## *Original Research Article*

**Effect of processing methods on the nutritional composition of ripe pumpkin fruit**


**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. 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.



**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 [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 [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 by [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 [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 [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 powder

Ripe pumpkin pulp was prepared according to the method described by [7].

Ripe pumpkin fruit

↓

Washing

↓

Cutting and removal of seeds and fluffy portion

↓

Peeling and slicing

↓

Cutting into large pieces

↓

Cooking in the pressure cooker after adding water (@ (5 %)

↓

Allow cooling

↓

Grinding in a mixer cum grinder

↓

Sieving

↓

Ripe pumpkin pulp

↓

Labelling

↓

Storage in refrigerator

**Flow chart 1: Unit operations for the preparation of pumpkin pulp**

**2.2 Preparation of ripe pumpkin pulp**

Ripe pumpkin powder was prepared as per the method described by [8].



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 $^{o}$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 (2009) 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 [12] method. Ascorbic acid, titratable acidity and Total Soluble Solids (TSS) were determined as per the procedure given by [13], reducing sugars and total sugars were analyzed according to the method suggested by [14]. 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 [15]. Changes in colour (ΔE), chroma (C*), and hue angle ($h^0$) were calculated as per the formula proposed by Goswami *et al*. (2015) [16].

**Comment [U1]:** The methodology used for sensory analysis should be included.

**2.4 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 [17, 18] respectively. The means were separated for comparison by Tukey's honest significant difference (HSD) and the statistical significance was defined as $p \leq 0.05$.

## 3. RESULTS AND DISCUSSION

### 3.1 Moisture (%)

The results obtained for chemical characteristics of ripe pumpkin, pulp and powder are depicted in Table 1. 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 19] for pumpkin fruit, lower than the result of [8], higher than the observations of [20] and almost similar to the data of [21] for fruit. [7] noticed the value closer to the current data in the pulp while [22] recorded a range inclusive to present findings in the pulp. [23] gave a higher value in comparison to the current results in powder. while [20] reported a higher value in powder while [24] and [25] examined lower values as compared to the present study in powder.

### 3.2 Total soluble solids ($^{o}$B)

The data presented in Table 1 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 [20] in fruit but lower than the values given by [7] and Dhiman *et al*. (2018a) [21] in pulp and powder, respectively.

### 3.3 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 [27] and near to the results of [8] in fruit. [7] has detected almost near results to current data in the pulp while [20] documented higher value in the pulp. Furthermore [25] studied a lower value than the present study in powder.

### 3.4 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 and Sharma (2013) but lower than the observations of [8] in fruit while almost in confirmation with the results of [7] in the pulp. [20] found a higher value in contrast to the present findings whereas, [25] revealed a lower value in comparison to current findings in powder.

**3.5 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 [26] in ripe pumpkin. The data is almost in line with the results of Rana (2020) for pulp while in conformity with the results of [20] for powder.

**3.6 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 [21] while in the range of [19] but lower than the observations of [8]. In pulp, results are higher than the value of [7] but lower than the range detected by [22]. Usha *et al*. (2010) [23] and [20] have noticed higher values as compared to the present study in powder.

**3.7 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 [19] in pumpkin fruit while higher than the value of [8]. The fruit pulp exhibited a value in the range of [22] but higher than the data revealed by [7]. The fat content of powder is reflecting a higher value as compared to the findings of [23] and [20] but is lower than the values noted by [24] and [25].

**3.8 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) [19] while higher than the observations of Dhiman *et al*. (2018a and 2020) in fruit. Further, [7] noticed almost similar results to the present data in the pulp while [22] gave a higher range of results in contrast to current findings in the pulp. [23], [20], , (2019), [24]and [25] have evaluated lower values as compared to the current data in powder.

**3.9 Total carbohydrate (%)**

The data (Table1) 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 [27], but in the range of [19] while lower than the results of [21] in fruit. [23] and [25] have exhibited lower data as compared to present findings in powder.

**3.10 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 [26], [28] and [21] while almost near observations were found by [20] in pumpkin fruit. [7] observed a lower value in pulp as compared to present observations while [20] have given almost near data for powder.

**3.11 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 [26] but in the range of [19]. An almost similar value was analyzed by [29] while a somewhat lower amount was recorded by [21] in pumpkin fruit. The results of [7] reported a comparatively lower value in the pulp. [23] and [20] have obtained lower values in comparison to current observations in powder. The present findings exceed the results detected by [24] and [25] in powder.

**3.12 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 [19] but higher than those recorded in the study of [29] and Dhiman *et al*. (2020) on pumpkin fruit. The current observations for pulp are in compliance with [7] and [22]. [23] and [24] evaluated higher values in powder as compared to the present study. The findings are also almost near to the data noted by [20] but higher than the finding reported by [25] in powder.

**3.13 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 [21] exhibited a higher value as compared to the present observations in pumpkin fruit.

**Table 1: 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 °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).**

**Comment [U2]:** The results must be expressed in the same base to establish a comparison between them.

### 3.14 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 2) and pictorial representation of the same is depicted in Fig 1, 2 and 3. Ripe pumpkin fruit has clear yellow to orange colour. Minimal changes to this attribute after processing is desirable [29]. 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 1). 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 [30]. 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 2: 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 |

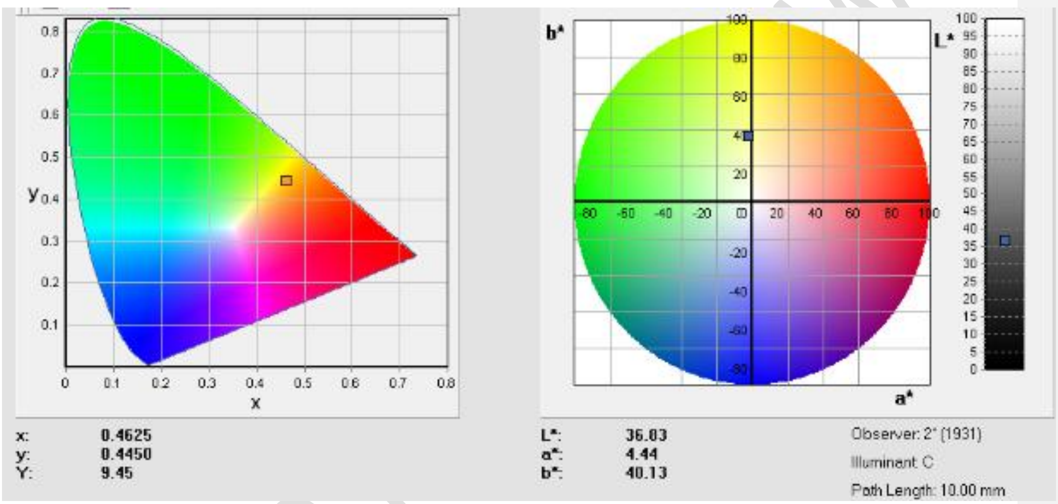


**Fig. 1. CIE readings of ripe pumpkin fruit**

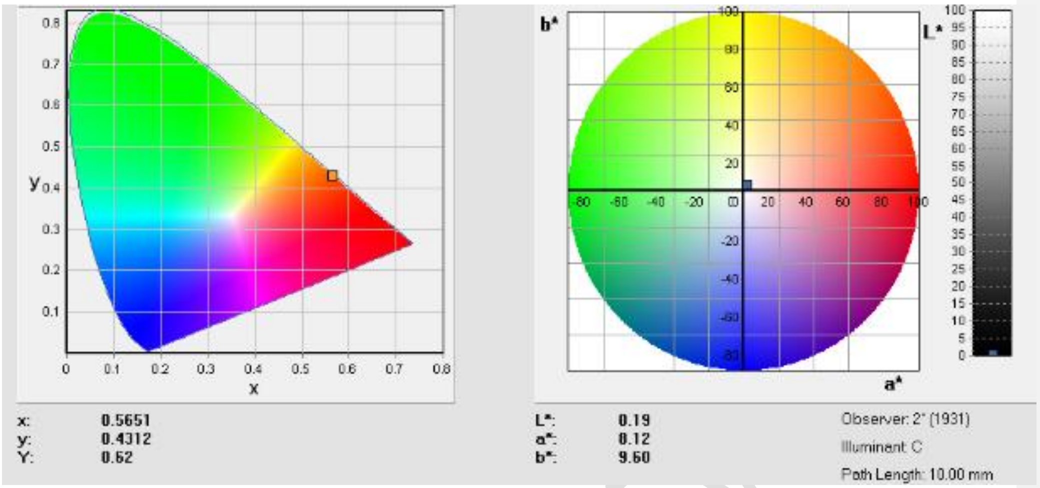


**Fig. 2. CIE readings of ripe pumpkin pulp**

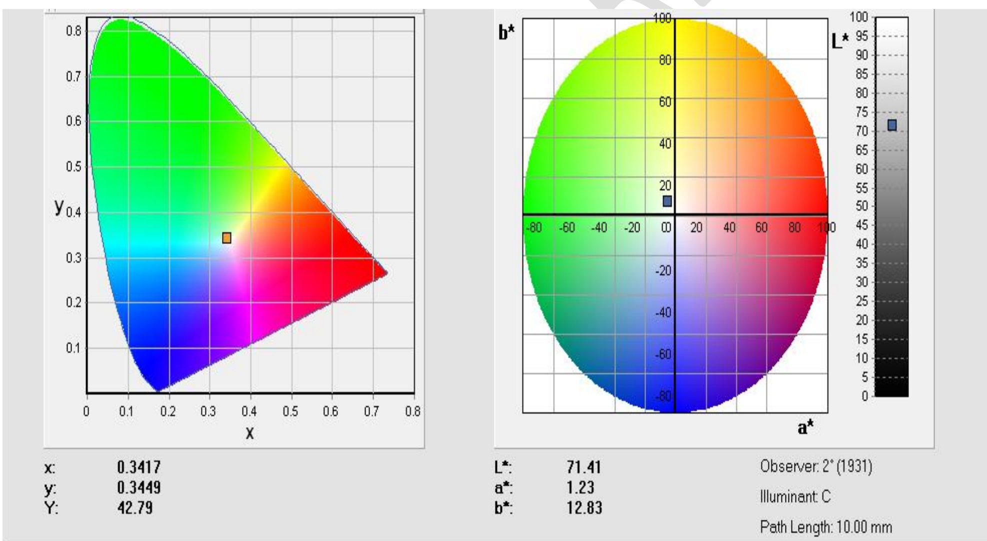


**Fig. 3. CIE readings of ripe pumpkin powder**

In data analysis, it refers to sensory healing, however, the results and discussion of this do not appear in the manuscript.

## 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. Processing pumpkin into pulp and 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. Pumpkin flour can act as an important food ingredient as a source of β-carotene for improving the body's immune system, vision and preventing Vitamin A deficiency (VAD), especially in young children. 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.

**Comment [U3]:** Assumptions should not be included in the conclusions

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