

Full Length Research Paper

Nutritional physico-chemical composition of pumpkin pulp for value addition: Case of selected cultivars grown in Uganda

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Pumpkin is one of the underutilized fruit-vegetables in Uganda although it is one of the crops believed to have carotenoids with pro-vitamin A activity that are not common to many other crops. While other crops are being bred or fortified to increase their nutritional benefits of β -carotene and other micro nutrients required for healthy growth and care for immunosuppressed people, the value of pumpkins in this regard remains under researched. This study sought to determine the nutritional physico-chemical parameters of selected pumpkin cultivars grown in Uganda. The seeds of 14 cultivars of pumpkin from four agro-ecological zones of Uganda were grown under similar conditions. Their mature pulp was then analyzed for their proximate, mineral and carotenoid composition including glucose, starch, crude fibre, crude fat, ash, crude protein, moisture, iron, zinc, calcium, potassium, lutein, α -carotene, *trans*- β -carotene, *cis*- β -carotene, total carotenoid and total pro-vitamin A carotenoid content using standard procedures. The proximate, calcium, potassium and the carotenoid content varied significantly across all the accessions ($P < 0.05$) while the iron and zinc content did not vary significantly across all the accessions ($P > 0.05$) respectively. The results from the study show that pumpkin pulp is a good source of dietary fibre, protein, calcium, potassium, iron and carotenoids with pro-vitamin A activity. Therefore, pumpkin can be utilized in the food processing industry as a food supplement and for several other value addition avenues such as wine and flour production.

Key words: Accession, carotenoid, cultivar, proximate, pumpkin, value addition.

INTRODUCTION

Pumpkins are fruits of several species belonging to the genus *Cucurbita* and family Cucurbitaceae. *Cucurbita* is one of the most economically important genera of vegetable crops (Paris, 2010). In much of Uganda,

pumpkins are mainly cultivated as a marginal crop often on the edges of field crops or scantily scattered between staple crops such as maize or sorghum (Hamisy et al., 2002). However, it is known that cultivation of any crop is

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necessary in order to know important characters considered by farmers in selecting crop varieties for improvement and commercialization (Ondigi et al., 2008).

Pumpkins are cultivated in different parts of the world for their pulp and seeds for human nutrition, either for direct consumption or for formulation of other foodstuffs such as syrups, jellies, jams, and purees (Provesi et al., 2011; Kim et al., 2012). Pumpkin pulp has both nutritional and health protective value of proteins, polysaccharides such as pectin, carotene, mineral salts, vitamins and other substances such as phenolic compounds and terpenoids (Jun et al., 2006; Kampuse et al., 2015). Pumpkin can be processed into flour which has a longer shelf-life. Pumpkin flour is used for wheat fortification and preparation of porridge because of its highly-desirable flavour, sweetness and deep yellow-orange colour (Nakazibwe et al., 2019). It has also been reported to be used to make soups, sauces, instant noodle and spice as well as a natural colouring agent in pasta and flour mixes (See et al., 2007; Kulaitiené et al., 2014).

Even though various studies about determining the physico-chemical composition of pumpkins have been conducted in other parts of the world, very few studies have been conducted to determine the physico-chemical parameters of the several pumpkin cultivars grown in Uganda since the pumpkin is one of the underutilized crops in the country. Consequently, this has created a knowledge gap about the nutritional composition of the pumpkin cultivars grown in Uganda to the processors and also the consumers, and this has continued to lead to the under exploitation of the pumpkin crop in the region. Therefore, this study was carried out to establish the status of some of the important nutritional physico-chemical parameters of pumpkin cultivars grown in Uganda. Need to say, these parameters are dependent on the species and the environment in which the pumpkins are grown (Achu et al., 2005; Applequist et al., 2006). Relating to this study, nutritional profiling of pumpkin cultivars is vital for the recommended increase in productivity of such traditional crops that are nutritionally rich (Sanchez and Swaminathan, 2005). The information from this study will also enable the consumers and processors to have an overview of the pumpkin cultivars that have better nutritional values, so that pumpkin consumption, processing and general value addition respectively is carried out based on factual information. In addition, the results will provide a basis for the processors to select specific cultivars for appropriate value addition avenues.

METHODOLOGY

Pumpkin accession collection and planting

Cross sectional surveys were used to look for pumpkin farmers.

Pumpkin seeds were collected from farmers in six districts from four agro-ecological zones of Uganda. These were Southwestern highlands (Kabale and Kanungu districts), Western mid-altitude farmlands and Semiliki flats (Masindi and Mubende districts), Western medium-high farmlands (Kabarole district) and Lake Victoria and Mbale farmlands (Mityana district) as represented in Figure 1. Villages namely, Mwangyale and Nyakibande in Kabale, Rugyeyo in Kanungu, Kihubba and Bugyenje in Masindi, Butologo in Mubende, Nyamiseke in Kabarole, Nkokonjeru and Kalangalo in Mityana were visited. The planted accessions were randomly assigned numbers basing on the districts from where they were collected. The accessions from Kabale were given 'Kab' with a corresponding number, those from Kanungu were given 'Kan' with a corresponding number, those from Masindi were given 'Mas' with a corresponding number, those for Fort portal, were given 'Fort' with a corresponding number and those from Mityana were given 'Mit' with a corresponding number.

The seeds were grown in a randomized complete block design experiment at the Mbarara Zonal Agricultural Research and Development Institute (MbaZARDI) located 0° 60' 20" S and 30° 60' 97" N. The garden was on an area of dimensions (32 x 72 m). The experiment had four complete blocks, assigned letters a, b, c and d for easy identification. Each block had 24 plots therefore, the garden had a total of 96 plots. Each plot had dimensions of 4 x 2 m, a modified spacing from that stated by (Balkaya et al., 2010). At the start, three seeds were planted per hole on a given plot. However, only one vine from one seed was maintained in each hole per plot. Therefore, two vines were planted in each plot per accession, with a spade full of well decomposed goats dung added to each of the holes where the seeds were planted. The accessions were randomly distributed in all the four blocks. The accessions acted as the different treatments, while the four blocks acted as the replicates in the experiment. The experiment ran from 30th March, 2017 to 22nd December, 2017 and two seasons were involved. However, the yields for the first season were so poor due to the low amounts of rainfall received in the region during the first season of the year hence yields from the second season were considered for analysis since they were reasonably high. Soil pH and soil texture were determined by use of a pH meter and a soil textural triangle respectively following the procedures described by Okalebo et al. (2002).

Pumpkin cultivar sampling and pulp sample preparation

At maturity, averagely after four months it was observed that out of the 24 accessions planted, 10 accessions were not consistent in morphological appearance throughout in all the four blocks while 14 accessions were consistent. Therefore, for the pumpkin accessions considered for analysis in the laboratory, a given accession in block one, had to bear fruits with similar morphological appearance with those of the same accession in the rest of the blocks. The identification of fruit morphological appearance at maturity was guided by pumpkin descriptors as described by Srivastava et al. (2001), with modifications. So, from the experiment, 14 accessions were observed to be consistent in at least two blocks where they had successfully grown to maturity. Eventually, three fruits of only one block for each consistent accession were randomly selected and further prepared for nutrient analysis. For each accession, the three fruits from the same vine were cut and the seeds removed to retain the pulp. A representative sample from each of the three pumpkin heads of a given accession was picked following the protocol described by Maria et al. (2015). The pulp was sliced into small pieces that were freeze dried for further analysis. The dried sample was ground into powder to form a homogenized sample using universal high-speed grinder model ID008760 and then

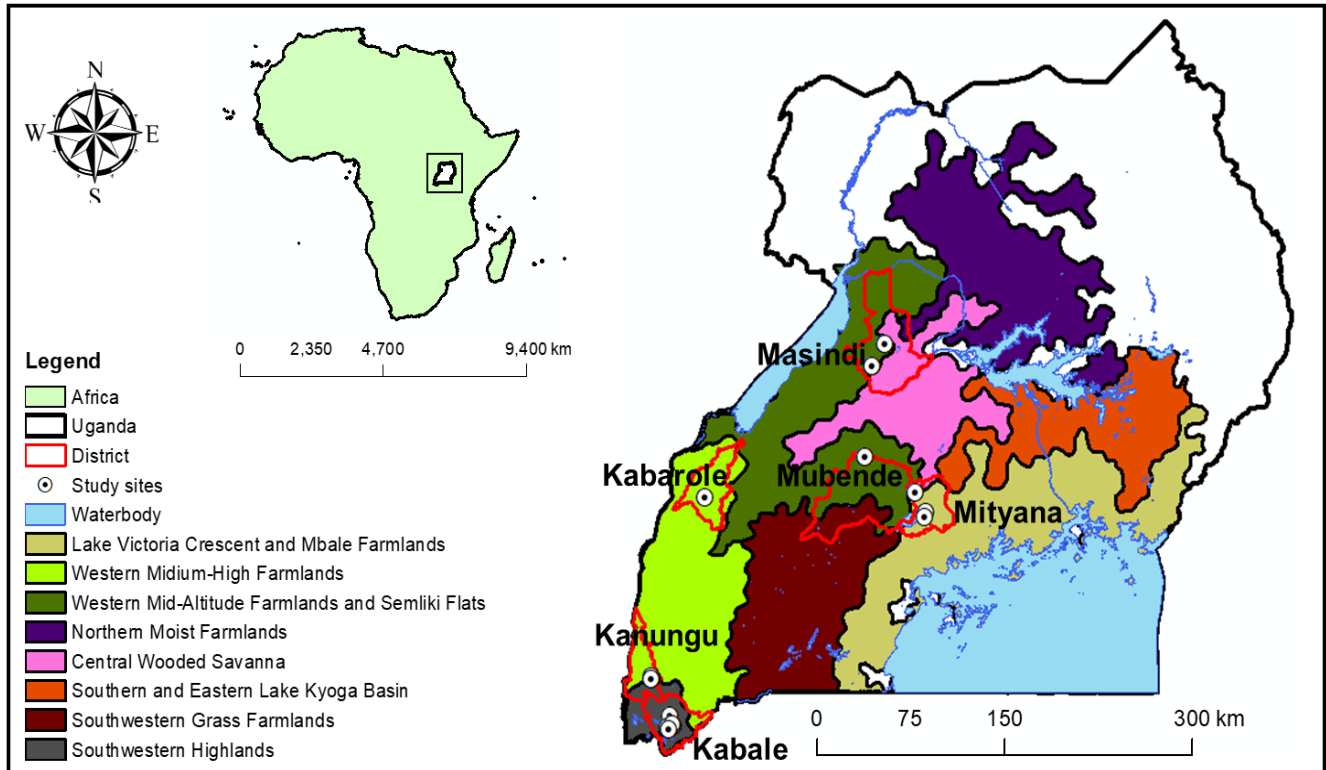


Figure 1. Map showing sites from which data was collected.

Source: Drawn using Arc GIS software version 10.5 (Agro-ecological Zones described by (Wortmann and Eledu, 1999).

stored in well labelled and sterilized sample bottles. Some parameters such as moisture, ash, starch and reducing sugars were determined using fresh samples.

Pumpkin pulp physico-chemical determination

Moisture and ash content

The moisture content was determined by using a moisture analyzer (Mettler Toledo model MJ33) as described by Nielsen (2010). 2 g per sample of fresh pumpkin pulp were used. The moisture content per sample was determined in triplicate.

Ash content

Ash content was determined by using the dry ashing method as described by Nielsen (2010). 2 g per sample of each sample were used for the analysis. The ash content per sample was determined in triplicate.

Crude fat content

Crude fat content was determined by using the AOAC Method 960.39, described by Nielsen (2010). 5 g of each sample were used for the analysis. The crude fat content per sample was determined in triplicate.

Crude fibre content

The crude fibre content was determined by using the A.O.A.C. method 930.10, which was modified as follows; 5 g per sample of ground material were extracted with petroleum ether to remove fat (Initial boiling temperature 35 - 38°C and final temperature 52°C). 5 g of dried material were boiled with 200 ml of sulphuric acid for 30 min with bumping chips. The mixture was filtered through muslin and washed with boiling water until the residue was no longer acidic. The mixture was boiled with 200 ml of sodium hydroxide solution for 30 min, followed by filtering through muslin cloth again and washing with 25 ml of boiling 1.25 % sulphuric acid, three 50 ml portions of water and 25 ml alcohol. The residue was removed and transferred to an ashing dish (pre-weighed dish W_1). The residue was dried for 2 h at 130°C, to a constant weight, and the dish cooled in a desiccator, then weighed to obtain (W_2). The mixture was ignited for 30 min at 600°C, followed by cooling in a desiccator and reweighed to obtain (W_3). The fibre content per sample was determined in triplicate according to the formula below:

$$\% \text{ crude fibre in ground sample} = \frac{\text{Loss in weight on ignition } (W_2 - W_1) - (W_3 - W_1)}{\text{Weight of sample}} \times 100$$

Crude protein content

Crude protein content was estimated by using Kjeldahl's method described by Okalebo et al. (2002). 2 g per sample was used and the analysis was done in triplicate.

Starch content

The starch content was determined with slight modification of the method reported by Mistry and Eckhoff (1992) as described. The fresh mature pumpkin was thoroughly washed with distilled water. It was peeled, and the pulp cut into small pieces. 150 g of small pieces of the pulp per sample were transferred to the blending motor (ID008760) and then blended. The blended suspension was filtered and washed with 0.1 N sodium hydroxide. The suspension was washed with excess distilled water and the filtrate left to stand for about 30 min. Then the excess alkali was removed by washing several times with distilled water; adding excess distilled water to the filtrate and leaving it to stand. The alkali and water were decanted off and left to stand for 10 min after which, the supernatant fluid a non-starch layer was decanted off. The tightly packed starch was then collected and dried in an oven at 60°C for 6 h. The starch was then ground to a fine powder and the weight of the dry starch was determined by use of the analytical balance (Mettler Toledo, MS304S/01). The analysis per sample was done in triplicate. The % of starch in the sample was calculated by using the formula below:

$$\% \text{ starch in sample} = \frac{\text{Weight of starch in sample}}{\text{Weight of sample}} \times 100$$

Glucose content

The amount of glucose in the pulp was determined using the Somogyi-Nelson assay as described by Nielsen (2010). The pumpkin samples were washed thoroughly with distilled water, then peeled and sliced into small pieces. 100 g of small pieces of the pulp per sample were transferred to the blending motor (ID008760) and then blended. The carbohydrate standards (glucosamine) were prepared with the concentrations 0, 2.5, 5, 7.5, 10, and 15 ml l⁻¹. 1 ml of each standard was added to separate tubes, and to the tube used as blanks 1 ml of distilled water was added. The samples whose concentration was unknown were prepared in appropriate dilution in separate tubes. Then to each tube, 1 ml of the copper reagent was added and mixed very well. The tubes were heated in a boiling water bath for 10 min. The tubes were then removed and allowed to cool to room temperature. 1 ml of arsenomolybdate reagent-Nelson reagent was added to each tube. The content in the tubes was mixed, diluted and remixed. Then the absorbance was measured at 520 nm (UV-spectrophotometer). The standard calibration curve was plotted for absorbance against the concentration of glucose in standard series. The concentration of the glucose in the sample solutions was read from the graph. Then the actual concentration of glucose in the sample was determined by subtracting the concentration of the blank from the determined concentration of glucose in the sample. The analysis per sample was done in triplicate.

Mineral content determination

The mineral cations in the samples were determined by first carrying out complete oxidation of the samples using Kjeldahl procedures then followed by spectrophotometric analysis. Flame photometer used for K and Ca analysis while atomic absorption spectrometer used to analyze iron (Fe) and zinc (Zn). All the procedures followed were extracted from (Okalebo et al., 2002). The analysis per sample was done in triplicate.

Carotenoid content determination

The leutin, α -carotene, trans- β -carotene, cis- β -carotene, total

carotenoids and total pro-vitamin A content analysis and quantification was done with High Performance Liquid Chromatography (HPLC), following the procedure described in a previous study by Buah et al. (2016). However, instead of using 200 mg of sample, 30 \pm 0.1 mg per sample were used since the amount of carotenoids were predicted to be in very high concentrations compared to those in banana tissue basing on the intense colour of the pulps of the samples. The analysis per sample was done in duplicate and on dry basis.

Data analysis

The data was presented as mean \pm standard deviation in tables. The proximate, mineral and carotenoid measurements were subjected to one-way analysis of variance (ANOVA) to establish the means with significant differences using IBM SPSS 20.0 software (SPSS, 2011) at 5% level of significance. A p-value < 0.05 was considered significant.

RESULTS AND DISCUSSION

Pumpkin cultivars selected

There is a wide range of pumpkin cultivars grown in Uganda. From the grown accessions obtained from farmers, the consistent cultivars that were used for analysis and their morphological descriptors are as summarized in Table 1. These were Kan 3, Kab 10, Kan 2, Kan 4, Kab 5, Kan 6, Mit 9, Mit 11, Mas 14, Mas 16, Fort 18, Fort 19, Kan 22 and Kab 23. The common names used by farmers to refer to the various accessions are also indicated in Table 1, although one needs to know that the local names vary from one ethnic group to another or from one agro-ecological zone to another.








Pumpkin pulp proximate composition

The chemical analysis of the pulp of the selected accessions for proximate composition, revealed a significant difference (p < 0.05) in the glucose, starch, moisture, ash, crude fat, crude fibre and crude protein content (Table 2). Accession Kan2 (Anderina) had the highest glucose concentration of 18.96 mg/ml while Mas14 had the lowest concentration of 4.24 mg/ml. However, the value of glucose content in this study was higher than that reported from the study by Muzzaffar et al. (2016). This difference could be due to the variation in pumpkin cultivars considered in the two studies and also difference in maturity stage at which the analysis was done since the glucose levels increase as the fruit ripens (Sharma and Rao, 2013). Determination of the glucose content of the pumpkin pulp gives an insight to a processor the accessions with relatively high sugar levels. The pumpkins with high sugar levels could be used for making sweet wine since glucose is broken down during fermentation to produce alcohol. However,

Table 1. Samples of pumpkin cultivars considered for nutritional physico-chemical analysis.

Accession (local name)	Picture of mature pumpkin	Morphological descriptor used
Kan22 (Anderina)		<ol style="list-style-type: none"> 1. A flared base of peduncle. 2. Cylindrical shape and a soft epicarp. 3. Fruit skin is mottled with dark green and creamish patches as primary and secondary mature skin colours respectively.
Kan3 (Kihaza/Wuju)		<ol style="list-style-type: none"> 1. Non-flared base of peduncle. 2. Globular shape and soft epicarp. 3. Fruit skin is stripped with a grey primary skin colour but without a secondary skin colour.
Kan4 (Enkogotte/Dulu)		<ol style="list-style-type: none"> 1. A flared base of peduncle. 2. Globular shape and hard epicarp. 3. Fruit skin is mottled with a dark green and whitish patches as primary and secondary skin colours respectively.
Kan2 (Anderina)		<ol style="list-style-type: none"> 1. A flared base of peduncle. 2. Cylindrical shape and intermediate epicarp. 3. Fruit skin is mottled with dark green and creamish patches as primary and secondary skin colours respectively.
Kan6 (Enkogotte/Dulu)		<ol style="list-style-type: none"> 1. A flared base of peduncle. 2. Pyriform shape and hard epicarp. 3. Fruit skin is mottled with dark green and creamish patches as primary and secondary skin colours respectively.
Kab10 (Ekihaza/Wuju)		<ol style="list-style-type: none"> 1. Non-flared base of peduncle. 2. Globular shape and soft epicarp. 3. Fruit skin is stripped with a grey primary skin colour but without a secondary skin colour.
Kab5 (Rwamabondo/Sweetie pumpkin)		<ol style="list-style-type: none"> 1. A flared base of peduncle. 2. Flattened shape and soft epicarp. 3. Fruit skin is uniform with a dark green and yellowish-green as primary and secondary skin colours respectively.

Table 1. Contd.

Kab23 (Mulembe/Dulu)		<ol style="list-style-type: none"> 1. A flared base of peduncle. 2. Cylindrical shape and hard epicarp. 3. Fruit skin is mottled with a dark green and creamish patches as primary and secondary skin colours respectively.
Mas16 (Oziga)		<ol style="list-style-type: none"> 1. A flared base of peduncle. 2. Globular shape and soft epicarp. 3. Fruit skin is mottled with a dark green and creamish patches as primary and secondary skin colours respectively.
Mas14		<ol style="list-style-type: none"> 1. A flared base of peduncle. 2. Globular shape and hard epicarp. 3. Fruit skin is uniform with an orange and yellowish-green as primary and secondary skin colours respectively.
Mit11 (Oziga)		<ol style="list-style-type: none"> 1. A flared base of peduncle. 2. Globular shape and soft epicarp. 3. Fruit skin is mottled with a dark green and creamish patches as primary and secondary skin colours respectively.
Mit 9 (Rwamabondo/Sweetie pumpkin)		<ol style="list-style-type: none"> 1. A flared base of peduncle. 2. Flattened shape and soft epicarp. 3. Fruit skin uniform with a dark green and yellowish-green as primary and secondary skin colours respectively.
Fort18 (Anderina)		<ol style="list-style-type: none"> 1. A flared base of peduncle. 2. Pyriform shape and soft epicarp. 3. Skin mottled with a dark green and creamish patches as primary and secondary skin colours respectively
Fort19 (Bala)		<ol style="list-style-type: none"> 1. A flared base of peduncle. 2. Globular shape and intermediate epicarp. 3. Skin color uniform with a dark green primary skin colour without a secondary skin colour.

this suggestion can be affirmed by conducting further research about the amount of phenolics, organics, mineral salts and pectins which are the major constituent of the wine extract and vary from wine to wine.

The starch content was highest in accession Fort19

(0.88%) while Kan4 (0.01%) had the lowest starch content. The relatively low starch content observed across all the varieties could be due to the reduction of starch content in a fruit as it ripens both on and off the vine. The loss of pumpkin starch seems to be highly

Table 2. The proximate composition of fourteen pumpkin accessions; Values are given as means of three replicates \pm Standard deviation.

Accession	Glucose (mg/ml)	Starch (%)	Moisture (%)	Ash (%)	Crude fat (%)	Crude fibre (%)	Crude protein (%)
Kan22	9.42 \pm 0.40	0.59 \pm 0.01	82.34 \pm 1.46	15.21\pm1.38	0.53 \pm 0.01	60.09 \pm 0.31	9.22 \pm 0.17
Kan3	6.38 \pm 0.13	0.53 \pm 0.00	88.49 \pm 0.28	0.75 \pm 0.03	0.55 \pm 0.12	22.12 \pm 0.10	7.41 \pm 0.12
Kan4	14.85 \pm 0.10	0.01 \pm 0.00	89.61 \pm 0.57	1.08 \pm 0.01	1.58\pm0.09	40.15 \pm 0.03	10.28 \pm 0.21
Kan2	18.96\pm0.02	0.40 \pm 0.00	81.26 \pm 0.07	2.07 \pm 0.07	1.55 \pm 0.10	31.26 \pm 0.01	8.88 \pm .24
Kan6	7.77 \pm 0.05	0.05 \pm 0.00	92.35 \pm 3.57	4.07 \pm 0.01	0.61 \pm 0.04	20.16 \pm 0.01	6.57 \pm 0.20
Kab10	4.33 \pm 0.03	0.06 \pm 0.00	82.54 \pm 1.71	1.62 \pm 0.01	1.24 \pm 0.00	37.77 \pm 0.12	7.61 \pm 0.24
Kab5	7.69 \pm 0.11	0.26 \pm 0.00	77.22 \pm 1.22	2.55 \pm 0.11	0.46 \pm 0.01	39.63 \pm 0.48	15.54 \pm 0.96
Kab23	10.55 \pm 0.15	0.48 \pm 0.00	80.60 \pm 0.36	4.43 \pm 0.17	0.63 \pm 0.01	70.55 \pm 0.06	16.55\pm0.37
Mas16	12.11 \pm 0.05	0.85 \pm 0.04	87.85 \pm 2.39	3.43 \pm 0.32	0.66 \pm 0.02	38.41 \pm 1.23	12.94 \pm 0.32
Mas14	4.24 \pm 0.14	0.41 \pm 0.00	90.22 \pm 0.03	1.27 \pm 0.00	0.83 \pm 0.11	22.26 \pm 0.01	11.12 \pm 0.35
Mit11	15.86 \pm 0.08	0.50 \pm 0.00	79.51 \pm 0.94	3.25 \pm 0.03	0.54 \pm 0.01	36.80 \pm 0.07	9.79 \pm 0.21
Mit9	8.67 \pm 0.10	0.05 \pm 0.00	83.59 \pm 8.39	6.11 \pm 0.15	0.78 \pm 0.10	50.95 \pm 0.11	9.91 \pm 0.22
Fort18	9.63 \pm 0.03	0.06 \pm 0.00	90.66\pm0.67	2.33 \pm 0.15	1.00 \pm 0.06	73.98\pm0.54	10.40 \pm 0.35
Fort19	5.88 \pm 0.04	0.88\pm0.00	82.22 \pm 0.67	2.46 \pm 0.22	1.20 \pm 0.04	52.73 \pm 0.23	12.37 \pm 0.17
P-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Highest values are bolded.

related to fruit climacteric and physiological changes such as increasing ethylene production and respiration rate (Thammawong and Arakawa, 2007).

The moisture content ranged from 77.22% for Kab 5 to 92.35% for Kan 6. The moisture content observed among the accessions in this study was similar to those reported in other studies by Karanja et al. (2014). Drying the pumpkins is one of the stages carried out during value addition process and also a way of reducing losses during surplus production seasons to ensure continuous availability of pumpkin products during the off peak season (Ravani and Joshi, 2014). However, the moisture content of a fruit influences the time taken for it to dry. Therefore, it would be better to use the cultivars such as Kab5 that have a relatively low moisture content for flour production as one of the pumpkin value addition avenues but also rich in other nutritional components as revealed by this study.

On the other hand, the ash content was highest in accession Kan 22 (15.21%) and lowest in Kan 3 (0.75 %). The ash content observed among some of the accessions analyzed in this study was far higher than that reported by some similar studies on pumpkin. The difference could be attributed to the dissimilarity in genetic constitution of the cultivars and soil characteristics in which the pumpkins considered for the studies were cultivated since environment has a significant influence on the inorganic composition of a crop. Furthermore, the difference could also be due to the maturity stage at which the fruits were picked for analysis (Shewfelt, 1990). This study reveals that accessions such as Kan22 could be a rich source of some important minerals for human health since ash content of a food

stuff represents the total mineral content in that food.

The crude fat content ranged from 0.46% in Kab5 to 1.58% in Kan4. Generally, the fat content in the pulp across all the accessions was very low. This is because fat is not the primary energy reserve in the pumpkin pulp but rather in the pumpkin seeds (Loy, 2004). It may be important to study the oil content in pumpkin pulp flour since fats/oil are important for gluten development during dough kneading for baking. This would also enable one to establish the status of the oil groups present in pumpkin pulp flour if it is to be used in wheat fortification since according to Figoni (2008), oils in wheat flour easily oxidize and turn rancid which in turn limits the shelf life of the flour.

The crude fibre content ranged from 22.12% in Kan3 to 73.98% in Fort 18. This study revealed that pumpkin cultivars grown in Uganda are a very good source of dietary fibre. Dietary fibre is good for human health since it is believed that they ease digestion and rate of food passage through the alimentary canal. Fiber-rich diet hence reduce the risk of certain alimentary canal cancers, coronary heart diseases (Černiauskiene et al., 2014). Therefore, pumpkin flour could be used to enrich other foods as fibre enhancement.

Crude protein content was recorded highest in accession Kab23 (16.55%) and lowest in Kan3 (7.41%). The protein values from this study were far higher than those reported by Karanja et al., (2014). The difference in results could mainly be attributed to the variation in the cultivars used in the two studies. In comparison, the protein compositions of pumpkin pulp are similar to those of staple food grains, such as maize (9.4%), rice (7.1%), wheat (12.6%), and sorghum (11.6%). In contrast,

Table 3. Mineral composition of the pulp of fourteen pumpkin cultivars; Values are given as means of three replicates \pm Standard deviation.

Accession	Calcium (g/100 g)	Potassium (g/100 g)	Iron (mg/100 g)	Zinc (mg/100 g)
Kan22	0.82 \pm 0.10	4.02 \pm 0.65	10.37 \pm 2.27	1.67 \pm 0.18
Kan3	0.86 \pm 0.07	4.51 \pm 0.29	11.45 \pm 1.64	5.17\pm5.02
Kan4	0.68 \pm 0.15	3.40 \pm 0.60	10.09 \pm 5.97	2.52 \pm 0.20
Kan2	0.62 \pm 0.06	3.14 \pm 0.37	8.61 \pm 3.62	2.12 \pm 0.51
Kan6	0.90 \pm 0.20	3.87 \pm 0.27	8.13 \pm 3.18	1.95 \pm 0.31
Kab10	0.71 \pm 0.18	2.57 \pm 0.43	9.94 \pm 3.33	2.56 \pm 0.96
Kab5	0.95 \pm 0.37	4.36 \pm 1.08	11.00 \pm 2.93	3.26 \pm 1.40
Kab23	1.33\pm0.52	4.81\pm0.26	18.34\pm7.83	3.11 \pm 1.25
Mas16	0.65 \pm 0.24	3.63 \pm 1.28	7.52 \pm 5.25	2.46 \pm 1.34
Mas14	0.74 \pm 0.07	3.42 \pm 0.59	10.12 \pm 3.06	2.56 \pm 0.19
Mit11	0.65 \pm 0.08	2.86 \pm 0.04	8.82 \pm 1.94	1.72 \pm 0.52
Mit9	0.78 \pm 0.11	4.03 \pm 0.34	12.93 \pm 5.66	2.40 \pm 0.46
Fort18	0.81 \pm 0.11	4.21 \pm 0.65	9.84 \pm 2.09	2.22 \pm 0.32
Fort19	0.68 \pm 0.05	3.93 \pm 0.40	9.10 \pm 1.46	2.65 \pm 0.69
P-value	0.042	0.004	0.263	0.515

Highest values are bolded.

pumpkin pulps' protein content is much higher than other staple root tubers such as irish potato (2 %), cassava (1.4%), white flesh sweet potato (1.6%), and yam (1.5%) (Neela and Fanta, 2019). In addition, according to Hui (2006), the nitrogenated compounds in fruits are generally low as the crude protein ranges from 0.1 to 1.5%, implying fruits are not an adequate source of proteins. However, fruits such as pumpkins, cherimoya and avocado are good sources of protein hence pumpkins may be a good alternative for value addition or bio-fortification to avail more protein. Generally, the significant difference between proximate compositions of different cultivars could be attributed to the genetic diversity within the accessions and the populations of the genus *Cucurbita* as also observed in the studies by Ferriol et al. (2004) and Martins et al. (2015).

Mineral composition of pumpkin pulp

The mineral composition analysis for this study revealed that there was a significant difference in the distribution of the selected macro-elements in the pulp across all the pumpkin accessions ($P < 0.05$) while the distribution of the selected micro-elements in the pulp did not differ significantly across the accessions ($P > 0.05$) as shown in Table 3. The calcium content ranged from 0.62 g/100 g in Kan2 to 1.33 g/100 g in Kab23. The calcium content of some of the common foods used to prepare baked products and baby weaning recipes are 15 – 25, 6, 4.2, 140, 13 and 6.4 mg/100 g for wheat flour, rice flour, edible mushroom, chicken egg York, butter and potatoes

respectively. The calcium content of the pumpkin pulp as per this study was higher than that of the mentioned foodstuffs, therefore, pumpkin pulp can also be used for preparing weaning food, porridge for children and wheat enrichment.

The potassium content was highest in Kab23 (4.81 g/100 g), but lowest in Kab10 (2.57 g/100 g). Potassium is involved in cell membrane transport, muscle building, protein and carbohydrate metabolism. Potassium deficiency is associated with a number of symptoms such as slow reflexes, fatigue, dry skin and muscle weakness (Vahčić et al., 2010). The minimum daily requirement for potassium by the human body is about 782 mg. The results from this study show that the pumpkin pulp could be a good source of potassium. This means that if pumpkin is used to enrich flour, it would increase the potassium content of the flour since the potassium content of wheat flour was only 96.35 mg/100 g according to Finnie and Atwell (2016). Furthermore, foods used to make baby weaning recipes, such as potatoes, rice flour, edible mushrooms, chicken egg yolk, butter contain 418, 103, 341, 138 and 16 mg/100 g respectively of potassium (Belitz et al., 2009). Pumpkin pulp can be a good source of potassium for baby weaning food since it contains a relatively higher amount compared to the foods mentioned above.

The iron content ranged from 7.52 mg/100 g in Mas16 to 18.34 mg/100 g in Kab23. Iron is vital for hemoglobin synthesis and whose deficiency can result into anemia and cognitive impairment. The Recommended Dietary Allowance (RDA) for iron for pre-menopausal women is 18 mg per day while post-menopausal women and men

Table 4. Lutein, α -carotene, *trans*- β -carotene, *cis*- β -carotene, total carotenoid and total pro-vitamin A carotenoid content of pulp of the 14 pumpkin accessions; Values are given as means of three replicates \pm Standard deviation.

Accession	Lutein ($\mu\text{g/g dW}$)	α -carotene ($\mu\text{g/g dW}$)	<i>Trans</i> - β -carotene ($\mu\text{g/g dW}$)	<i>Cis</i> - β -carotene ($\mu\text{g/g dW}$)	Total carotenoids ($\mu\text{g/g dW}$)	Total PVA carotenoids ($\mu\text{g/g dW}$)
Kan 22	230.52 \pm 9.02	88.15 \pm 2.50	666.38 \pm 16.31	0.00 \pm 0.00	985.04 \pm 27.82	754.53 \pm 18.80
Kan 3	1.89 \pm 0.28	54.7 \pm 7.27	27.00 \pm 2.07	10.50 \pm 0.74	94.07 \pm 10.35	92.19 \pm 10.08
Kan 4	32.92 \pm 7.01	18.88 \pm 3.71	175.74 \pm 33.41	0.00 \pm 0.00	227.53 \pm 44.13	194.61 \pm 37.12
Kan 2	156.01 \pm 4.96	76.39 \pm 3.05	424.87 \pm 20.39	0.00 \pm 0.00	657.27 \pm 28.40	501.26 \pm 23.43
Kan 6	44.98 \pm 4.63	72.85 \pm 8.50	323.33 \pm 31.20	0.00 \pm 0.00	441.16 \pm 43.34	396.18 \pm 39.70
Kab10	0.97 \pm 0.31	46.5 \pm 16.83	61.14 \pm 21.31	19.31\pm6.85	127.92 \pm 45.30	126.95 \pm 45.00
Kab 5	1157.56\pm76.48	665.03 \pm 26.13	1215.49\pm70.20	0.00 \pm 0.00	3038.08\pm172.80	1880.52 \pm 96.32
Kab 23	43.43 \pm 7.10	48.83 \pm 8.18	129.14 \pm 21.04	0.00 \pm 0.00	221.42 \pm 36.32	177.98 \pm 29.22
Mas16	308.15 \pm 16.21	326.5 \pm 22.96	802.46 \pm 53.44	0.00 \pm 0.00	1437.12 \pm 92.61	1128.96 \pm 76.39
Mas14	7.75 \pm 0.41	17.97 \pm 0.27	98.28 \pm 2.58	0.00 \pm 0.00	124.00 \pm 3.26	116.25 \pm 2.84
Mit 11	361.48 \pm 10.80	90.79 \pm 2.79	544.65 \pm 17.97	0.00 \pm 0.00	996.93 \pm 31.56	635.44 \pm 20.75
Mit 9	901.53 \pm 23.02	889.39\pm8.70	1212.09 \pm 0.30	0.00 \pm 0.00	3003.01 \pm 14.02	2101.48\pm9.00
Fort 18	213.24 \pm 18.10	68.14 \pm 6.03	472.76 \pm 44.11	0.00 \pm 0.00	754.14 \pm 68.25	540.90 \pm 50.14
Fort 19	483.71 \pm 32.11	96.02 \pm 12.39	569.05 \pm 40.06	0.00 \pm 0.00	1148.78 \pm 84.56	665.07 \pm 52.45
P value	0.000	0.000	0.000	0.000	0.000	0.000

Analysis carried out on dry weight basis. Highest values are bolded.

is 8 mg/day respectively. However, the RDA for iron for expectant mothers is 27 mg/day (Russell et al., 2001). The pumpkin pulp could be a good source of iron to enrich diets that have low iron content. However, the pregnant mothers need to consume more iron rich foodstuffs such as meat, poultry, fish and non-animal sources such as green leafy vegetables, cereals and oilseeds (Gautam et al., 2008) in order to meet their daily iron requirements.

On the other hand, the zinc content was highest in Kan 3 (5.17 mg/100 g) and lowest in Kan22 (1.67 mg/100 g). Zinc is an essential component of a large number of enzymes, and plays a central role in cellular growth and differentiation in tissues that have a rapid differentiation and turnover including those of the immune system and those in the gastrointestinal tract (Allen et al., 2006). The RDAs for zinc are 8 and 11 mg/day for women and men, respectively (Russell et al., 2001). The zinc content was relatively low in pulp. Therefore, other sources such as egg yolk, read meat, milk, legumes, grains and cereals (Harris, 2014) can be consumed to enhance zinc intake to meet the recommended values for proper body functioning. The calcium, potassium, iron and zinc content recorded in this study was higher than that reported by Adubofuor et al. (2016). These differences could be as a result of the variation in the soils in which the pumpkins were grown and other environmental factors such as precipitation. Furthermore, from the studies conducted by Karanja et al., (2014); Adubofuor et al. (2016), the pumpkins were collected from different

gardens but yet the pumpkins assessed in this study, were grown in the same garden which could be another source of the differences observed. However, the limitation of this study was that the mineral content of the soil was not assessed after amending the soil with goats' dung. Nonetheless the soil pH was 6.41 and the soil texture was sandy loam. The soil pH 6.4 was just in the recommended range for good pumpkin yields as reported by Kemble et al. (2000).

Carotenoid composition

There was a significant variation in the lutein content, α -carotene content, *trans*- β -carotene content, *cis*- β -carotene content, total carotenoid content and total pro-vitamin A carotenoid content of pulp across the different pumpkin accessions analyzed ($p < 0.05$) as shown in Table 4. The lutein content ranged from 0.97 $\mu\text{g/g dW}$ in Kab10 to 1157.76 $\mu\text{g/g dW}$ in Kab5. The α -carotene content was highest in Mit9 (889.39 $\mu\text{g/g dW}$) and lowest in Mas14 (17.97 $\mu\text{g/g dW}$). The *trans*- β -carotene content was highest in Kab5 (1215.49 $\mu\text{g/g dW}$) and lowest in Kan3 (27.00 $\mu\text{g/g dW}$). *Cis*- β -carotene content was detected in only two accession Kab10 (19.31 $\mu\text{g/g dW}$) and Kan3 (10.50 $\mu\text{g/g dW}$). The total carotenoids were highest in Kab5 (3038.08 $\mu\text{g/g dW}$) and lowest in Kan3 (94.07 $\mu\text{g/g dW}$). The total pro-vitamin A carotenoid content was highest in Kab5 (1880.52 $\mu\text{g/gdW}$) and lowest in Kan3 (92.19 $\mu\text{g/g dW}$). The α -carotene, *trans*- β -

carotene, and the total carotenoid content observed in this study, for some accessions such as Kab5, Mit9, Mas16, Mit11, Fort19, Kan22 was higher than that for the cultivars studied by Maria et al. (2012), but the *cis*- β -carotene content was very low just like what was observed in this study. The difference in the composition could mainly be due to the genetic diversity among the *Cucurbita* species and the environmental conditions under which the pumpkins were grown. The α -carotene, *trans*- β -carotene, and the total carotenoid content observed in the pumpkin is by far higher than that reported in fruits like banana (Mbabazi et al., 2020). Therefore, considering that *trans*- β -carotene has 100% pro-vitamin A activity (Carvalho et al., 2014), accessions like Kab5, Kan22, Mit9, Mas16, Mit11 and Fort19 are promising sources of vitamin A. Pro-vitamin A carotenoid availability is of particular importance in developing countries where vitamin A deficiency (VAD) is a significant public health concern. The main underlying cause of VAD in low-income countries is a poor diet that is consistently insufficient in vitamin A, eventually leading to depleted stores that fail to achieve physiological needs in the human body. Persistent and severe deficiency can lead to xerophthalmia, a form of preventable, but irreversible, blindness in young children, and facilitates infectious diseases such as measles, diarrhea, and intestinal parasites, which increase infant mortality risks (Chen, 2015; NIH, 2016). Kab 5 and Mit 9 accessions can be given first priority to be used for bio-fortification of foodstuffs commonly consumed by people especially children but yet have low quantities of carotenoids such as lutein, β -carotene and α -carotene. These accessions can also be used in the preparation of baby foods and immune-depressed patients such as those with Acquired Immune Deficiency Syndrome (AIDS). The limitation of this study was that the colour of the pulp of the analyzed accessions was not scientifically assessed yet it can help one to have a rough estimate of the type and concentration of the total carotenoids present in a given cultivar. In addition, genetic finger printing was not performed to conclude if some of the accessions included in this study were not genotypically the same though their seeds had been picked from different agro-ecological zones.

Conclusion

The different pumpkin accessions analyzed can be used for various value addition avenues for example, Kan2, Kan4 and Mas16 can be used for production of pumpkin pulp juice and also pumpkin pulp wine because they contain a high moisture and glucose content. Accessions Kan22, Kab23 and Fort18 can be processed to produce dietary fibre supplements since this study revealed that they contain a very high crude fibre content. On the other hand, accessions Kab5, Mit11 and Mit9 can be used for

production of pumpkin pulp flour for wheat fortification and preparation of baby foods such as porridge since they have relatively lower moisture content yet rich in mineral content, lutein, *trans*- β -carotene and α -carotene. However, the pumpkin pulp generally has a very high moisture content thus, the processors should dry the pumpkin pulp with appropriate methods to prevent microbial and aflatoxin attack to the produce but yet not destroying the other nutraceutical components of the pumpkin fruit during processing. In general pumpkin pulp is recommended for consumption by people of all ages to meet their daily nutritional and nutraceutical needs.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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