Current Journal of Applied Science and Technology

41(20): 47-56, 2022; Article no.CJAST.88529
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Effect of Processing Methods on the Nutritional Composition of Ripe Pumpkin Fruit

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2022/v41i2031748

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/88529

Original Research Article

Received 11 April 2022
Accepted 21 June 2022
Published 25 June 2022

ABSTRACT

This research was carried out to assess processing methods on the nutritional composition of ripe pumpkin (*C. moschata*). Thermal processing (steam blanching and drying) was used to prepare pulp and powder. Pumpkin slices of treatment T_6 were steam blanched for 4 minutes, soaked in potassium metabisulfite (KMS) for 15 minutes and awarded the highest overall acceptability score (8.79) by panellists were used for the preparation of pulp and powder. A significant difference was observed in moisture content between fresh, pulp and powder i.e. 88.14 %, 88.93 % and 6.12 % respectively. The heat-sensitive nutrients (ascorbic acid and β-carotene) were significantly decreased after processing to a pulp (13.88 mg/ 100 g) and powder (10.77 mg/ 100 g) in comparison to fresh fruit (15.81 mg/ 100 g). The ash, crude fibre, fat, protein, total soluble solids, titratable acidity, total carbohydrate, energy, reducing sugars and total sugars significantly increased in powder as compared to fresh and pulp due to moisture content difference. The colour was recorded to be (L* 36.83, a* 4.44, b* 40.13), (L* 0.19, a* 8.12, b* 9.60) and (L* 7.41, a* 1.23, b* 12.83) for fresh, pulp and powder, respectively. The chroma (C*) analyzed was 40.37, 12.57 and 12.89, respectively while hue angle (h^{o}) was 83.69, 49.77 and 84.52, respectively while the browning index (BI) was 0.75, -0.43 and 0.35 for fruit, pulp and powder respectively. Several value-added products such as pumpkin concentrate, jam, juice, syrup, chutney, confectioneries, bakery products, ready to cook instant food premixes as well as reconstituted products and weaning foods with improved vitamin A content and minerals can be prepared from ripe pumpkin pulp and powder.

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Keywords: Ripe pumpkin; Cucurbita moschata; pumpkin pulp; pumpkin powder; β-carotene.

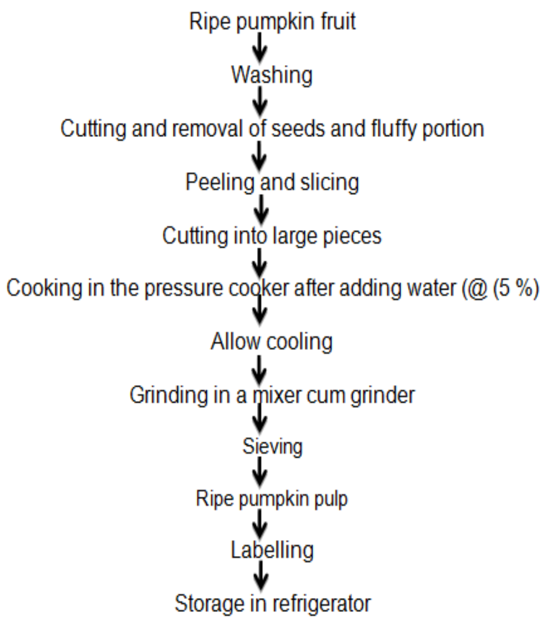
1. INTRODUCTION

Pumpkin, also known as auyama, squash, or sambo, belongs to the family of cucurbits and is classified into the species *Cucurbita maxima*, *Cucurbita pepo, Cucurbita moschata*, and *Cucurbita mixta.* Worldwide production is approximately 27,643,932 tonnes which produced a total of 2,042,955 tonnes/ ha with an average of 13.53 t/ha FAO [1]. Ripe fruit is characterized by the hard outer cover, with yellow to orange-fleshed, firm texture and flavour depending on a different location. Based on the nutritional aspect, it contains low carbohydrates 8.8 % in comparison to other vegetables. Other nutrients like protein, fat, and fibre are less than two per cent. According to Rodríguez et al. [2], it is the richest source of minerals such as potassium (439 mg), calcium (26 mg) and phosphorus (17 mg). Furthermore, it contains the highest amount of β-carotene which is converted to vitamin A. Apart from this, vitamin C, vitamin E, lycopene and dietary fibre were found in higher amounts Ward [3]. Many nutritional studies have shown that traditional vegetables, which are often overlooked by urban populations are an essential source of nutrients and vitamins for the rural population in low-income countries FAO [4]. Since the fruit pulp has a low lipid concentration, lipids are mobilized and retained in the seeds, making the fruits a healthy food for people who are overweight. Excess fat intake has been linked to atherosclerosis, cancer and ageing in the cardiovascular system Chuwa et al. [5]. As a result, pumpkin diets should be recommended to minimize the risk of the aforementioned ailments in humans. Moisture content reduction in fruits and vegetables extends their shelf life, reduces enzymatic browning and prevents microbial spoilage. Blanching and KMS solution deeping enhanced the structural changes in the food that facilitate the dehydration process as well as enzymatic inactivation [6]. The aim of this study was to determine the effect of processing methods on the nutritional quality of ripe pumpkin (*C. moschata*).

2. MATERIALS AND METHODS

2.1 Preparation of Ripe Pumpkin Pulp

Ripe pumpkin pulp was prepared using the standardized method given by Rana S [7]. For that ripe pumpkins were thoroughly washed and cut into halves. After removing the seeds and fluffy portion (fibrous strains/brains), pumpkins were cut into slices. The slices were peeled, washed and cut into small pieces. The pumpkin pieces (1 Kg) were heated in a pressure cooker of five kg capacity using a domestic gas stove with 5 per cent water followed by cooking for 5 min. The whole mass was allowed to cool down and then converted into pulp by grinding in a mixer cum grinder (Model MX-1155). The developed pulp was filled in pre-sterilized PET jars and kept under refrigerated conditions for further use. Flow Chart 2 highlights steps for the preparation of ripe pumpkin pulp.



Flow Chart 1. Unit operations for the preparation of pumpkin pulp

2.2 Preparation of Ripe Pumpkin Powder

Ripe pumpkin powder was prepared as per the method described by Dhiman AK et al. [8].

Ripe pumpkin fruits were washed and cut into halves. After removing the seeds and fluffy portion (fibrous strains), the pumpkin was peeled and cut into slices of uniform size. The slices were steam blanched for 4 minutes followed by dipping in 500 ppm potassium metabisulphite ($K_2S_2O_5$) solution for 15 minutes. The slices were dried in a mechanical dehydrator at 60 ± 2°C for 16 hours to achieve the equilibrium moisture content. The dried slices were ground in a mixer cum grinder (Havells, Model MX-1155) and passed through a 36 mm mesh sieve to get uniform powder. The powder was packed in PET jars which were closed tightly with a lid, labelled and kept for storage under ambient condition for further use. The flow sheet of unit operations is outlined in chart 2.

Ripe pumpkin fruit
↓
Washing
↓
Cutting and removal of seeds and fluffy portion
↓
Peeling and slicing
↓
Cutting into uniform size pieces
↓
Steam blanching (4 minutes)
↓
Soaking in 500 ppm KMS solution (15 min)
↓
Drying in mechanical dehydrator at (60 ± 2 °C for 16 h)
↓
Grinding and sieving
↓
Pumpkin powder
↓
Packaging in PET jars
↓
Labeling
↓
Storage under ambient temperature

Flow Chart 2. Unit operations for the preparation of pumpkin powder

2.3 Chemical Analysis

The moisture content (%), ash (%), protein (%) and minerals (iron mg/100 g) was determined as per the method suggested by AOAC [9]. Crude fibre (%) was analyzed as per [10], Crude fat (%) was determined using [11] method. Ranganna [12] procedure was employed in scrutinizing *β*-carotene (mg/100 g), total carbohydrates (%) whereas total energy (Kcal/100 g) was calculated by the differential method as per [13] method. Ascorbic acid, titratable acidity and Total Soluble Solids (TSS) were determined as per the procedure given by AOAC [14], reducing sugars and total sugars were analyzed according to the method suggested by Dubois M et al. [15]. The colour of fresh, pulp and powder was measured in a Lovibond Colour Tintometer Model PFX-I series spectrocolourimeter in which RYBN colour units were obtained along with CIE readings i.e. L*, a* and b* values. Each sample was measured three times for colour Goswami D et al. [16]. Changes in colour (ΔE), chroma (C*) and hue angle (h^0) were calculated as per the formula proposed by Goswami D et al. [16].

2.4 Sensory Evaluation

9-point Hedonic scale, panellists asked to rate fresh, pulp and powder on colour, texture/body, taste, and general acceptability (1=dislike highly, 5=neither like nor dislike, 9 = like excessively), as reported by Meilgaard M et al. [17].

2.5 Data Analysis

The chemical parameters were analyzed by Complete Randomized Design (CRD) and sensory evaluation was analyzed using Randomized Block Design (RBD) as described by (Cochran WG and Cox CM) and [18,19], respectively. The means were separated for comparison by Tukey's honest significant difference (HSD) and the statistical significance was defined as $p \le 0.05$.

3. RESULTS AND DISCUSSION

3.1 Sensory Evaluation

Ripe pumpkin slices of different treatments were steam blanched and soaked in KMS solution using different time combinations. The peroxidase taste was conducted to reveal whether the slices were properly blanched. The proper blanched slices gave negative while unproper blanched slices gave positive results. Each treatment combination was subjected to the panellists for sensory evaluation using a 9-point hedonic scale. The best combination was taken for the preparation of pulp and powder for further evaluation of nutritional characteristics. Table 1 indicates the different combinations of blanching time, soaking time, peroxidase taste and sensory acceptability of each treatment combination. The results showed that treatment combination (T_6) with 4 minutes blanching time, 15 minutes soaking time and –ve peroxidase test was awarded the highest overall acceptability of 8.79. The results are in conformity with Dhiman AK et al. [8].

3.2 Moisture (%)

The results obtained for chemical characteristics of ripe pumpkin, pulp and powder are depicted in Table 2. The findings revealed moisture content of 88.14 ±1.34, 88.93 ± 0.08 and 6.12 ± 0.05 per cent in pumpkin fruit, pulp and powder, respectively. The values analyzed are in the range given by Karanja JK et al. [20] for pumpkin fruit, lower than the result of Dhiman AK et al. [8], higher than the observations of Dhiman AK et al. [21] and almost similar to the data of Nakazibwe I et al. [22] for fruit. Rana S [7] noticed the value closer to the current data in the pulp while [23] recorded a range inclusive to present findings in the pulp. Khatib SE and Muhieddine M [24] gave a higher value in comparison to the current results in powder while Dhiman et al. [21] reported a higher value in powder while Khan et al. [25] and Rao and Sharma [26] examined lower values as compared to the present study in powder. The reason for deviation of moisture content either higher or lower may be due to variety of differences, soil type and geographical location.

3.3 Total Soluble Solids (^{o}B)

The data presented in Table 2 observed total soluble solids to be 7.90 ± 0.03, 5.40 ± 0.05 and 52.80 ± 0.32 ^{o}B in ripe pumpkin, pulp and powder, respectively. The findings are near to the results of Karanja et al. [20] in fruit but lower than the values given by Rana S [7] and Dhiman et al. [21] in pulp and powder, respectively. The lower value of TSS in the current study may be due to the maturity stage of a ripe pumpkin.

3.4 Total Sugars

The pumpkin fruit, pulp and powder contain 4.81 ± 0.11, 3.42 ± 0.19 and 40.32 ± 0.75 per cent total sugars as per the current study. These findings are higher than the value reported Blessing et al. [27] and near to the results of Dhiman AK et al. [8] in fruit. Rana S [7] has detected almost near results to current data in the pulp while Dhiman AK et al. [21] documented higher value in the pulp. Furthermore, Khan MA et al. [25] studied a lower value than the present study in powder. The differences might be due to geographical location, variety differences and agronomic practice.

3.5 Reducing Sugars (%)

Reducing sugars of 1.98 ± 0.05, 2.15± 0.03 and 16.40 ± 0.05 per cent were noticed in pumpkin fruit, pulp and powder, respectively. These results are higher than the value noted by Rao TVR and Sharma S [26] but lower than the observations of Dhiman et al. [8] in fruit while almost in confirmation with the results of Rana S [7] in the pulp. Dhiman AK et al. [21] found a higher value in contrast to the present findings whereas, Khan MA et al. [25] revealed a lower value in comparison to current findings in powder. The differences in redusing sugar values may be due to maturity stage of ripe pumpkin fruit used in the studies, vatiety diffrences, soil type and location.

3.6 Titratable Acidity (%)

The value for titratable acidity recorded was 0.06 ± 0.01, 0.05 ± 0.001 and 0.83 ± 0.01 per cent in pumpkin fruit, pulp and powder, respectively which is lower than the value noted by by Rao TVM and Sharma S [26] in ripe pumpkin. The data is almost in line with the results of Rana S [7] for pulp while in conformity with the results of Dhiman AK et al. [21] for powder. The differences in titratable acidity values may be due to maturity stage of ripe pumpkin fruit used in the studies, vatiety diffrences, soil type and location.

3.7 Crude Protein (%)

The crude protein content perceived in pumpkin fruit, pulp and powder are 1.99 ± 0.27, 1.72 ± 0.02 and 5.04 ± 0.06 per cent, respectively. The values analyzed in pumpkin fruit are higher than the findings of Dhiman AK et al. [21] while in the range of Karanja JK et al. [20] but lower than the observations of Dhiman AK et al. [8]. In pulp, results are higher than the value of Rana S [7] but lower than the range detected by Nakazibwe I et al. [22]. Usha R et al. [23] and Dhiman AK et al. [21] have noticed higher values as compared to the present study in powder. The differences in crude protein content may be due to the variety difference used in the studies, maturity stage of ripe pumpkin fruit used, location of the study and soil type.

3.8 Crude Fat (%)

The crude fat content was found to be 0.80 ± 0.32, 0.51 ± 0.01 and 2.72 ± 0.27 per cent in pumpkin fruit, pulp and powder, respectively. The results are in the range given by Karanja JK et al. [20] in pumpkin fruit while higher than the value of Dhiman AK et al. [8]. The fruit pulp exhibited a value in the range of Nakazibwe I et al. [22] but higher than the data revealed by Rana S [7]. The fat content of powder is reflecting a higher value as compared to the findings of Usha R et al. [23] and Dhiman AK et al. [21] but is lower than the values noted by Khatib SE and Muhieddine M [24] and Khan MA et al. [25]. The differences in crude fat content may be due to the variety difference used in the studies, maturity stage of ripe pumpkin fruit used, location of the study and soil type.

3.9 Crude Fibre (%)

The analysis of pumpkin fruit, pulp and powder showed the crude fibre content of 0.85 ± 0.05, 0.49 ± 0.03 and 4.91 ± 0.01 per cent, respectively. The values for fruit have been found lower in comparison to the range of Karanja JK et al. [20] while higher than the observations of Dhiman AK et al. [21] and Dhiman AK et al. [28] in fruit. Further, Rana S [7] noticed almost similar results to the present data in the pulp while Dhiman AK et al. [28] gave a higher range of results in contrast to current findings in the pulp. Usha et al. [23], Dhiman AK et al. [21], Karanja JK et al. [20], Khatib SE and Muhieddine M [24] and Khan MA et al. [25] have evaluated lower values as compared to the current data in powder. The differences in crude fibre content may be due to the variety differences used in the studies, maturity stage of ripe pumpkin fruit used, location of the study and soil type.

3.10 Total Carbohydrate (%)

The data (Table 1) represented the total carbohydrate content of 8.21 ± 0.26, 8.06 ± 0.03 and 81.54 ± 0.94 per cent in pumpkin fruit, pulp and powder, respectively. The values determined in the present study are higher than the range given by Blessing AC et al. [27], but in the range of Karanja JK et al. [20] while lower than the results of Dhiman AK et al. [28] in fruit. Usha R et al. [23] and Khan MA et al. [25] have exhibited lower data as compared to present findings in powder. The differences in total carbohydrates content may be due to the variety difference used in the studies, maturity stage of ripe pumpkin fruit used, location of the study and soil type.

3.11 Ascorbic Acid (mg/100 g)

The ascorbic acid content in pumpkin fruit, pulp and powder was examined to be 14.22 ± 1.02, 12.01 ± 0.07 and 10.26 ± 0.70 mg/100 g, respectively. The results are lower than the values reported in the studies of Rao TVR and Sharma S [26], Dhiman AK et al. [29] and Dhiman AK et al. [28] while almost near to the observations found by Dhiman AK et al. [21] in pumpkin fruit. Rana S [7] observed a lower value in pulp as compared to present observations while Dhiman AK et al. [21] have given almost near data for powder. The differences in ascorbic acid content may be due to the variety difference used in the studies, maturity stage of ripe pumpkin fruit used, location of the study and soil type.

3.12 β-carotene (mg/100 g)

The mean value revealed for β-carotene values of pumpkin fruit, pulp and powder was 15.81± 0.34, 13.88 ± 0.06 and 10.77 ± 0.31 mg/100 g, respectively. The results for pumpkin fruit reflected a higher value as compared to as recorded by Rao TVR and Sharma S [26] but in the range of Karanja JK et al. [20]. An almost similar value was analyzed by Dhiman et al. [29] while a somewhat lower amount was recorded by Dhiman AK et al. [28] in pumpkin fruit. The results of Rana S [7] reported a comparatively lower value in the pulp. Usha R et al. [23] and Dhiman AK et al. [21] have obtained lower values in comparison to current observations in powder. The present findings exceed the results detected by Khatib SE and Muhieddine M [24] and Khan MA et al. [25] in powder. The differences in β-carotene content may be due to the variety difference used in the studies, maturity stage of ripe pumpkin fruit used, location of the study and soil type.

3.13 Ash (%)

The results for ash content showed a value of 0.86 ± 0.06, 0.78 ± 0.02 and 4.58 ± 0.26 per cent, respectively in pumpkin fruit, pulp and powder. These results are in the range of findings by Karanja JK et al. [20] but higher than those recorded in the study of Dhiman AK et al. [29] and Dhiman AK et al. [28] on pumpkin fruit. The current observations for pulp are in compliance with Rana S [7] and Nakazibwe I et al. [22]. Usha R et al. [23] and Khatib SE and Muhieddine M [24] evaluated higher values in powder as compared to the present study. The findings are also almost near to the data noted by Dhiman AK et al. [21] but higher than the finding reported by Khan MA et al. [25] in powder. The differences in ash content may be due to the variety difference used in the studies, maturity stage of ripe pumpkin fruit used, location of the study and soil type.

3.14 Total Energy Value (Kcal/100 g)

The total energy value calculated in pumpkin fruit, pulp and powder weres 44.60 ± 1.70, 41.75 ± 0.12 and 351.16 ± 1.24 Kcal/100 g, respectively. The findings of Dhiman AK et al. [28] exhibited a higher value as compared to the present observations in pumpkin fruit. The differences in protein content may be due to the variety difference used in the studies and maturity stage of ripe pumpkin fruit used

Table 1. Pre-treatment of ripe pumpkin slices and sensory evaluation

Treatments	Blanching time (min)	Soaking time in (0.1% KMS)	Peroxidase test	Sensory scores			
				Colour	Texture	Taste	Overall acceptability
T_0	1.00	3.00	+ve	7.33	7.33	7.33	7.33
T_1	1.50	5.00	+ve	6.58	6.63	7.08	7.18
T_2	2.00	7.00	+ve	7.08	7.13	7.90	8.00
T_3	2.50	9.00	+ve	7.85	7.90	7.18	7.28
T_4	3.00	11.00	+ve	8.48	8.53	8.50	8.60
T_5	3.50	13.00	+ve	6.95	7.00	6.80	6.90
T_6	**4.00**	**15.00**	**-ve**	**8.82**	**8.75**	**8.79**	**8.79**
T_7	4.50	17.00	-ve	7.21	7.16	7.34	7.25
T_8	5.00	19.00	-ve	6.98	7.45	7.12	7.18

Table 2. Nutritional characteristics of fresh and processed pumpkin fruit

Parameters	Ripe pumpkin fruits		
	Fresh (WB)	Pulp (WB)	Powder (DWB)
Moisture (%)	88.14 ± 1.34^b	88.93 ± 0.08^a	6.12 ± 0.05^c
Total Soluble Solids (TSS ^{o}B)	7.90 ± 0.03^b	5.40 ± 0.05^c	52.80 ± 0.32^a
Total sugars (%)	4.81 ± 0.11^b	3.42 ± 0.19^c	40.32 ± 0.75^a
Reducing sugars (%)	1.98 ± 0.05^c	2.15 ± 0.03^b	16.40 ± 0.05^a
Titratable acidity (%)	0.06 ± 0.01^c	0.05 ± 0.001^b	0.83 ± 0.01^b
Crude protein (%)	1.99 ± 0.27^b	1.72 ± 0.02^c	5.04 ± 0.06^a
Crude fat (%)	0.80 ± 0.32^b	0.51 ± 0.01^c	2.72 ± 0.27^a
Crude fibre (%)	0.85 ± 0.05^b	0.49 ± 0.03^c	4.91 ± 0.01^a
Total carbohydrates (%)	8.21 ± 0.26^b	8.06 ± 0.03^c	81.54 ± 0.94^a
Ascorbic acid (mg/ 100 g)	14.22 ± 1.02^a	12.01 ± 0.07^b	10.26 ± 0.70^c
β-carotene (mg/ 100 g)	15.81 ± 0.34^a	13.88 ± 0.06^b	10.77 ± 0.31^c
Ash (%)	0.86 ± 0.06^b	0.78 ± 0.02^c	4.58 ± 0.26^a
Total energy (Kcal/ 100 g)	44.60 ± 1.70^b	41.75 ± 0.12^c	351.16 ± 1.24^a

WB=wet basis and DWB= dry weight basis; The means sharing the same superscript letter in rows are not significantly different from each other (Tukey's HSD test, p≤ .05)

3.15 Colour

Colour is often used as an indication of the quality and freshness of food products. It is a critical parameter in defining the uses and acceptability of a product. The colour was recorded to be (L* 36.83, a* 4.44, b* 40.13), (L* 0.19, a* 8.12, b* 9.60) and (L* 71.41, a* 1.23, b* 12.83) for fresh, pulp and powder respectively (Table 3) and pictorial representation of the same is depicted in Figs. 1, 2 and 3. Ripe pumpkin fruit has clear yellow to orange colour. Minimal changes to this attribute after processing is desirable Thakur BR et al. [30]. a* and b* represent the redness and yellowness of the product, respectively while L* indicates the lightness. The increment of L* and a* values in powder and pulp means a more pure and intense yellow colour. In this case, positive values indicate red. The higher b* values indicated yellowness (Table 3). Therefore, yellowness was highly observed in fresh and powder than pulp due to enzymatic browning which occurs in pulp samples during preparation. The changes in redness and yellowness of pumpkin powder can be evaluated by chroma. The higher value of chroma was obtained in fresh (40.37) followed by powder (12.89) which indicated a more pure and intense colour Pomeranz Y and Meloan C [31]. Hue angle (h^o) which is the dimension of the colour perceived was observed higher in powder (84.52), fresh (83.69) and pulp (49.77). The higher the hue angle the pure the colour perceived and vice versa. In pulp samples, enzymatic browning may be due to the effect of low hue value compared to fresh and powder. The browning index (BI) was 0.75, -0.43 and 0.35, respectively for fresh, pulp and powder. The positive value in fresh and powder indicate there was no colour defect but the negative value signifies a defect of colour due to enzymatic browning during processing.

Table 3. Colour of ripe pumpkin fruits

Food material	Colour					
	L*	a*	b*	Chroma (c*)	Hue angle (h^o)	Browning Index (BI)
Fresh	36.83	4.44	40.13	40.37	83.69	0.75
Pulp	0.19	8.12	9.60	12.57	49.77	-0.43
Powder	71.41	1.23	12.83	12.89	84.52	0.35

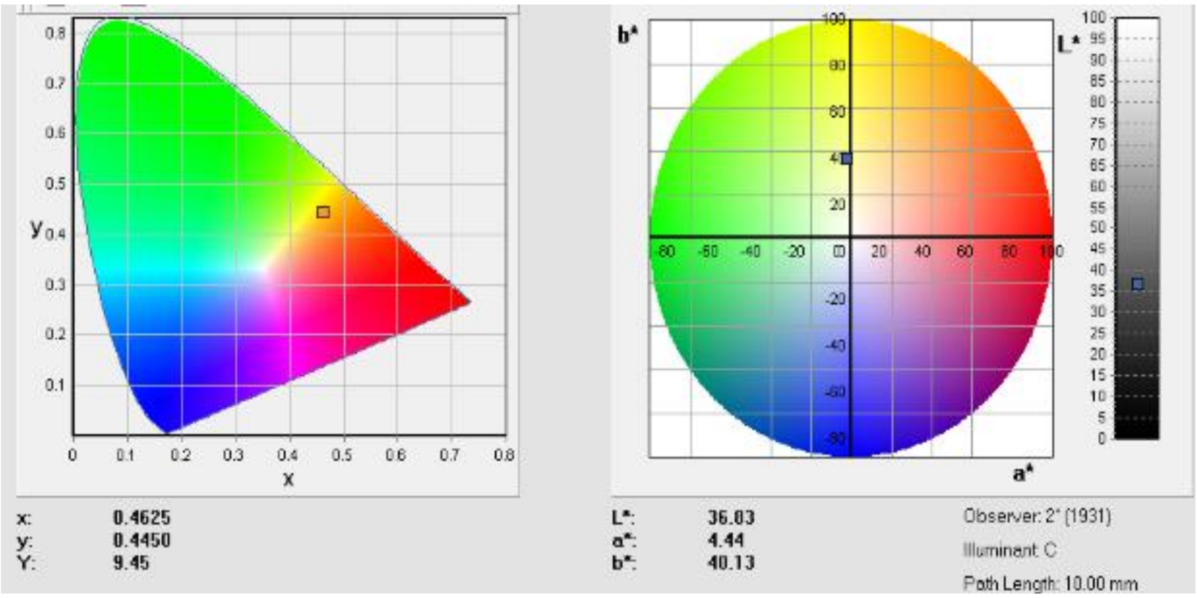


Fig. 1. CIE readings of ripe pumpkin fruit

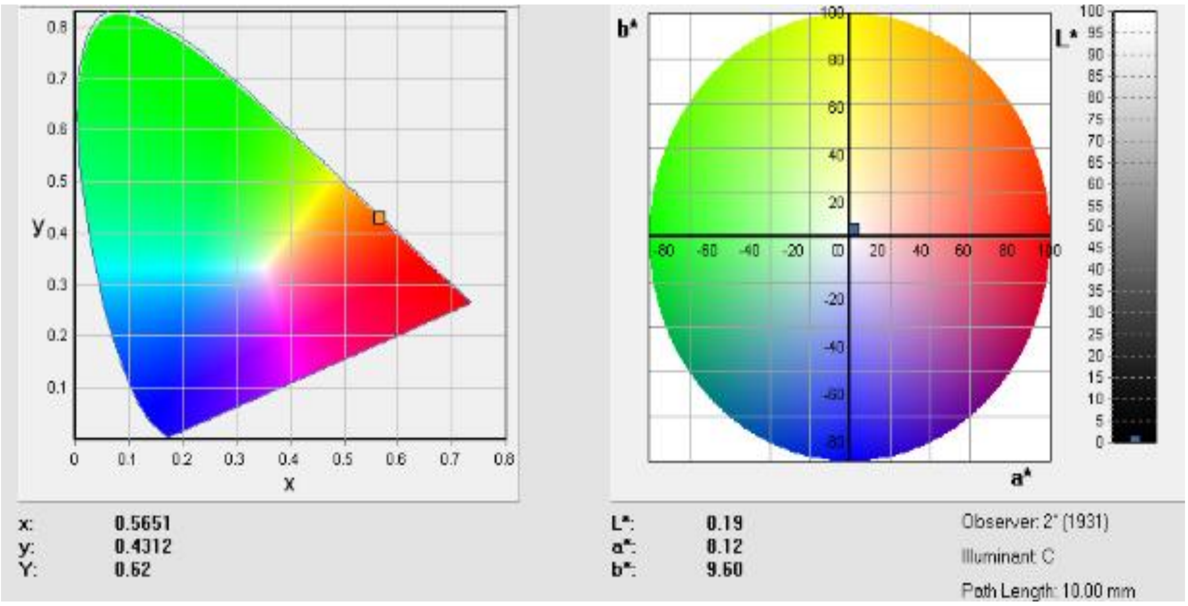


Fig. 2. CIE readings of ripe pumpkin pulp

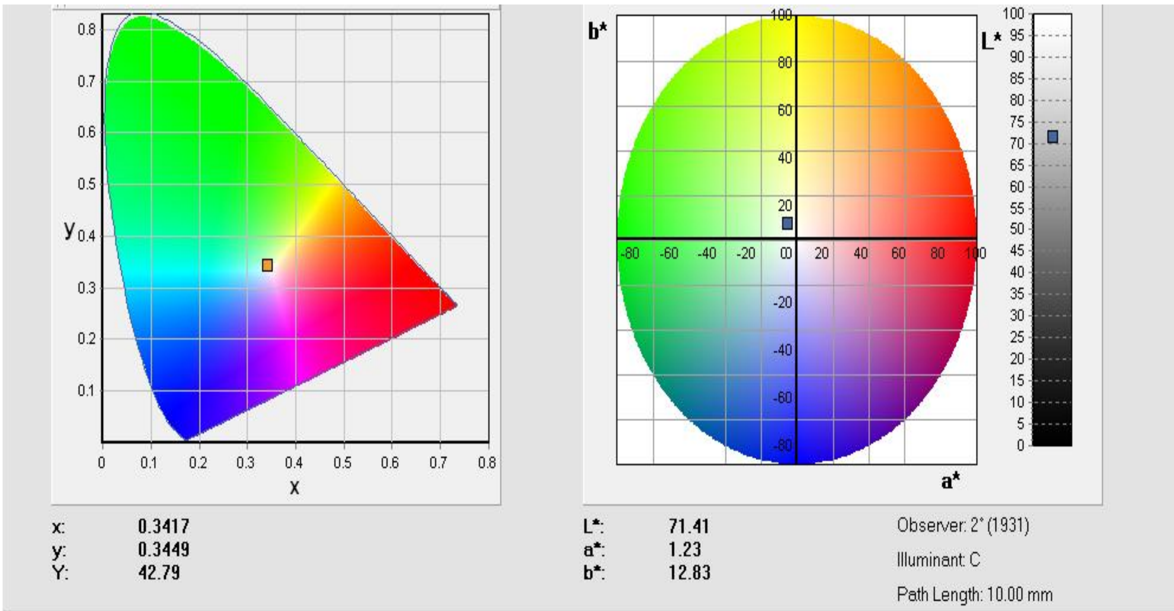


Fig. 3. CIE readings of ripe pumpkin powder

4. CONCLUSION

The results have shown that steam blanching of pumpkin slices followed by deeping in Potassium Metabisulfite (KMS) solution before drying produces high quality and stable colour of the final products (Table 3 and Figs. 1, 2 and 3) having positive values of L* a* and b* is evident that colour of the products was stable. Ripe pumpkin is the richest source of nutrients (Table 1) remarkably β-carotene ranging from (14.22-10.26 mg/100 g) and ascorbic acid (15.81-10.77 mg/100 g) in fresh, pulp and powder. These vitamins are dietary antioxidants which remove free radicals from the body cell with a combination of superoxide dismutase, catalase and glutathione peroxidase. Apart from antioxidants, β-carotene and ascorbic acid are important vitamins to boost the immune system of the body, especially in children and pregnant women, improvement of the eyesight, soften the skin and prevent Vitamin A deficiency (VAD). The low carbohydrate content of fresh fruit (8.21 %), pulp (8.06 %) and powder, (81.54 %) place it under low glycemic index fruit which can be utilized to control overweight and obesity. Not only that but also diabetic patients are recommended to use ripe pumpkin products to control diabetes type 2. Processing pumpkin into powder reduced moisture content significantly from (88.14 %) fresh to (6.12 %) powder will extend the keeping quality and enhance utilization into different value-added products after harvest hence food and nutritional security. This could lead to efficient and profitable utilization of ripe pumpkin fruit thereby ensuring reduction of postharvest losses. If pumpkin fruits will be processed immediately after harvest, post-harvest losses will be minimized, food and nutrition security will be improved as well as people's income through value-added products. Therefore, authors recommended pumpkin fruit and its products for public health nutrition.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
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https://www.sdiarticle5.com/review-history/88529