



# **Evaluation of Nutritional and Functional Properties of Squash Pulp Powder from Cameroon and Squash Base Biscuit**

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*This work was carried out in collaboration among all authors. Author GI Study design, protocol writings DMA, DAW and DDFF. Analyses management authors AV and BGV. Litterature searches author AV. Statistical analysis: DAW writing of the first draft of the manuscript. Author DMA Reading and approval of the final manuscript.*

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## **ABSTRACT**

**Aims:** The aim of this study was to evaluate the nutritional and functional properties of powder from 2 Cameroonians squash pulp species (*Cucurbita moschata* Yellow and Orange pulp, and *Cucurbita pepo* orange pulp) and squash pulp-base biscuit to promote the integration of squash in the diet to help fight against micronutrient deficiencies and non-communicable diseases

**Methodology:** The squash were cleaned and the pulp was blanched in boiling water for 3 minutes and dried at 60 °C for 24 h. The dried pulp was then finely crushed and sieved to obtain the powder. The proximal composition, the levels of macronutrients, vitamin C, carotenoids and

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minerals were determined as well as the functional properties. The powder sample with the highest carotenoid content was substituted by wheat flour in the proportions 0%, 5%, 10%, 15% and 20% for the biscuit formulation. Sensory properties (color, taste and overall acceptability) and total carotenoids content of the biscuit were then evaluated.

**Results:** The nutrient contents per 100g of powder were 1.65g, 6.38-23.36 mg, 15.70-20.54 mg, 102.56-119.65 mg respectively for crude fibers, total carotenoids, vitamin C and potassium. Water absorption capacity (WAC), Water holding capacity (WHC) and oil holding capacity (OHC) varied from 7.50-8.25, 3.35-6.05 and 1.02-2.04 respectively. Values of swelling capacity (SC) and water solubility index (WSI) varied from 119-140 and 15-17.63, 314-348 and 22.33-24.9, 388-459 and 35.08-38.75 at room temperature, 65°C and 95°C respectively. Sensory analysis of the biscuits showed that the biscuit made with 10% of squash powder was the most appreciated and contained 2.29 mg/100g of total carotenoids.

**Conclusion:** Regular consumption of these Cameroonians squash pulp powder or foods formulated with them could help to combat nutritional disease.

*Keywords: Cameroon squash; pulp powder; biscuit formulation; sensory properties*

## 1. INTRODUCTION

Squashes are annual herbaceous plants, more or less creeping, belonging to the cucurbitaceous family. They are cultivated in all tropical and subtropical regions for their leaves, seeds and especially for their fruits. Several previous investigations showed that squash pulp contains many components that alleviate micronutrient deficiencies and non-communicable diseases. We can quote: Carotenoids which are powerful antioxidants, more particularly carotenoids provitamins A [1-5] which are a less expensive way to fight against vitamin A deficiency. It was reported that the consumption of 100g of steam-dried squash pulp could satisfy on average 5 and 8 times the daily vitamin A needs of pregnant women and under 7 years children respectively [3]. Moreover, they strengthen the immune system and contribute to maintaining the skin and bones growth. Vitamin C, which, in addition to its antioxidant properties, protects the body against infections and promotes the absorption of iron. Fibers, which regulate the intestinal transit and also intervene in the regulation of blood sugar and cholesterol. Minerals in particular potassium, which helps reduce blood pressure and water retention, thus, protecting against stroke and coronary heart disease. Potassium also helps to prevent osteoporosis and kidney stones [6-7]

It was shown that the administration of a high-fat meal in combination with squash polysaccharides for 6 weeks significantly reduced body weight gain, the levels of plasma insulin, serum triglyceride, cholesterol, low-density lipoprotein cholesterol and blood glucose in mice and improved the level of high-density

lipoprotein cholesterol and liver glycogen compared to control [8]. In addition, the investigation of Mahmoodpoor *et al.* showed that glucose level of diabetic critically ill patients decreased significantly after consumption of *C. maxima* pulp juice for three days [9].

In Cameroon, the number of people affected by nutritional diseases is high. Vitamin A deficiency still remains a major nutritional preoccupation [10]. Among 29.9% of the Cameroonian population are suffering from high blood pressure, 6 % are diabetic, 11.4% obese and 35% of death rates were recorded in 2016. This mortality rate could be doubled by 2035 if nothing is done [11-12]. Given these alarming statistics and the virtues of squash pulp, it is important to popularize squash and squash-based products to help fight these diseases.

In Cameroon, the production of squash is very low. Only 205471 tones was produced in 2019. However, they are grown in all agro-ecological zones of Cameroon [13]. The low production stems from the fact that squash pulp is not well known and therefore under used. as steamed [14].

Nevertheless, squash pulp, leaves, and sometimes the peduncle have long been used as nutraceuticals or traditional medicines for the prevention and control of non-communicable diseases and parasitic infections. In fact, the pharmacological activities of squash pulp such as antidiabetic, antimicrobial, hypocholesterolemic, anti-oxidant potential, anticancer, immunomodulatory or immune-enhancing, antimutagenic, anthelmintic, and anti-bladderstone are well documented [15-18].

To help increase the consumption of squash in Cameroon, fried and steam-dried squash pulp were produced and these were highly valued by panelists [2]. The extension of squash can also be done by transforming the pulp into powder. This form of processing not only offers an alternative to fresh squash but also extends the shelf life and facilitates handling. In addition, squash powder can be used as a supplement to cereal flours for its micronutrient richness, or in complementary weaning food [19-21]. Squash powder can also be used as an ingredient in sauces and soups.

With the aim of integrating squash and squash based products in the fight against nutritional diseases, we have set the objective of producing and evaluating the nutritional and functional properties of squash powder as well as using it in the test formulation of a biscuit.

## 2. MATERIALS AND METHODS

### 2.1 Plant Material

The plant material consisted of mature *Cucurbita moschata* with yellow (A) and orange (B) pulp and *Cucurbita pepo* with orange pulp without visible alterations.

They were bought in the Coastal zone (Moungo-Littoral) in August and transported to the laboratory of biochemistry of the Faculty of Science, University of Douala in a perforated polyethylene bag. The latter were classified in a clean and dry place for one week before processing.

### 2.2 Preliminary Investigation to Choose the Best Powder Processing Methods

The choice of the process for transforming squash pulp into powder was made on the basis of preliminary tests to determine the method limiting nutrient losses. The markers used were total carotenoids and vitamin C, due to their sensitivity during food processing.

The squash was washed with tap water and soap and split into two equal parts. Each part was equally sub-divided into 2 and one piece was retained for both (The two pieces retained were opposite) [22]. The seeds and internal soft parts were removed with a tablespoon and cut into slices (5x10 cm) and then into 10x2 mm strips. The strips were peeled and separated into two batches, the first of which was used to

determine vitamin C and total carotenoids before and after drying at 60°C. The second batch was bleached in boiling water for 3 min and vitamin C and total carotenoids were also determined before and after drying at the same temperature.

Depending on the total carotenoids and vitamin C contents of the powders obtained, the bleaching method was used for squash powder production. The squash were cleaned and after peeling, the (5x10) cm slices were reduced into (10x2) cm x mm slices and then bleached by soaking in boiling water for 3 min (1.5L/ 600g squash).

The blanched squash was then drained and dried in a Binder-type oven at 60°C for 24 h [2, 15]. The dried squash pulp was cooled on the absorbent paper for 5 min and crushed in a Moulinex stainless steel blender to obtain the powder. The resulting squash powder was sifted, packed in hermetically sealed bottles and stored in a clean, dry place. For each variety, three squashes were used to prepare samples.

### 2.2.1 Evaluation of nutritional, functional properties and energy contribution of squash powder

#### 2.2.1.1 Evaluation of the nutritional properties

The moisture content was determined by gradual dehydration of the food in an oven until a zero mass variation was obtained [20]. Total carbohydrates were obtained by difference between dry weight with the weight of ash, protein, fat and total fiber [23].

Total lipid content was determined by continuous extraction in a soxhlet apparatus about 8 hours using hexane as solvent [24]. Total nitrogen was determined after mineralization of the samples using the Kjeldahl method [25]. The crude fibre content of the samples was determined by the Scharrer and Kurschner method [26]. Ascorbic acid content was measured using titration with 2,6-dichlorophenolindophenol [27]. Total carotenoids were evaluated using a photometer (icheck™ carotene; Bioanalyt GmbH, Teltow, Germany) after extraction with hexane/ethanol mixture (1/1 v/v) [28]. Total ash and minerals were determined according to the method described by Pauwels et al. [29]. Briefly, 1g of squash powder from each sample was incinerated in a muffle furnace (Carbolite Eurotherm) at 450°C for 2 hours and ash content was determined. Minerals were extracted by

successive digestion of 0.5g ash with nitric acid and per-chlorhydric acid. The mixture was boiled for 10 minutes, filtered and the volume was made up to 100ml with distilled water. The potassium and calcium contents content were determined with a flame photometer. Iron and zinc contents were evaluated by UV visible spectrophotometer. Phosphorus contents were determined by colorimetry using the nitro-vanadomolybdique reagent. Each analysis was done in triplicate.

### 2.2.1.2 Functional properties

Water absorption retention capacity, swelling capacity and powder solubility index in water and also oil retention capacity, were determined according to previously described methods [30-32].

### 2.2.1.3 Energy contribution

The energy contribution was calculated as follows:

Carbohydrate energy (Kcal) = Carbohydrate content (g) x 4

Protein energy (Kcal) = Protein content (g) x 4

Fat energy (Kcal) = Fat content (g) x 9

Energy value (Kcal) = Sum of carbohydrate, protein and fat energy

Energy value (Kj) = Energy value (Kcal) x 4.18

### 2.2.2 Test for formulation of a biscuit

The test of formulation was made with the squash powder which had the highest nutrient contents. The powder was used to substitute wheat flour in several proportions: 0%, 5%, 10%, 15% and 20%.

The mixture was homogenized and ingredients such as sugar, powdered milk, baking powder, egg, vanilla sugar, butter, salt, sodium bicarbonate and water were added. The mixture was homogenized again to obtain the dough which was wrapped with aluminum foil and kept in the refrigerator for 2 hours. It was then rolled on a cutting board to a uniform thickness of about 5 mm. The dough was cut into 4 cm square pieces. The cut pieces were placed on a perforated tray and transferred to an oven preheated at 175°C and cooked for 15 min. The biscuits were removed from the oven, cooled at room temperature and stored in hermetically sealed packages for the appreciation test and

the evaluation of total carotenoid contents.

### 2.2.3 Sensory assessment of biscuits

The biscuits were submitted to a panel of 15 students selected at the Biochemistry Unit of the University of Douala made up of men and women used as guinea pig for degustation [33]. A questionnaire was presented to them and they were instructed on how to complete it. Samples were presented simultaneously at random in coded containers and the sensory attributes such as color, taste and texture were evaluated in each biscuit sample. Overall acceptability was calculated by taking the average of all sensory attribute scores.

### 2.3 Statistical Analysis

The data obtained were input to Excel spreadsheet (Microsoft office 2013) and means were calculated and expressed as an average  $\pm$  standard deviation. One way ANOVA was performed to establish the difference in the samples using Graphpad Prism software version 5.0. The Duncan test was used for multiple range comparisons. Results are presented in the form mean  $\pm$  standard deviation for the variables. The difference was considered for a p-value less than 5%.

## 3. RESULTS AND DISCUSSION

### 3.1 Results

#### 3.1.1 Preliminary investigation to choose the best powder processing methods

The powder from bleached squash pulp (Fig. 1a) kept a good color compared to that of the unbleached pulp. In fact, the bleaching phenomenon with boiling water inactivates enzymes, thereby preventing them from degrading carotenoids.

The total carotenoids and vitamin C contents of the powder from unbleached and bleached squash pulp are present on Table 1. The total carotenoids contents of the unbleached squash powder were significantly lower compared to those of the bleached powder for all the species. As far as vitamin C is concerned, there was no significant difference between the vitamin C content in the unbleached squash powder and bleached squash powder.



Fig. 1a. Bleached powder



Fig. 1b. Unbleached powder

**Table 1. Total carotenoids and vitamin C contents of the powder from unbleached and bleached squash pulp**

Contents (mg/100g Dry weight)			
Samples		Vitamin C	Total carotenoids
<i>Cucurbita moschata</i> A (Yellow pulp)	Unbleached	18.04 <sup>a</sup> ± 0.38	0.9 <sup>a</sup> ± 0.11
	Bleached	16.21 <sup>a,b</sup> ± 0.64	7.14 <sup>b</sup> ± 0.11
<i>Cucurbita moschata</i> B (Orange pulp)	Unbleached	24.43 <sup>c</sup> ± 0.01	7.79 <sup>c</sup> ± 0.41
	Bleached	15.6 <sup>a,b,d</sup> ± 0.46	21.65 <sup>d</sup> ± 0.24
<i>Cucurbita pepo</i> (Orange pulp)	Unbleached	30.61 <sup>e</sup> ± 0.19	8.66 <sup>c,e</sup> ± 0.19
	Bleached	23.39 <sup>c</sup> ± 0.62	26.31 <sup>f</sup> ± 0.45

For the same nutrient, (column), values with different superscript letters are significantly different ( $P < 0.05$ )

### 3.1.2 Proximal composition and functional properties of squash powder

#### 3.1.2.1. Proximal composition of squash powder

Table 2 presents the macronutrient contents of squash powder with energy values. Water, fat, protein, ash, fibre and carbohydrate contents varied according to the species and landrace of squash studied. The powder of *Cucurbita moschata* B had a significantly high water content compared to the powder of *Cucurbita moschata* A and *Cucurbita pepo*. These water contents ranged from 10.65% (*Cucurbita moschata* A) to 12.5% (*Cucurbita moschata* B). The lipid contents of the different samples were low (3%) and differed significantly with species and landraces ( $p < 0.05$ ). The protein contents were below 5mg/100g for all the samples. However, their level varied significantly with species and landraces ( $p < 0.05$ ). The ash and total fiber content did not differ among the species. The total carbohydrate level was higher in *Cucurbita moschata* A (77.39g/100g) than in other landraces ( $p < 0.05$ ). For the energy value, the species *Cucurbita pepo* had the highest energy value (333.75 kcal), followed by orange

pulp *Cucurbita moschata* (328.44 kcal) and finally yellow pulp *Cucurbita moschata* (324.87 kcal).

The micronutrient contents of squash powder are present on Table 3. The table shows that the contents of total carotenoids, vitamin C, phosphorus, calcium, iron, potassium and zinc of powders varied according to the species and landraces. Total carotenoids levels (mg/100g) were higher in the species *Cucurbita pepo* (23.36) than in *Cucurbita moschata* (18.94 and 6.38). Likewise, vitamin C levels (mg/100g) were higher in the species *Cucurbita pepo* (20.54) than in *Cucurbita moschata* (14.58 and 15.70).

With regard to the colour of the pulp, total carotenoids contents were higher in orange powder than in yellow powder. *Cucurbita pepo* with orange pulp had the highest total carotenoids content (23.36mg/100g) followed by *Cucurbita moschata* orange pulp (18.94 mg/100g) and finally *Cucurbita moschata* yellow pulp (6.38mg/100g). Vitamin C level of yellow *Cucurbita moschata* (15.70mg/100g) was higher than that of orange pulp (14.58mg/100g). However, the vitamin C content of *Cucurbita*

*pepo* orange was higher than that of *Cucurbita moschata* orange. High levels of potassium (119.65-102.56), followed by calcium (60.98-39.6 mg/100g), phosphorus (26.45-13.76 mg/100g) and low levels of iron (0.77-0.55 mg/100g) and zinc (0.56- 0.24mg/100g) were found in the powder whatever the specie.

### 3.1.2.2 Functional properties of squash powder

Functional properties are intrinsic physico-chemical characteristics that can affect the behaviour of food during processing and storage.

Tables 4 and 5 show some functional properties of squash powder. The water absorption capacity, water retention capacity and oil absorption capacity of the squash powder (Table 4) varied relatively among species. The swelling capacity and the solubility index of squash powder (Table 5) also varied relatively with temperature and species.

The swelling capacity increased with temperature in all species and landraces. For the powder with the highest total carotenoids content

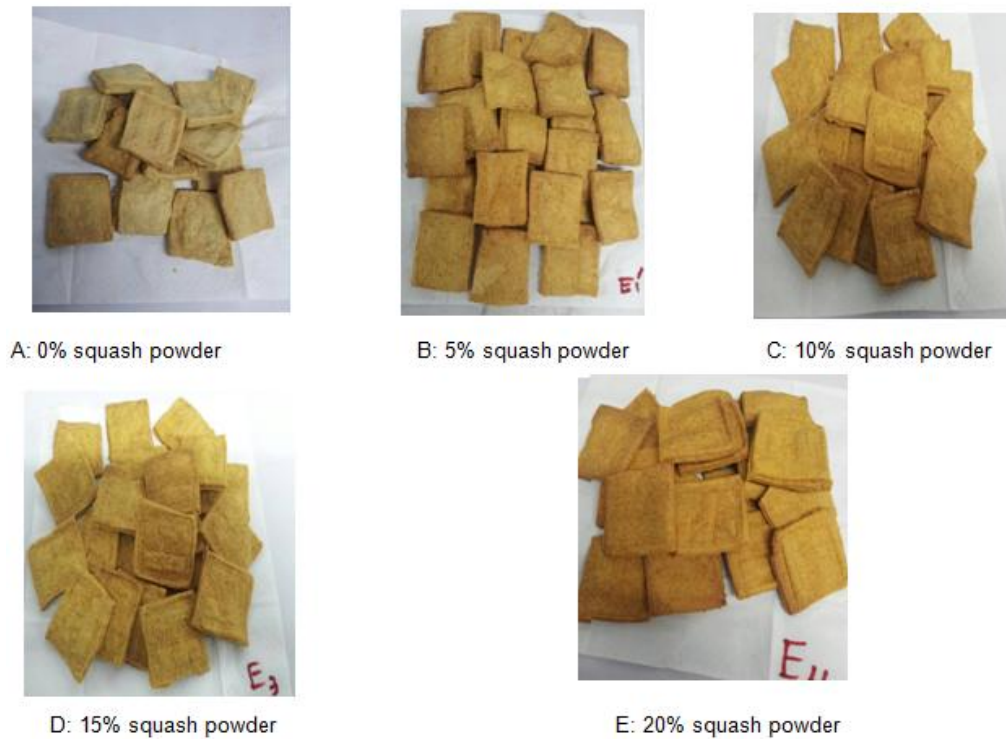
(*Cucurbita pepo*), the swelling capacity varied from 140.4 to 459.43% respectively from room temperature to 95°C. The water solubility index also increased with temperature (17.63 at room temperature to 35.08 at 95°C).

### 3.1.3 Samples of formulated biscuits with *Curcubita pepo* pulp powder

The Fig. 2 presents different biscuit samples formulated from squash powder in different proportions. Wheat flour was used as control. The biscuits become more colorful with the increase in the proportion of squash powder in the preparation.

### 3.1.4 Sensory analysis of biscuit

The results of the sensory analysis of the various samples of the biscuit are presented on Table 6. The most popular sample was the one made with 10% squash powder and 90% wheat flour. With a 75% overall acceptability frequency. The order of appreciation of the other samples were: 0%, 5%, 15% and 20% with the acceptability of (69%), (58%), (42%) and (40%) respectively.



**Fig. 2. Samples of biscuits formulated with squash powder and wheat flour**

**Table 2. Macronutrient content of squash powders**

Species	Contents (g/100g Fresh matter)						
	Water	Lipids	Proteins	Ash	Fibers	Carbohydrates	Energy (kcal)
<i>Cucurbita moschata</i> A (Y)	10.65 <sup>a</sup> ± 0.35	0.8 <sup>a</sup> ± 0.03	2.92 <sup>a</sup> ± 0.06	6.61 <sup>a</sup> ± 0.48	1.65 <sup>a</sup> ± 0.01	77.39 <sup>a</sup> ± 0.18	328.44 <sup>a</sup> ± 2.55
<i>Cucurbita moschata</i> B (O)	12.50 <sup>b</sup> ± 0.50	1.59 <sup>b</sup> ± 0.02	3.36 <sup>b</sup> ± 0.05	6.81 <sup>b</sup> ± 0.20	1.64 <sup>ab</sup> ± 0.05	74.28 <sup>ab</sup> ± 0.36	324.87 <sup>ab</sup> ± 3.66
<i>Cucurbita pepo</i> (O)	11.23 <sup>a</sup> ± 0.40	2.19 <sup>c</sup> ± 0.050	4.76 <sup>c</sup> ± 0.05	6.41 <sup>ab</sup> ± 0.18	1.65 <sup>ab</sup> ± 0.09	73.76 <sup>ab</sup> ± 0.49	333.75 <sup>ab</sup> ± 5.30
P-value	0.0680	< 0.0001	< 0.0001	0.2365	0.0440	0.9914	0.9915

The letters A, B, represent squash landraces. The letters in brackets represent the color of the squash pulp (Y: Yellow and O: Orange). The factor used to calculate the energy value is 4 for carbohydrates and proteins and 9 for lipids. kcal: kilocalorie. For the same nutrient, (column), values with different superscript letters are significantly different ( $P < 0.05$ )

**Table 3. Micronutrient content of squash powders**

Species	Contents (g/100g Fresh Matter)						
	Total carotenoids	Vitamin C	Phosphorus	Calcium	iron	Potassium	Zinc
<i>Cucurbita moschata</i> A (Y)	6.38 <sup>a</sup> ± 0.20	15.70 <sup>a</sup> ± 0.40	24.38 ± 0.91 <sup>a</sup>	52.03 <sup>a</sup> ± 0.57	0.72 <sup>a</sup> ± 0.01	105.36 <sup>a</sup> ± 0.97	0.43 <sup>a</sup> ± 0.08
<i>Cucurbita moschata</i> B (O)	18.94 <sup>b</sup> ± 0.26	14.58 <sup>b</sup> ± 0.25	26.45 ± 0.59 <sup>b</sup>	60.98 <sup>b</sup> ± 0.35	0.55 <sup>b</sup> ± 0.02	102.56 <sup>b</sup> ± 0.69	0.34 <sup>ab</sup> ± 0.02
<i>Cucurbita pepo</i> (O)	23.36 <sup>c</sup> ± 0.45	20.54 <sup>c</sup> ± 0.53	13.76 <sup>c</sup> ± 0.31	39.60 <sup>c</sup> ± 0.27	0.97 <sup>c</sup> ± 0.01	119.65 <sup>c</sup> ± 1.39	0.56 <sup>a</sup> ± 0.07

The letters A, B, represent squash landraces. The letters in brackets represent the colour of the squash pulp (Y: Yellow and O: Orange). For the same nutrient, (column), values with different superscript letters are significantly different ( $P < 0.05$ )

**Table 4. Water absorption capacity, water retention capacity and oil absorption capacity of squash powders**

Species	WAC	WHC	OHC
<i>Cucurbita moschata</i> A (Y)	8.25 <sup>a</sup> ± 0.05	3.35 <sup>a</sup> ± 0.35	1.02 <sup>a</sup> ± 2.88
<i>Cucurbita moschata</i> B (O)	9.13 <sup>b</sup> ± 0.31	6.05 <sup>b</sup> ± 0.21	2.03 <sup>b</sup> ± 5.77
<i>Cucurbita pepo</i> (O)	7.50 <sup>c</sup> ± 0.20	4.6 <sup>c</sup> ± 0.14	2.04 <sup>b</sup> ± 4.04

WAC = Water absorption capacity, WHC: Water holding capacity, OHC: Oil holding capacity, The letters A, B, represent squash landraces. The letters in brackets represent the color of the squash pulp (Y: Yellow and O: Orange). For the same property, (column), values with different superscript letters are significantly different ( $P = 0.05$ )

**Table 5. Swelling capacity and water solubility of squash powders**

Values (%)			
Species	Temperatures	SC	WSI
<i>Cucurbita moschata</i> A (Y)	Room temperature	119.33 <sup>a</sup> ±2.08	15.29 <sup>a</sup> ± 0.53
	65°C	336.43 <sup>b</sup> ±3.37	22.87 <sup>b</sup> ±0.59
	95°C	388.46 <sup>c</sup> ±2.13	36.09 <sup>c</sup> ±0.58
<i>Cucurbita moschata</i> B (O)	Room temperature	143.33 <sup>d</sup> ±3.05	18.17 <sup>d</sup> ±0.54
	65°C	348.71 <sup>e</sup> ±2.23	24.91 <sup>e</sup> ±0.55
	95°C	400.33 <sup>f</sup> ±2.51	38.75 <sup>f</sup> ±0.56
<i>Cucurbita pepo</i> C (O)	Room temperature	140.4 <sup>d</sup> ±2.62	17.63 <sup>d</sup> ±0.94
	65°C	314.26 <sup>g</sup> ±3.53	22.33 <sup>b</sup> ±0.43
	95°C	459.43 <sup>h</sup> ±3.02	35.08 <sup>c</sup> ±0.59

SC = Swelling Capacity, WSI: Water Solubility Index. For the same property, (column), values with different superscript letters are significantly different ( $P = 0.05$ ). The letters A, B, represent squash landraces. The letters in brackets represent the color of the squash pulp (Y: Yellow and O: Orange)

**Table 6. Sensory analysis of biscuits**

Percentage squash powder	0%		5%		10%		15%		20%	
	Panelist	Frequencies (%)	Panelist	Frequencies (%)	Panelist	Frequencies (%)	Panelist	Frequencies (%)	Panelist	Frequencies (%)
<b>Color</b>										
Bad	6	40	1	6	3	20	2	14	4	26
Good	7	46	12	80	9	60	6	40	5	34
Very good	2	14	2	14	3	20	7	46	6	40
<b>Total</b>	15	100	15	100	15	100	15	100	15	100
<b>Taste</b>										
Bad	2	14	8	54	2	13	5	34	8	54
Good	12	80	6	40	11	74	9	60	7	46
Very good	1	6	1	6	2	13	1	6	0	0
<b>Total</b>	15	100	15	100	15	100	15	100	15	100
<b>Crispy</b>										
Yes	12	80	8	54	14	94	4	26	6	40
No	3	20	7	46	1	6	11	74	9	60
<b>Total</b>	15	100	15	100	15	100	15	100	15	100
<b>Acceptability</b>										
<b>Frequencies (%)</b>	<b>69</b>		<b>58</b>		<b>75</b>		<b>42</b>		<b>40</b>	



### 3.1.5 Total carotenoid contents of biscuits

Table 7 shows the total carotenoid contents of the various biscuit samples. The total carotenoid content varied significantly among the samples. Moreover, these contents were proportional to the increase in squash powder. The sample 2 (S2) most appreciated by panelists had 2.29 mg/100g total carotenoids.

## 3.2 Discussion

### 3.2.1 Macronutrient contents

Water contents of squash powder between 10-12% are comparable to those found by Sathiya et al. [34]. These value are in accordance with the FAO recommendations [35] which state that the water content of dried vegetables should be less than 12%.

The lipid contents of the squash powder samples from *Cucurbita moschata* are comparable to those found by El-Demery [36]. The lipid contents of the different samples corroborate those found by [2] in steam-dried squash. These low lipid content, agree with the conclusions that squash powder can be added to rich lipids meal to reduce their total fat content. Moreover, it can also be recommended for individuals who wish to control their weight. Indeed, it is known that the consumption of foods rich in lipids increase the risk of obesity [37,38]. Crude fibre contents of squash powder samples were comparable. Values ranged from 1.6 to 1.82 and support the results of Pongjanta et al. [39]. However, these values were lower than those found by Mala et al. [34]. This difference would be attributed to the degree of maturity of squash as it is known that the fibre content decreases with fruit maturation [40]. Fibers are the part of food that is not digested by humans but important for the normal functioning of the intestinal tract. In addition, the fibres increase the bulk stool and decrease the time waste remains in the gastrointestinal tract. Fibres contribute to the maintenance of human

health. We can quote the insulin sensitivity, gut motility, healthy gut microflora, regulation of appetite, inhibition of chronic inflammation and so on [41]. Low-fiber diet leads to heart disease, colon cancer and rectal disease, varicose veins, obesity, appendicitis, diabetes and even constipation [42].

### 3.2.2 Micronutrients content

Total carotenoids contents were variable according to the species of squash. In fact, these levels were higher in the species *Cucurbita pepo* compared to all *Cucurbita moschata* landraces. Furthermore, carotenoids content were higher in orange powder than in yellow powder. As the colour is related to the total carotenoids content, particularly  $\beta$ -carotene, and vitamin A activity, We can said that orange pulp *Cucurbita pepo* had the highest  $\beta$ -carotene content followed by the orange pulp *Cucurbita moschata* and the yellow pulp *Cucurbita moschata*. As a consequence, the orange pulp *Cucurbita pepo* would therefore have the highest vitamin A activity.

Total ash and mineral contents differed relatively with landraces. Phosphorus levels were comparable to those found in *Cucurbita moschata* after bleaching and drying [34]. Phosphorus level of the *Cucurbita pepo* powder was very low compared to that of *Cucurbita moschata*. This may be due to the effect of species. High levels of potassium and calcium were found in squash powders. This makes their use beneficial for the body. Indeed, potassium is the main cation of the intracellular medium. It is involved in the regulation of blood pressure and takes part in the acidobasic balance of the body. Calcium helps build strong bones, teeth and the skeletal system. Moreover, the consumption of these powders could also contribute to the formation of hemoglobin thanks to their significant iron content. In addition, their significant zinc content allows them to participate in the proper functioning of the immune system.

**Table 7. Total carotenoid contents of biscuits sample**

Biscuits sample	Contents (mg/100g)		Total carotenoids
	Proportion (%)		
	Wheat flour	Squash powder	
S 0	100	0	0.22 <sup>a</sup> ± 0.11
S 1	95	5	0.85 <sup>b</sup> ± 0.78
S 2	90	10	2.29 <sup>c</sup> ± 0.95
S 3	85	15	3.02 <sup>d</sup> ± 0.71
S 4	80	20	3.83 <sup>e</sup> ± 0.11

For the same nutrient, (column), values with different superscript letters are significantly different ( $P < 0.05$ )

### 3.2.3 Nutritional intakes of squash powder

The calculation of the energy contribution showed that squash pulp powders remained a low-energy food (324.87 to 333.75 kcal/100g) and should be used by people with mild or moderate activity that does not require a lot of energy expenditure.

These Squashes powders could be used as a diet food in the fight against over-nutrition. They could also be used as a supplement to other high-fat and protein cereal flours (soy flour, peanut paste) for its low lipid and protein content or cereal flour low in  $\beta$ -carotene (wheat flour) for its high total carotenoids precisely in beta carotene. For a balanced diet, it is essential to combine the powder with a high-fat food because it is known that lipids not only have a high energy value but they facilitate the absorption of provitamins A in the body. Squash pulp powders obtained were also a source of vitamin C. Referring to the recommended daily intake of vitamin C, it is found that a minimum intake of 100g per person per day could satisfy 58.8% (yellow *Cucurbita moschata*), 62.8% (orange *Cucurbita moschata*) and 82.16 to 102.7% (orange *Cucurbita pepo*) of vitamin C needs for children from 6 months to 5 years. Besides, considering the recommended daily requirements, the minimum consumption of 100g of orange pulp *Cucurbita pepo* powder per person per day could satisfy 10.87 - 14.95% (potassium), 6.6 - 10.16% (calcium), 3.93 - 4.58% (phosphorus), 6.87 - 12.12% (Iron) and 11.2% (Zinc) of needs for children aged 4 to 6 years [7].

### 3.2.4 Functional properties of squash powder

Flour properties such as the water solubility index, water retention capacity, oil absorption, and powder swelling capacity are critical parameters for quality control [43]. Powders from fruits and vegetables with high water and oil retention capacities are essential in the confessional of bakery products [44]. The oil absorption capacity and the high water retention capacity of squash pulp powders obtained offer it an alternative to be used as a thickener in liquid and semi-liquid foods processing industries [45]. The values obtained on the swelling capacity and the solubility index were higher than the values of Yin and Wang [46] who worked on the *Cucurbita moschata* and *maxima* species of China. This would be due to the temperature of the powder heating. Indeed, the increase in

temperature is accompanied by an increase in the swelling capacity and solubility in the water of the squash powder.

The molecules of the starch polymer become solvent during heating. At the same time, the crystalline and amorphous structures are disturbed, resulting in increased granule swelling and starch solubility [47,48].

Many factors affect the water solubility of powdered products, including treatment conditions, composition, grain size, density, pH, and storage conditions [42]. The increase in temperature weakens the hydrogen binding interactions of starch granules and improve the swelling capacity and solubility of squash starches. Solubility is contributed by hydrophilia, amyloidosis content, and granule structure and organization [49,50].

### 3.2.5 Sensory analysis of biscuit made with squash powder and wheat flour

The sensory evaluation of the various samples of the biscuit showed that the sample consisting of 10% squash powder and 90% wheat flour was the most appreciated by the panelists and even more than sample without pumpkin pulp powder. The biscuits enriched with squash powder were much more coloured than the control, and had a positive influence on the acceptability of the product. A similar result was found with sandwich bread enriched with squash powder where the colour of the bread crumb was significantly affected by the addition of the squash powder [31]. Indeed, colour seems to be a very important criterion for the initial acceptability of the biscuit by consumers. The overall acceptability results of the biscuit with 10% of squash powder pulp are similar to those of El-Demery [36] which showed that the taste, the overall flavour and acceptability of control bread and bread with flour substitution levels of 5 and 10% squash powder had the highest score and that the addition of squash powder to proportions greater than 10% gave an unpleasant flavour.

## 4. CONCLUSION

Squash powder obtained remained a good source of micronutrients and could potentially be important in reducing Vitamin A deficiencies and chronic diseases. The functional properties of the squash pulp powder precisely the oil absorption capacity, the water retention capacity,

the swelling capacity and the high solubility index offer it the possibilities to be used as thickener of liquid and semi-liquid foods in culinary preparations and in the food processing industries. The sample with the best sensory appreciation was the one consisting of 10% squash powder and 90% wheat flour. Total carotenoids were 2.29 mg/100 g.

This study will help to implement the use of squash and squash base-products in Cameroon to combat nutritional related problems.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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