C showed the most pronounced drop in hue angle (from 89.96 to 68.47), indicating higher pigment degradation, possibly due to greater exposure to oxygen and heat. Conversely, chopped samples retained slightly better color at the same temperature.

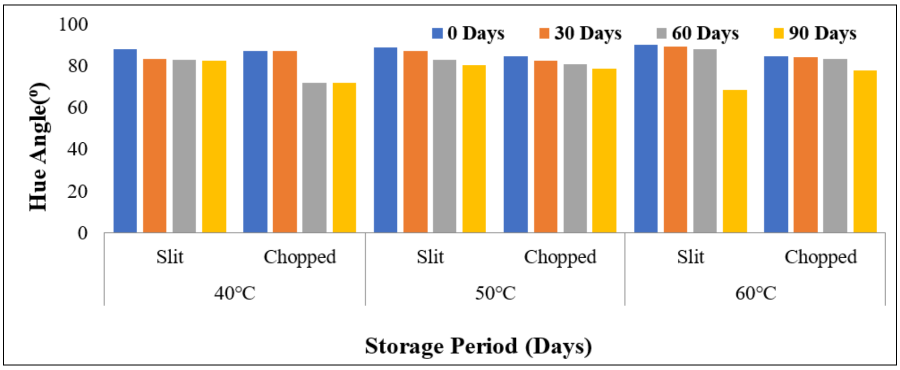

Fig 13: Changes in Hue Angle of Green Chilli Flakes

Organoleptic evaluation

A 9-point hedonic Rating scale was used to evaluate the colour, taste, flavor, texture and overall acceptability to the green chilli flakes. Organoleptic acceptability Colour, Flavour, Taste, Texture and Overall acceptability of the Slit and Chopped Green chilli flakes prepared from dried green chilli were acceptable and mean score observed were in the category of "liked moderately to liked very much".

Overall Acceptability

Overall acceptability is a composite sensory attribute derived from color, flavor, texture, and taste, reflecting the consumer's final preference for the product. The data for overall acceptability of slit and chopped green chilli flakes dried at different temperatures (40 °C, 50 °C, and 60 °C) and stored for up to 90 days visualized in Fig. 14. At the initial stage (0 day), chopped samples consistently scored higher (8.5-8.8) than their slit counterparts (8.3-8.6), with the highest score (8.8) observed in chopped samples dried at 50 °C. This can be attributed to better uniformity in drying, enhanced flavor release, and improved rehydration behaviour in chopped samples, which aligns with previous findings by [26, 23] who emphasized the impact of drying temperature and sample form on product acceptability. As storage progressed, a gradual decrease in acceptability was evident. By Day 90, the scores dropped across all samples, with slit chilli dried at 60 °C recording the maintained better sensory quality throughout the storage period, scoring 8.0 and 7.3 respectively at Day 90. This trend further confirms that moderate drying temperatures coupled with chopping as a pretreatment enhance the sensory retention of dried green chilli flakes. The decline in scores over time could be due to oxidation of pigments, loss of volatile flavour compounds, and textural degradation, particularly in slit and high-temperature dried samples. In addition to overall acceptability, pungency feelings were also evaluated using the 9-point hedonic scale, where terms such as "Extremely Pleasant Pungency" and "Extremely Unpleasant Pungency" provided attribute-specific insights. The results indicated that chopped samples dried at 50 °C not only maintained higher overall acceptability but were also rated closer to "pleasant pungency," highlighting that moderate drying conditions help preserve the desired balance of spiciness throughout storage.

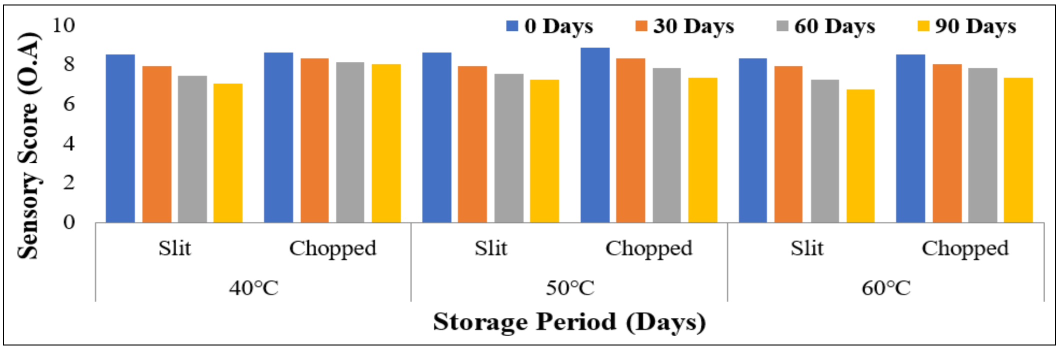

Fig 14: Changes in Overall Acceptability of Green Chilli Flakes

Conclusion

During 90 days of storage, drying temperature and cutting style significantly influenced the quality of green chilli flakes. Moisture stability, ascorbic acid, capsaicin, and colour retention were best maintained at 50 °C. Slit samples preserved higher ascorbic acid and capsaicin, while chopped samples showed better moisture control, chroma, hue, and overall acceptability. Rehydration ratio and coefficient of rehydration also remained higher in samples dried at 50 °C. Extreme drying temperatures (40 °C and 60 °C) caused greater nutrient loss, pigment degradation, and reduced sensory quality. Overall, chopped flakes retained better sensory attributes, whereas slit flakes performed well in nutrient retention. Based on combined physicochemical and sensory characteristics, chopped chilli flakes dried at 50 °C proved most suitable for long-term storage.

References

1. Tasirin SM, Puspasari I, Lun AW, Chai PV, Lee WT. Drying of kaffir lime leaves in a fluidized bed dryer with inert particles: kinetics and quality determination. Ind Crop Prod. 2014;61:193-201.
2. Spices Board India. Annual report 2022-2023. Ministry of Commerce & Industry, Govt. of India; 2023. Available from: https://www.indianspices.com
3. Jitbunjerdkul S, Kijroongrojana K. Formulation of Thai herbal Namprik. Song Kanakar in Journal of Science and Technology. 2007;29(3):837-846.
4. Henderson DE. Thermal decomposition of capsaicin. 1. Interactions with oleic acid at high temperatures. J Agric Food Chem. 1992;40:2263-2268.
5. Ruth S, Boscaini E, Mayr D, Pugh J, Posthumus M. Evaluation of three gas chromatography and two direct mass spectrometry techniques for aroma analysis of dried red bell peppers. Int J Mass Spectrom. 2003;223-224:55-65.
6. Jiang L, Kubota K. Differences in the volatile components and their odour characteristics of green and ripe fruits and dried pericarp of Japanese pepper (*Zanthoxylum piperitum* DC.). J Agric Food Chem. 2004;52:4197-4203.
7. Kim S, Lee KW, Park J, Lee HJ, Hwang IK. Effect of drying in antioxidant activity and changes of ascorbic acid and colour by different drying and storage in Korean red pepper (*Capsicum annuum* L.). Int J Food Sci Technol. 2006;41:90-95.
8. Wang Y, Xia Y, Wang J, Luo F, Huang Y. Capsaicinoids in chili pepper (*Capsicum annuum* L.) powder as affected by heating and storage methods. Am Soc Agric Eng. 2009;52:2007-2010.
9. Yaldiz G, Ozguven M, Sekeroglu N. Variation in capsaicin contents of different *Capsicum* species and lines by varying drying parameters. Ind Crops Prod. 2010;32:434-438.
10. Kunii D, Levenspiel O. Fluidization engineering. 2nd ed. Butterworth-Heinemann; 1991.
11. Thiex N, Novotny L, Crawford A. Determination of ash in animal feed: AOAC official method 942.05 revisited. J AOAC Int. 2012;95(5):1392-1397.
12. Balasubramanian T, Sadasivam S. Changes in starch, oil, protein and amino acids in developing seeds of okra (*Abelmoschus esculentus* L. Moench). Plant Foods Hum Nutr. 1987;37(1):41-46.
13. Ademoyegun OT, Fariyike TA, Aminu Taiwo RB. Effects of poultry dropping on the biologically active compounds in *Capsicum annuum* L. (var. Nsukka yellow). Agric Biol J N Am. 2011;2(4):665-672.
14. Kumar C, Karim MA. Postharvest technology and processing of minimally processed fruits and vegetables: critical review. Food Rev Int. 2007;23(2):91-120.
15. Mujumdar AS. Handbook of industrial drying. 4th ed. CRC Press; 2014.
16. Yadav AS, Sehgal S. Effect of storage on physicochemical properties of dehydrated green leafy vegetable powders. Plant Foods Hum Nutr. 2003;58(3):1-9.
17. Gupta S, Prakash J. Shelf life of dehydrated green leafy vegetable powders stored in different packaging materials. J Food Sci Technol. 2009;46(6):538-541.
18. Lee SK, Kader AA. Preharvest and postharvest factors influencing vitamin C content of horticultural crops. Postharvest Biol Technol. 2000;20(3):207-220.
19. Sablani SS. Drying of fruits and vegetables: retention of nutritional/functional quality. Drying Technol. 2006;24(2):123-135.
20. Lewicki PP. Effect of pre-drying treatment, drying and rehydration on plant tissue properties: a review. Int J Food Prop. 1998;1(1):1-22.
21. Krokida MK, Maroulis ZB. Structural properties of dehydrated products during rehydration. Int J Food Sci Technol. 2001;36(5):529-538.
22. Sagar VR, Kumar PS. Recent advances in drying and dehydration of fruits and vegetables: a review. J Food Sci Technol. 2010;47(1):15-26.
23. Ahmed J, Shivhare US. Thermal color degradation and kinetics of green chilli puree. J Food Sci. 2001;66(7):1045-1048.
24. Govindarajan VS, Sathyanarayana MN. Capsicum production, technology, chemistry and quality. Crit Rev Food Sci Nutr. 1991;29(6):435-474.
25. Alam MS, Islam MM, Rahman MM. Influence of drying methods on capsaicin content in chilli powder. Int J Food Prop. 2018;21(1):1572-1581.
26. Maskan M. Drying, shrinkage and rehydration characteristics of kiwifruits during hot air and microwave drying. J Food Eng. 2001;48(2):177-182.
27. Vega-Gálvez A, Di Scala K, Rodríguez K, Lemus-Mondaca R, Miranda M, López J, Pervéz-Won M. Effect of air-drying temperature on physico-chemical properties, antioxidant capacity, color and total phenolic content of red pepper (*Capsicum annuum* L. var. Hungarian). Food Chem. 2009;117(4):647-653.