Chapter

Nutritional Profile and Medicinal Properties of Pumpkin Fruit Pulp

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Abstract

Having high nutritional value and low cultivation costs, pumpkin fruit makes a great candidate to be used by the food industry as a functional ingredient. To prolong its shelf life and widen the array of its potential uses in food products, drying and powdering have been applied, producing pumpkin flour. Several studies have been done to optimize the drying method of pumpkin in order to preserve or reduce the loss of its nutritional constituents and color changes during drying and storage. As vacuum freeze drying produces great quality pumpkin powder and best preserves the β-carotene and phenolic contents of the fruit, it is considered an expensive technique that could be inconvenient to be used in developing countries or for cost-reduction purposes. Air drying is a cheaper technique but results in less nutrient preservation than vacuum drying. This highlights the role of pretreatments in order to reduce the loss of nutrients and produce better quality pumpkin flour. Hot water blanching followed by metabisulfite pretreatment results in the best carotenoid stability and preservation of phenolic compounds in the produced powder. Incorporation of pumpkin powder in wheat bread could increase its nutritional value by increasing the levels of dietary fiber, pro-vitamin A β-carotene, calcium, iron, and zinc and by decreasing the carbohydrate and caloric contents.

Keywords: pumpkin fruit, pumpkin flour, artisanal food

1. Introduction

Pumpkin belongs to the family *Cucurbitaceae*, genus *Cucurbita*. It is extensively grown throughout the tropical and subtropical countries, with the most common types worldwide being *Cucurbita maxima*, *Cucurbita moschata*, and *Cucurbita pepo* (**Figure 1**) [1]. The giant type pumpkins tend to be *C. maxima* varieties ('Boston Marrow' and 'Mammoth'), and the miniature pumpkins tend to be *C. pepo* ('Jack-O-Lantern'). *C. moschata* is the most commonly cultivated species in Asia and United States [2]. The characteristic yellow-orange color of pumpkins is due to the presence of carotenoids that have major roles in nutrition as pro-vitamin A [3]. Pumpkins have an abundance of macro- and micro-nutrients and antioxidants that promote the human body immunity against cancer and other diseases; "*It has such nutritional potential unequal to any other single crop*" [4].

Pumpkins are high-yield fruits and their cultivation is inexpensive [5]. They are stable for 1–3 months after their harvest, but they become susceptible to microbial spoilage, moisture loss, and color changes after peeling. Thus, in order to prolong their shelf life, drying and powdering techniques have been applied. This also allows pumpkin to be used as an ingredient in manufacturing foods such as bakery

Figure 1.
(A) Cucurbita moschata Duchesne; (B) Cucurbita pepo (variety ovifera) [8].

products for quality addition [6], as the rich nutrient base of this vegetable increases the nutritional quality of baked products [7]. Pumpkin wheat composite bread has been found to have good nutritional value and sensory characteristics that could make it acceptable and well-appreciated to consumers [3].

2. Nutritional profile and medicinal properties of pumpkin fruit pulp

A growing interest in pumpkin fruit and its derived products has been taken by agriculture, pharmaceuticals, and food-processing due to its nutritional and health promoting values [9]. Many countries, such as India, China, Brazil and Argentina have been using different species of this fruit as a medicine. The Traditional Chinese Medicine considers pumpkin as being *immensely valuable for human health* [8]. The various health benefits of pumpkin nutritional components include anti-diabetic, anti-carcinogenic, antioxidant [10] and possible anti-fatigue effects [11].

The composition of fresh pumpkin is shown in **Table 1**. Additional physical and chemical characteristics of ripe pumpkin fruit are shown in **Table 2**. It must be noted though that differences in the chemical components are found between different species of pumpkin, and among cultivars grown in different regions [5]. Pumpkin fruit is composed of pulp and seeds. Pumpkin pulp contains polysaccharides, pigments, amino acids, active proteins, and minerals. Pumpkin seeds are high in lipids and proteins, and they are a good source of many elements such as potassium, phosphorus and magnesium [8]. This chapter aims at characterizing the main nutritional components of pumpkin fruit pulp and its medicinal properties.

Composition of fresh pumpkin (%)	
Moisture	92.24
Fat	0.15
Protein	0.98
Ash	0.76
Crude fiber	0.56
Carbohydrate	5.31

Table 1.
Proximate composition of fresh pumpkin [9].

Weight, g	3730.0 ± 67.71
Length, cm	32.6 ± 2.32
Diameter, cm	69.1 ± 2.05
Color	YGY
Pulp recovery, %	76.7 ± 0.006
Pulp:Skin:Seed	23:6:1
Firmness, lb./in^2	21.3 ± 0.11
Seed oil recovery, %	35.7 ± 0.003
Moisture, %	6.2 ± 0.07
Total soluble solids, °B	9.2 ± 0.06
Total sugars, %	3.9 ± 0.01
Reducing sugars, %	2.1 ± 0.02
Titratable acidity, %	0.07 ± 0.003
pH	4.5 ± 0.003
β-carotene, mg/100 g	11.2 ± 0.007
Ascorbic acid, mg/100 g	14.5 ± 0.03
Pectin, %	1.2 ± 0.01
Fiber, %	0.66 ± 0.003
Ash, %	0.52 ± 0.003
Minerals, mg/100 g edible portion	
Ca	10
P	30
Fe	0.44
Mg	38
Na	5.6
K	139
Cu	0.05
Mn	0.05
Zn	0.26
S	16
Cl	4

(n = 4), YGY: Yellow to golden yellow.

Table 2.
Physical and chemical characteristics of ripe pumpkin [2].

2.1 Pumpkin pulp polysaccharides

Many studies have been done on the anti-diabetic effect of pumpkin polysaccharides. They have been shown to decrease blood glucose and lipid levels in diabetic rats. *C. moschata* polysaccharides, which include soluble and insoluble dietary fiber, had a clear effect on reduction of serum glucose in diabetic rats. Clinical trials have also demonstrated significant reduction of post-prandial serum glucose and fasting glucose in non insulin dependent diabetes mellitus (NIDDM) subjects, after oral administration of pumpkin polysaccharides liquid and granules; and they have also shown that a daily supplement of 30 g pumpkin powder can significantly reduce blood glucose concentrations in NIDDM patients [8]. A Protein-bound polysaccharide isolated from water-soluble substances of pumpkin fruits, was also proven to improve tolerance to glucose by reducing blood glucose levels and increasing the levels of serum insulin in alloxan diabetic rats [5].

Pectin, a complex polysaccharide, is an important structural component of the cell wall of plants. It is mainly found in the peels of pumpkin, but the pressed pulp also contains a promising amount of it. Pumpkin pectin has been reported to have remarkable effects on lowering cholesterol levels in blood plasma and reducing triacylglycerols in liver, and thus reducing fatty acids in blood. It also simultaneously decreases the rate of fat assimilation and causes quick dissimilation of fat. In addition to their hypoglycemic and hypolipidemic activities, pumpkin polysaccharides antitumor effects were investigated and observed [8].

2.2 Pumpkin pulp pigments

Pumpkin pulp pigments are widely used as additives in food products, in medicine and in cosmetics. Pumpkin pigments include carotenoids, lutein and zeaxanthin. The carotenoids are responsible for the characteristic yellow-orange color of pumpkins [8]. In fact, the yellow color of pumpkin at its young stage develops to orange in its ripened stage due to a dramatic increase by 11 fold in the carotenoid content of the fruit [12].

The high carotenoid content is one of the reasons why pumpkin is such a nutritionally valuable fruit [13]. Carotenoids are considered a major source of vitamin A which is necessary for embryonic development, growth, and normal eyesight. Pumpkin is an excellent source of pro-vitamin A carotenoids. The major carotenoid in pumpkin is β-carotene, followed by small amounts of α-carotene, lutein and lycopene [8]. β-carotene content of pumpkin varies from 1.6 to 45.6 mg/100 g [14]. Indian cultivars have 132 to 527 mg/100 g of β-carotene content [1]. Research has indicated that pumpkin could be a primary vegetable to satisfy children's needs for carotenoids [8]. Moreover, β-carotene can protect against certain cancers and is considered a *powerful ally against degeneration aspect of aging*. Analysis of β-carotene content of pumpkin fruit has also been done for its possible use in combating eye diseases [2].

2.3 Pumpkin pulp minerals, amino acids, and active proteins

The human body acquires its needed minerals from the daily diet. Minerals have key roles in several body functions. Pumpkin is considered as an eminent source of many minerals important for human health [8]. Pumpkin pulp is rich in K, Fe, Mn, Mg, P, vitamin C, vitamin E and phytosterols [2]. The pulp of *C. moschata* contains high amounts of calcium (205.45 μg/g) and potassium (1840.30 μg/g) and a low amount of sodium (28.70 μg/g), making it a suitable food for the prevention of osteoporosis and hypertension. Chrome is another mineral that is found in pumpkin in an amount higher than any other vegetable. Chrome is part of glucose tolerance factor which is essential for the activity of insulin and improves tolerance of blood glucose. Cobalt is also an essential microelement present in pumpkin. It is essential for islet cells of the pancreas and improves the body's metabolic capacity and participates in the synthetic action of vitamin B12 [8].

Protein content of pumpkin is less than 2.0% of dry matter weight. Yet, there are some essential amino acids present in pumpkin pulp. *C. moschata*, for example, contains 0.609% valine, 0.700% leucine, and 0.508% lysine, which are relatively high amounts. Several studies of purified pumpkin extracts including proteins and polysaccharides have shown anticancer activity against melanoma, ehrlich ascites and leukemia. In addition, enzyme preparations of pumpkin have been found to possess antitumor potential [8].

3. Pumpkin flour

3.1 Characteristics of pumpkin flour

Processing of fruits or vegetables can transform these perishable foods into more stable foods that can be advantageous to both consumers and food industries. Pumpkins are consumed in various ways, whether fresh, canned, frozen, or dried. Preservation of pumpkin by drying is an important way to prevent postharvest losses. Though they keep longer than other fruits and vegetables, they can only do so if the fruits are free from any bruise. However, this is sometimes not possible because of insect bites or bruises acquired by harvesting, or by transportation after harvest [4].

Pumpkin fruit can be processed into flour which has a longer shelf-life, highly desirable -sweet- flavor, and deep yellow-orange color [2]. The rich nutrient potential of dried pumpkin makes utilization of pumpkin flour or pumpkin flour based products a good source of vitamin A from the β-carotene content, protein [4] and dietary fiber [15].

Analyses on the composition of pumpkin (*Cucurbita moschata* Decne) flour, for example (**Table 3**), show that it contains high levels of carbohydrates, starch, dietary fiber, protein, total ash, and low levels of lipids and crude fiber. Authors proposed that it is an ideal food for diabetes patients, cardiovascular disease patients, and elderly [9]. Moreover, the functional properties of the flour such as water solubility and absorption indices and the pasting properties suggest that it may have suitable applications in the food industry such as a thickener in soup, gravy, and as an ingredient in bakery products such as bread, cake and fried noodles [9].

3.2 Effect of different convective drying methods on selected characteristics of pumpkin fruit flour

Production of powders from vegetables and fruits have been done by various drying techniques such as hot air-drying, freeze drying, spray drying, vacuum

Parameter	
Moisture content (%)	3.73 ± 0.01
Fat (%)	3.60 ± 0.12
Crude fiber (%)	3.65 ± 0.14
Protein (%)	7.81 ± 0.18
Ash (%)	5.29 ± 0.01
Carbohydrate (%)	79.57 ± 0.01
Dietary fiber (g/100 g)	12.1 ± 0.00
Starch (%)	48.30 ± 0.54
Vitamin A (μg/100 g)	262 ± 0.32

Table 3.
Proximate composition of pumpkin powder [9].

drying, and microwave vacuum drying. Spray and freeze drying have been reported to produce a good quality product, but are too expensive. On the other hand, hot air-drying *could result in a quality product that is characterized by uniform, hygienic, and attractive color of dried fruit and vegetable powder* in a condition that it is not done in a rapid manner which might result in an inferior product quality [6].

A study performed by Kiharason et al. [4] aimed to determine the effect of three drying methods of pumpkin fruit slices on the nutrient integrity of certain components of pumpkin: open solar (OSD), oven electric (OED), and enhanced solar (ESD) drying methods. The drying methods were applied, then dry fruit slices were milled and analyzed to determine their nutritive value.

3.2.1 Drying of pumpkin slices

After washing, peeling and deseeding mature fruits, the fruit pulps were sliced and then cut at 2.55 cm length by 0.5 cm width. Next, they were blanched by dipping fast in boiling water for 1 min, cooled with running tap water for 1 min as well, and then wiped with absorbent paper. Afterwards, they were subjected to drying while weighing every 3 h until constant weight was recorded. The dried pumpkin slices obtained were ground, sieved and analyzed to determine their nutritive value [4].

3.2.2 The effect of the three drying methods on the moisture content and nutritive value of pumpkin powder

3.2.2.1 Moisture content

In ESD and OED (temperature set at 50°C), different shelves at which pumpkin slices were put had great variations in terms of drying time, whereas the drying time in OSD, where tables used to dry pumpkin slices were at the same height, did not have much variation. Generally, OED took the shortest time and ESD took the longest time to dry the pumpkin slices (**Table 4**). As for the moisture content (MC), milled pumpkin slices that were dried by the OED exhibited the highest MC while ESD had the lowest (**Table 6**) [4].

Drying in a solar drier occurs in a closed environment whereas open sun drying happens in the open without any barrier, leading to quicker drying. A high evaporation rate during drying leads to a high possibility of nutrient losses. In addition, open sun drying has the poorest protection against insects, dust, microbes, and is inconvenient due to certain weather conditions such as rain where samples become subject to spoilage. Both oven drying and open solar drying showed a moisture content above the acceptable safe level, which is 14%. Moisture levels of 14% and above make the food susceptible to attack by microbes and promote fungal growth, while lower

Drying method	Average drying time (hours)*	Average moisture content (%)
Enhanced solar drying	13.27[a]	12.82
Open solar drying	9.50[b]	14.91
Open drying	7.25[c]	15.15

**Means followed by the same letter within a column are not significantly different at P = 0.05.*

Table 4.
The mean drying time of pumpkin fruit slices and the average moisture content obtained by three drying methods [4].

levels slow down the growth of microbes and prolong the shelf-life. These results make enhanced solar drying a better method for longer preservation of pumpkin flour [4].

3.2.2.2 Analysis of nutritive value

Pumpkin flour obtained by oven drying OED retained the highest amount of β-carotene, followed by ESD (**Table 5**). The fast rate of drying caused less nutrients to be lost, and samples at the core were still intact by the time constant weight was achieved. OSD had the least amount of β-carotene, most likely since unprotected exposure to the sun's UV rays caused photo-degradation of the carotenoids. Protein content showed no significant differences between the three drying methods but it showed a significant difference between the flours and the fresh fruits for almost 800% increase in the flour [4].

As for mineral, drying generally was found to reduce their levels compared to fresh fruits. Zinc was significantly lower in enhanced solar drying than oven and open sun drying, yet the fresh fruit exhibited the highest amount. Calcium levels were reduced greatly after drying showing 200% loss from fresh fruit. Whereas for iron, calcium and energy levels, no significant difference was noted between all treatments. It is therefore concluded, in this study, that enhanced solar drying is the best method for drying pumpkin and obtaining better quality pumpkin flour [4].

Treatment	β-carotene (μg/g)*	Protein (%)	Zinc (ppm)	Iron (ppm)	Calcium (ppm)	Energy (kcal/g)
Fresh fruit	16.6150^{c}	2.6175^{b}	44.075^{c}	94.5000^{a}	1116.82^{a}	4.26575^{a}
Oven dried	74.8425^{a}	13.7850^{a}	24.948^{a}	66.3225^{a}	830.23^{a}	3.84675^{a}
Enhanced solar	62.9875^{ab}	16.4875^{a}	9.058^{b}	49.5400^{a}	539.08^{a}	3.76350^{a}
Open sun	27.1750^{bc}	16.4900^{a}	20.995^{ba}	94.7975^{a}	525.43^{a}	3.62875^{a}
F-value	8.497	58.832	17.616	1.595	1.705	2.376
P-value	0.003	0.000	0.000	0.242	0.219	0.121

**Means followed by the same letter within a column are not significantly different at P = 0.05.*
ppm parts-per-million, 10^{-6}.

Table 5.
Nutrient levels of fresh pumpkin fruit and pumpkin flour obtained from three drying methods [4].

Temperature (°C)	MC_{db} of fresh pumpkin	MC_{db} of dried pumpkin powder	a_w of fresh pumpkin	a_w of dried pumpkin powder
50	82.10	10.21^{a}	0.98	0.65^{a}
60	82.58	7.46^{b}	0.95	0.42^{b}
70	84.09	5.47^{c}	0.97 ns	0.30^{c}

Data are expressed as mean values. Mean values with different superscripts in the same column differ significantly at $P \leq 0.05$. The symbol ns means that the mean values are not significantly different.
MC_{db} Moisture Content – dry basis matter.
a_w Water Activity.

Table 6.
Mean values for moisture content and water activity of dried pumpkin powders prepared by hot air-drying at different temperatures [6].

3.3 Hot air-drying of pumpkin: the effects of using different temperatures on physico-chemical characteristics of pumpkin flour

3.3.1 Drying of pumpkin slices by three different temperatures

A study performed by Roongruangsri and Bronlund [6] examined the effect of three hot-air drying temperatures (50, 60, and 70°C) on physico-chemical properties and sorption characteristics of pumpkin powder after the drying process. *Cucurbita maxima* Duch., also called buttercup pumpkin, was cleaned, peeled, and deseeded. The pulp was cut into slabs with a 5 mm thickness, 40 mm length and 20 mm width. Pumpkin slices were then blanched by immersing in hot water at 95°C for 5 minutes, then cooled to room temperature. Hot-air drying was then performed in a cross-flow cabinet hot-air tray dryer at three different temperatures of 50, 60 and 70°C. Afterwards, samples were weighed to calculate the moisture content (MC_{db}), and then ground in a blender and sieved.

3.3.2 The effect of drying temperatures on the characteristics of pumpkin powder

3.3.2.1 Moisture content and water activity

Results of MC_{db} and water activity analyses showed that dried pumpkin powder produced at 70°C exhibited the lowest MC_{db} and water activity levels compared to those produced at drying temperatures 50 and 60°C, as shown in **Table 6**. The low MC_{db} and water activity levels of pumpkin powders produced at 60 and 70°C suggest a better keeping quality than those produced at 50°C, since the occurrence of most unfavorable changes of food during storage is less when water activity drops below 0.4 [6].

3.3.2.2 Color of pumpkin powder

Color of food is one of the important quality parameters since it may indicate changes in food quality due to processing, storage or other conditions. As mentioned earlier, the yellowish color of dried pumpkin powder is due to the carotenoid pigments naturally found in the pumpkin fruit. Powders produced at drying temperatures of 50 and 60°C showed lighter color retention than those produced at 70°C. Pumpkin powder produced at 50°C had the lightest color compared to that produced at 60 and 70°C, indicating that increase of drying temperature causes increase in the darkening of the color [6].

3.3.2.3 Carotenoid content

Dried pumpkin powder produced at 70°C showed the highest percentage decrease in carotenoid content (56%) compared to the decrease in those produced at 50 and 60°C (18% and 33% respectively). Decrease in total carotenoid content may be attributed to the degradation of β-carotene and other carotenoids due to auto-oxidation, since the highly unsaturated chemical structure of carotenoids makes them very sensitive to thermal degradation and oxidation [6].

3.3.2.4 Powder properties

Table 7 shows the effects of drying temperatures on bulk density, solubility, water adsorption and oil adsorption capacities of the pumpkin powder. These

Temperature (°C)	Bulk density (g/ml)	Water solubility (%)	Water adsorption (g water/g dry sample)	Oil adsorption capacity (g oil/g dry sample)
50	0.62^{c}	54^{a}	3.50^{a}	4.42^{a}
60	0.86^{b}	50^{b}	3.00^{b}	3.97^{b}
70	0.91^{a}	43^{c}	2.33^{c}	3.87^{b}

Data are expressed as mean values.
$^{a, b, c}$Mean values with different superscripts in the same column differ significantly at $P \leq 0.05$.

Table 7.
Physical characteristics of dried pumpkin powders obtained by hot air-drying at different temperatures [6].

properties affect the functional characteristics of the powder and are critical parameters for controlling quality; fruit and vegetable powders that have high water adsorption and oil adsorption capacities can convey water-retention and fat-binding properties that are important in bakery products [6].

The results implied that higher drying temperatures have an effect of decreasing water solubility and water and oil adsorption capacities of pumpkin powder: the dried pumpkin powder produced at 50 and 60°C had a water solubility above 50%, and higher water and oil adsorption capacities compared to that obtained at 70°C. These results indicate that dried pumpkin powders produced at 50 and 60°C have more potential for baking purposes than those produced at 70°C [6].

3.4 Freeze-dried pumpkin powder

Freeze drying is a dehydration process employing two steps: freezing the food material, and sublimation of ice from the frozen material. Freeze drying is generally recommended for drying foods that have heat sensitive components such as tocopherols, carotenoids, and phenolics. It is considered a great method for drying foods of high quality where color, flavor, texture, nutrient content, taste, chemical composition and biological activity of the fresh sample only undergo minimal changes [16].

In a study performed by Dirim and Caliskan [16], it was observed that the chemical compositions such as vitamin C and total phenolics contents of dried pumpkin powder obtained by freeze-drying were not significantly different from that of fresh pumpkin. Freeze drying only reduced the total phenolic content by 3% in this study, but in the study performed by Aydin and Gocmen [17], pumpkin powder that was produced by hot-air oven scored higher than that produced by

Samples	Pretreatment
T1	Control
T2	Dipping in 0.1% Citric Acid (CA) for 15 minutes
T3	Hot water blanching at 95°C for 3 minutes
T4	Steam blanching for 5 minutes
T5	Blanching at 95°C in 1%NaCl for 3 minutes
T6	Dipping in 0.2% potassium metabisulfite (KMS) for 45 minutes
T7	Hot water blanching for 2 minutes followed by dipping in potassium metabisulfite (KMS) for 45 minutes

Table 8.
Different types of pretreatments [1].

Composition	Pumpkin flour (0 days)						
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**
Moisture (%)	6.40 ± 0.005	7.38 ± 0.01	12.78 ± 0.02	12.62 ± 0.01	13.8 ± 0.05	11.44 ± 0.01	10.99 ± 0.01
Protein (%)	8.51 ± 0.01	7.25 ± 0.01	5.17 ± 0.02	6.16 ± 0.01	6.68 ± 0.01	9.54 ± 0.01	5.45 ± 0.02
Ash (%)	6.52 ± 0.02	5.70 ± 0.15	4.02 ± 0.01	6.61 ± 0.02	6.59 ± 0.03	6.04 ± 0.01	6.54 ± 0.01
Crude fiber (%)	6.58 ± 0.02	6.41 ± 0.03	6.9 ± 0.2	7.04 ± 0.02	7.5 ± 0.05	8.36 ± 0.01	12.011 ± 0.02
Minerals (mg/100 g)							
Phosphorus	241.977 ± 0.02	317.545 ± 0.02	177.449 ± 0.06	167.514 ± 0.01	28.35 ± 0.05	269.451 ± 0.02	142.988 ± 0.04
Iron	22.54 ± 0.05	16.01 ± 0.03	5.078 ± 0.00	10.075 ± 0.01	11.629 ± 0.00	18.61 ± 0.04	21.794 ± 0.01
Total carotene (mg/100 g)	2.816 ± 0.01	5.492 ± 0.03	9.196 ± 0.01	10.35 ± 0.01	2.17 ± 0.01	7.581 ± 0.00	17.769 ± 0.00
Starch (%)	30.16 ± 0.05	40.77 ± 0.01	19.8 ± 0.01	23.7 ± 0.05	22.68 ± 0.02	30.22 ± 0.03	32.14 ± 0.04
SO_2 (mg/kg)	—	—	—	—	—	—	1279.14 ± 0.03

Table 9.
Effect of pretreatments on the proximate parameters of pumpkin flour [1].

freeze drying in terms of phenolic contents and antioxidant activity. The latter study, however, showed that freeze drying reduced browning, preserved redness, resulted in a lighter color, higher water holding capacity, oil binding capacity, emulsion stability, and the highest total dietary fiber compared to oven produced powders. Color values obtained by Aydin and Gocmen [17] and Mujaffar et al. [18] supported the overall results that freeze drying was able to preserve a closer color of powder to that of fresh pumpkin, producing pumpkin powder of high quality color. Moreover, freeze drying was reported to produce higher yields of powder [18] and less carotenoid degradation [16] than that of hot-air oven drying.

Although freeze drying preserved the deep-orange color of fresh pumpkin and produced better physico-chemical properties of pumpkin flour, the cost of freeze drying application is very high [17], making oven drying a more suitable technique in developing countries or for cost-reduction purposes.

3.5 The effect of pre-treatments on selected properties of pumpkin flour

Fruits and vegetables are often pretreated in order to extend their shelf life, preserve their color and flavor, decrease the loss of nutrients and reduce activity of enzymes. In the production of dried products, pretreatments can lead to improvement of product quality and help in the inhibition of enzymatic browning (Kripanand et al., 2016). Since conventional air drying can adversely affect the color, flavor and nutritional value of the dried products, pretreatments prior to air drying are considered one of the most important factors that affect the quality of the final powder product produced by drying [17].

In order to optimize different pretreatments to obtain good quality pumpkin powder and β-carotene retention during storage, Kripanand et al. [1] performed a study employing six different pretreatments for the production of pumpkin flour from fresh *Cucurbita maxima*. The different types of pretreatments are presented in **Table 8**, where the control sample (T1) represents no pretreatment.

Results of this study (**Table 9**) showed that pretreated flour samples retained a higher moisture content compared to the control sample. Blanching was found to significantly affect the protein content, where cold pre-treated samples (T1, T2 and T3) had higher protein values compared to hot pre-treated samples. Blanching was also found to reduce starch, ash, fiber, phosphorus and iron quantities due to leaching out during the blanching process [1].

As for the carotenoid content, it was observed that chemical pretreatments lead to improvement in the amount of total carotene in pumpkin flour. But the use of blanching and sulfiting together (T7) showed a most favorable effect on total carotenoid stability T7 pretreatment also attained the highest score for color and overall acceptability, followed by T6. In addition, less browning was observed in all T7 samples during storage indicating that metabisulfite reduced the formation of browning compounds during storage [1].

4. Pumpkin wheat composite bread

4.1 Nutritive value of pumpkin wheat composite flour

Consumers are becoming more aware of healthy eating and high quality foods that contain additional health benefits. Yet, the modern consumers rely on the food industry to provide such high quality food products as they purchase more processed foods and ready meals [7]. Development of healthy products with the incorporation of fruits and vegetables represent one strategy for the production

	Wheat Flour	Pumpkin Flour
Moisture	11.1%	4.8%
Protein	12.4%	11.6%
Fat	1.4%	2.4%*
Dietary fiber	10.1%	28.3%
Crude fiber	1.2%	16.9%
Ash	0.63%	6.7%
Calcium	17.0 mg/100 g	121.7 mg/100 g
Iron	5.3 mg/100 g	7.1 mg/100 g
Zinc	2.8 mg/100 g	3.1 mg/100 g
β-carotene	—	1.8 mg/100 g

This study does not mention whether pumpkin seeds were removed or not before drying and powdering, which might explain the higher fat content in pumpkin flour compared to wheat flour if the seeds were kept.

Table 10.
Proximate composition of wheat flour and pumpkin flour [19].

Level (%PF)	Protein (g/mg)	β-carotene (μg/g)	Calcium (mg/g)	Iron (mg/g)	Zinc (mg/g)	Energy (kcal/g)
1 (0%)	0.1108[b*]	1.433[b]	0.2736[b]	0.0216	0.0344[b]	2.6792[a]
2 (5%)	0.1284[ab]	3.583[ab]	0.2850[b]	0.0739[c]	0.0407[ab]	2.4494[b]
3 (20%)	0.1298[ab]	3.768[ab]	0.4549[ab]	0.0164[bc]	0.0512[ab]	2.3141[bc]
4 (50%)	0.1350[a]	5.125[a]	0.8063[ab]	0.1175[ab]	0.0551[ab]	2.2147[bc]
5 (95%)	0.1378[a]	5.128[a]	1.0113[a]	0.1495[a]	0.0631[a]	2.1104[c]
RDI (adult)	34–71 g/d	600–1300 μg/d**	1000–1300 mg/d	8–18 mg/d	8–13 mg/d	2403–3067 kcal/d
RDI (child)	13–19 g/d	300–400 μg/d**	500–800 mg/d	7–10 mg/d	3–5 mg/d	1046–1742 kcal/d

Means followed by the same letter within a column are not significantly different at P = 0.05. PF = pumpkin flour. g/d = grams per day. mg/d = milligrams per day. Kcal/d = kilocalories per day.
***Applies to retinol: 1 μg retinol = 12 μg β-carotene, hence RDI values should be multiplied by 12 to relate to table values.*
RDI Reference Daily Intake

Table 11.
Mean of nutrient content in pumpkin bread at five blending levels [7].

of these 'functional foods' [19]. Use of functional ingredients in bakery products for the aim of nutrient enrichment is increasingly becoming important in bakery industries [7]. Pumpkin flour has been used to supplement cereal flours in bakery products, soups, sauces, instant noodles and spices [3].

Pumpkin wheat composite flour improves the texture, nutritional value, and color of different bakery products and thus, it is likely to produce bread with improved nutritional value and good sensory characteristics by using pumpkin wheat composite flour [20]. **Table 10** compares the proximate composition of wheat flour and pumpkin flour. Pumpkin flour was shown to have higher amounts of calcium, iron, zinc, β-carotene, ash and total dietary fiber. This indicates that pumpkin flour could be used to supplement wheat flour with these nutrients for the production of higher quality bread [19].

Table 11 shows the contents of various nutrients in wheat bread supplemented with different levels of pumpkin flour. Incorporation of pumpkin flour resulted

Composition %	Control	5%	10%	15%
Moisture	32.02 ± 0.54^{bc}	32.63 ± 0.50^{c}	34.25 ± 0.08^{ab}	35.32 ± 0.06^{a}
Fat	2.59 ± 0.01^{a}	2.55 ± 0.01^{a}	2.48 ± 0.01^{b}	2.44 ± 0.01^{b}
Protein	15.72 ± 0.04^{a}	15.17 ± 0.09^{b}	14.71 ± 0.02^{c}	14.47 ± 0.06^{c}
Ash	1.83 ± 0.07^{d}	2.09 ± 0.01^{c}	2.26 ± 0.02^{b}	2.43 ± 0.03^{a}
Crude fiber	1.56 ± 0.02^{d}	2.46 ± 0.03^{c}	2.62 ± 0.01^{b}	2.90 ± 0.04^{a}
Carbohydrate	46.28 ± 0.14^{a}	45.10 ± 0.21^{b}	43.68 ± 0.05^{c}	42.44 ± 0.05^{d}
Calorie (kcal/100 g)	271.31^{a}	264.03^{b}	255.88^{c}	249.60^{d}

$^{a, b, c}$ *Means in a row with similar superscripts are not significantly different at α = 0.05.*
Values are the Means ± SD and n = 3 for each group.

Table 12.
Proximate composition of bread for different levels of pumpkin flour [3].

in a uniform trend of increase in protein, β-carotene, calcium, iron and zinc, and uniform decrease in energy content with increasing levels of pumpkin flour. Reduction of calories with increasing pumpkin flour levels is attributed to increased fiber content and lower carbohydrate content in the composite flour, which is a good approach in the direction of health promotion [7].

4.2 Physico-chemical properties of pumpkin wheat composite bread

The effects of adding different levels of pumpkin flour on the physico-chemical properties of bread have been studied. Substitution of higher levels of pumpkin powder in bread have been shown to decrease the fat content of the bread. This might be attributed to the lower content of fat in pumpkin flour compared to wheat flour. The same effect was observed for the carbohydrate content, as increasing the level of pumpkin flour resulted in decreased total carbohydrate content of the bread [3]. Protein content has been also shown to decrease with increased incorporation of pumpkin flour (**Table 12**) [3, 20], which opposes the results obtained by Kiharason et al. [7] (**Table 11**) that shows increased protein content with increased pumpkin flour content. This might be attributed -as mentioned in chapter I- to the different nutritional profile of different species and cultivars of pumpkin, or to the pumpkin powder preparation methods in which seeds were removed or kept. Pumpkin seeds are rich in protein and lipids [2], and thus keeping them as part of the pulp in the flour preparation process would increase the amount of these constituents in the produced powder. Ash, total fiber and reducing sugar levels increased with increasing substitution of pumpkin flour in bread [3, 21]. Increasing the level of pumpkin flour also resulted in increase of the moisture content of the composite bread which could be explained by the higher water absorption capacity of the composite flour compared to wheat flour [3].

In the study conducted by See et al. [3], incorporation of 5% pumpkin flour resulted in the highest loaf volume and specific volume compared to the other samples giving more significant softness in bread. The weight of the loaf significantly increased as increasing levels of pumpkin flour were incorporated, which was attributed to the increased water absorption capacity of pumpkin flour. Opposite results were obtained by Kundu et al. [19] where supplementation of increased levels of pumpkin flour lead to decreased water absorption (**Table 13**). The result was related to the dilution of gluten.

Dough development time, defined as *the time to the nearest half minute from the first addition of the water to the development of the maximum consistency of the dough*

Parameter	Flour supplemented with 5% pumpkin powder	Flour supplemented with 10% pumpkin powder	Flour supplemented with 15% pumpkin powder
Water absorption (%)	67.0 ± 0.0	65.0 ± 0.0	62.5 ± 0.16
Dough development time (min.)	2.5 ± 0.0	2.7 ± 0.0	4.1 ± 0.08
Dough stability	2.0 ± 0.83	3.0 ± 0.08	3.5 ± 0.08
Mixing tolerance index (BU)	70.0 ± 1.6	60.0 ± 1.6	50 ± 1.6
Time to break down (min.)	5.1 ± 0.0	6.0 ± 0.08	7.5 ± 1.6
Farinographic quality number	51.4 ± 0.0	60 ± 0.83	75 ± 1.6

Table 13.
Effect of incorporation of various levels of pumpkin powder on farinographic characteristics of wheat flour [19].

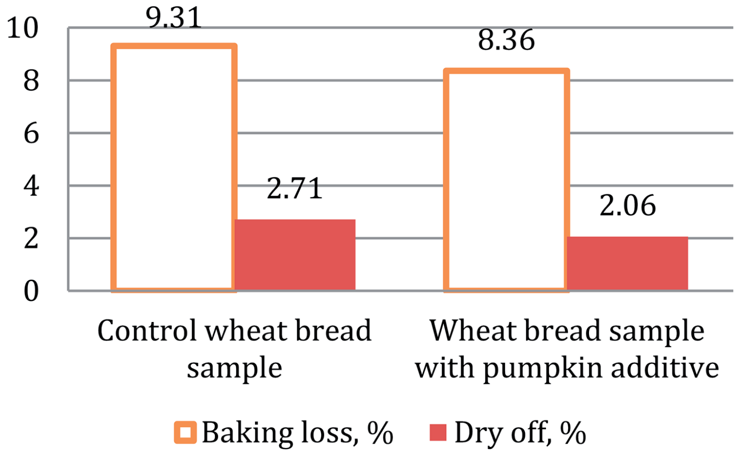

Figure 2.
The changes in the value of dry off and baking loss in bread samples [21].

increased with the addition of pumpkin flour, which was related to the difference in the physiochemical properties between the constituents of pumpkin flour and wheat flour. Dough consistency was also maintained almost at the same level after increased levels of pumpkin flour indicating that the dough was stable and had more resistance against mechanical mixing. Increased concentration of pumpkin flour also lead to decrease in mixing tolerance index indicating stronger flour, since the lower the mixing tolerance index, the stronger the flour. Extensibility and resistance to extensibility were also shown to significantly increase with increased incorporation of pumpkin flour, resulting in rubber-like properties [19].

Rakcejeva et al. [21] studied the effect of incorporating 10% pumpkin flour in wheat bread on the bread baking loss which *forms the biggest loss in technological processes*. Results showed an insignificant decrease by 0.95% compared to 100% wheat flour bread (**Figure 2**). Thus, technological bread weight loss during the addition of 10% pumpkin flour is considered insignificant. These results show that pumpkin powder supplemented bread can be used for making good quality bread.

4.3 Sensory evaluation of pumpkin wheat composite bread

Conducting tests that determine consumer acceptance, liking, preference and opinions is among the key activities that relay important information for consumer

Parameter	Control	5%	10%	15%
Crust color	6.00 ± 1.67^{a}	6.07 ± 0.88^{a}	5.67 ± 0.81^{a}	5.33 ± 0.90^{a}
Crumb color	6.13 ± 0.99^{ab}	7.67 ± 0.49^{c}	6.67 ± 0.49^{b}	5.73 ± 0.70^{a}
Moistness	5.60 ± 0.51^{ab}	6.07 ± 0.80^{a}	5.33 ± 0.49^{bc}	5.00 ± 0.38^{c}
Softness	5.93 ± 0.80^{ab}	6.47 ± 0.83^{a}	5.53 ± 0.64^{bc}	5.20 ± 0.41^{c}
Aftertaste	5.73 ± 0.59^{a}	6.13 ± 0.52^{a}	5.20 ± 0.41^{b}	4.87 ± 0.35^{b}
Overall acceptability	6.60 ± 0.74^{ab}	6.93 ± 0.59^{a}	6.13 ± 0.35^{bc}	5.73 ± 0.46^{c}

$^{a, b, c}$ *Means in a row with similar superscripts are not significant different at α = 0.05.*
Values are the Means ± SD and n = 15 for each group.

Table 14.
Mean value of sensory attributes of bread incorporated with different levels of pumpkin flour [3].

Treatments	Volume of bread	Crust color	Symmetry of form	Evenness of bake	Character of crust
T0	7.00^{a}	7.00^{a}	2.80^{a}	2.90^{a}	2.90^{a}
T1	8.00^{b}	7.00^{a}	2.80^{a}	2.80^{a}	2.80^{a}
T2	7.10b^{c}	6.90^{b}	2.60^{a}	2.60^{a}	2.60^{a}
T3	6.90^{c}	6.62^{a}	2.20^{a}	2.20^{a}	2.20^{a}

T0 = control (0% pumpkin flour), T1 = 5% pumpkin flour, T2 = 10% pumpkin flour, T3 = 15% pumpkin flour.
$^{a, b, c}$ *Means in a row with similar superscripts are not significantly different.*

Table 15.
External characteristics of bread [20].

Treatments	Grain of bread	Crumb color	Aroma of bread	Taste of bread	Mastication of bread	Texture of bread
T0	7.50^{a}	8.10^{a}	8.00^{a}	12.60^{a}	8.00^{a}	12.20^{a}
T1	7.50^{a}	8.00^{a}	7.70^{a}	12.60^{a}	7.60^{a}	12.20^{a}
T2	7.40a^{b}	7.60^{a}	7.50^{ab}	11.00^{b}	7.20^{a}	11.90^{a}
T3	6.80^{b}	6.90^{b}	6.90^{b}	10.80^{b}	6.40^{b}	10.80^{b}

T0 = control (0% pumpkin flour), T1 = 5% pumpkin flour, T2 = 10% pumpkin flour, T3 = 15% pumpkin flour.
$^{a, b, c}$ *Means in a row with similar superscripts are not significantly different.*

Table 16.
Internal characteristics of bread [20].

goods companies. The results of these tests help companies make product decisions concerning marketing, development of new products, reformulation of existing products, etc.. Sensory evaluation performed to assess pumpkin wheat composite bread showed the highest acceptability and preference for 5% pumpkin flour supplemented bread in the studies conducted by See et al. [3] and Pasha et al. [20]. **Table 14** shows the data of the sensory evaluation obtained by See et al. [3]. The data indicated that consumers preferred the crust color, moistness, softness and aftertaste of the 5% pumpkin flour bread and the control sample that were not significantly different. Similar results were obtained by Pasha et al. [20] where external and internal characteristics (**Tables 15** and **16**) of control bread and 5% pumpkin flour supplemented bread were only significantly different by volume of bread (higher for 5% pumpkin flour bread).

In the study performed by Rakcejeva et al. [21], the highest assessment after expert sensory evaluation was scored for 10% pumpkin flour bread, and elevated levels of pumpkin flour (over 10%) became unacceptable due to worse porosity, stickier bread soft part and unpleasantly sweet taste of bread. A higher degree of liking was also scored for 10% pumpkin flour bread over control bread: bread sample with pumpkin additive was shown to be tastier than the control bread sample.

5. Conclusion and discussion

The nutritional value of pumpkin fruit is high and exquisite, which calls for its exploitation by the food industry as a functional food. Studies have found antioxidant, anti-diabetic, anti-carcinogenic and anti-fatigue effects of pumpkin pulp nutritional components. Being a perishable fruit, means for prolonging its shelf life had to be employed. Drying is one of the methods that prolong the shelf life of food products by reducing the moisture content to inhibit the growth of microbes and thus prevent spoilage of the food material.

To preserve the nutritional value of the dried pumpkin, several drying methods were studied in an attempt to reduce the degradation of nutritive components during drying and during storage. Vacuum freeze drying was shown to be a great method to preserve the β-carotene and phenolic acid contents of dried pumpkin but is an expensive drying technique. Convective drying methods are common methods to dry food materials and are cheaper but could result in a greater loss of nutrients. To reduce this loss, the appropriate drying conditions such as drying temperature and pretreatments had to be optimized. It was found that a drying temperature of 60°C resulted in good quality pumpkin powder with acceptable water activity, β-carotene content retention, color quality and good potential for baking purposes. Drying temperatures of 50 and 70°C lead to unacceptable water activity level and greater degradation of β-carotene, respectively. Metabisulfite pretreatment of pumpkin slices preceded by hot water blanching was found to have the most favorable effect on total carotenoid stability, color, phenolic content and overall acceptability compared to several other pretreatments in the production of hot air dried pumpkin powder.

Production of pumpkin powder from dried pumpkin slices allows its supplementation into baking products –among others- to enhance their nutritional value. Development of pumpkin wheat composite bread was studied using different levels of pumpkin flour. Increasing the level of pumpkin flour incorporation into wheat flour led to increased contents of total fiber, β-carotene, calcium, iron and zinc, and it led to decrease in carbohydrate and caloric contents which is a good approach for health promotion. Incorporation of 5 and 10% pumpkin flour were found to have good dough and bread physical characteristics and the best sensory evaluation of pumpkin wheat composite bread.

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