Extraction, quantification and characterization of oil from pumpkin seeds

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Abstract: A quantification and characterization study of oil from pumpkin seeds was carried out on three pumpkin varieties, namely, Japanese type of the *Curcubita maxima* species, Green Kabocha and butternut squash of the *Cucurbita moschanta* species. Oil extraction was done using the Soxhlet method with petroleum ether as the solvent. The physicochemical properties of acid value, iodine value, specific gravity and refractive index were determined. The results were analyzed statistically using one way ANOVA at a 5% level of significance. The mean values of oil content, acid value, iodine value, specific gravity and refractive index for Japanese type pumpkin were found to be 35.67%, 2.24 mg KOH/g, 26.45 mg I_2/100 g, 0.9126 and 1.47, respectively. For Green Kabocha, the mean values of the above five properties were 30.12%, 3.35 mg KOH/g, 25.3 mg I_2/100 g, 0.9126 and 1.469, respectively. For the Butternut squash type the mean values of the above five properties were 34.76%, 3.74 mg KOH/g, 26.61 mg I_2, 0.9131 and 1.471, respectively. It can be noted that from the low acid values of the pumpkin oil, pumpkin oil can be identified as edible. Also the low iodine value indicated that the pumpkin oil was non-drying. In addition, the low iodine value also suggested that the oil contains few unsaturated bonds and therefore has low susceptibility to oxidative rancidity. With a comparison of extraction rates from other oil sources in Uganda such as cotton (15%-20%), soybeans (19%-21%), the obtained results in this study suggested that pumpkin seeds are a viable source of vegetable oils that can be utilized for commercial vegetable oil extraction in Uganda.

Keywords: pumpkin seeds, pumpkin varieties, oil extraction, physicochemical properties, vegetable oil, characterization

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1 Introduction

Pumpkin is from genus *Cucurbita* of the family *Cucurbitaceae*. The common pumpkin types worldwide are *Curcubita maxima*, *Curcubita pepo* and *Curcubita moschata*[1]. Pumpkin shapes range from round to oblong among varieties, and size from less than 0.45 kg to more than 4.50 kg, though most weigh 4-8 kg[2]. Pumpkins have a long shelf life of over 6 months without addition of any chemical if stored in a cool dry place of temperatures between 13–15℃[3]. In other words, pumpkins are a good food security crop. A lot of

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attention has been focused on the pumpkin flesh but not the seeds that offer a valuable source of unsaturated oils that are often missing in diets of many rural communities in Africa. According to reference [4], pumpkins of the *Curcubitaceae* family have seeds that are rich in oils that can be extracted using any of the methods of seed oil extraction. It has been noted that the solvent extraction method is the most efficient one as it achieves 98% of the oil from the oil seeds[5]. Pumpkin seed oil has been produced in Slovenia, Austria, and Hungary and much is used as cooking oil in many parts in Africa and the Middle East[6].

Oil from pumpkin seeds has been proven to provide a vast number of health benefits[7]. It is typical highly unsaturated oil with levels ranging from 60% to 90% with oleic and linoleic acids. Low linoleic acid levels and highly unsaturated fatty acids provide the oil with a high oxidative stability for storage and industrial purposes and low free radical production in human diets and this qualifies it to be a key in improving the nutritional benefits of food[8]. Pumpkin seed oil prevents the growth and size reduction of the prostate, slows down the progression of hypertension and reduces the levels of cholesterol in blood[9]. Pumpkin seed lipid components have been linked with the contribution to the reduction of bladder and urethral pressure and improved bladder compliance[10]. Pumpkin seed oil promotes hyperglycemic activity and this helps alleviate diabetes. It is a source of vitamin E which helps prevent barrenness in females. Diets high in pumpkin seeds have also been associated with lower levels of gastric, breast, lung and cholesterol cancer[11]. Pumpkin seeds are utilized in different ways all over the world and more prevalent in the Arabian countries where they are salted and roasted[6]. The seeds have been used as an additive for several food dishes[12]. In this study, the main objective was to quantify and characterize pumpkin seed oil as an alternative vegetable oil for consumption. Additionally to date there is no information available about the oil characteristics of pumpkin seed oil in Uganda. Information from this study provides a platform to embrace a new source of vegetable oil that is not yet utilized in Uganda.

2 Materials and methods

2.1 Sample collection and preparation

Pumpkin fruits were bought from a local market in Nakawa division, Kampala City (Uganda) located at geographical coordinates 00°18′56″N, 32°33′56″E. Three pumpkin varieties, namely, Japanese, Green Kabocha and Butternut weighing between 2.8–4.0 kg were randomly chosen from the market. During laboratory analysis, the pumpkin fruits were washed, cleaned and then cut to manually separate the seeds from the flesh. Seeds were weighed and the average seed weight composition to the whole pumpkin fruit weight was determined. Seeds were dried in an oven at a temperature of 105℃ for a period of 24 h and then crushed to fineness to pass through a 2 mm sieve using a blender. Oil was extracted using the automatic Soxhlet for a period of 1 h and 30 min with petroleum ether as the solvent after which the oil was dried in an oven at a temperature of 105℃ for 2 h.

Then the oil content was obtained from Equation (1):

$$Percentage\ oil\ content = \frac{W_3 - W_2}{W_1} \tag{1}$$

Where, W_3 is weight of extraction cup + oil, g; W_2 is weight of extraction cup, g; W_1 is weight of original sample, g.

2.2 Physicochemical characterization

The specific gravity, acid value and iodine value were determined according to reference [13]. The refractive index was determined using a digital refractometer (Misco Palm Abbe PA-202X Model).

Acid value was determined using ethanol, 0.1 mol/L sodium hydroxide, 0.5 mol/L potassium hydroxide and phenolphthalein indicator. The acid value was computed from Equation (2):

$$Acid\ value = \frac{V \times 5.61}{M} \tag{2}$$

Where, V *is* volume of standard volumetric potassium hydroxide used, mL; M is mass of test portion, g.

Iodine value was determined using cyclohexane, acetic acid, Wij's reagent, 10% potassium iodide solution, 0.1 mol/L sodium thiosulphate and starch as an indicator.

Iodine value was obtained from Equation (3):

$$Iodine\ value = \frac{(V_b - V_a)\times 1.269}{W} \tag{3}$$

Where, V_a is volume of titre for the sample, mL; V_b is volume of titre for the blank, mL; W is weight of the sample, g.

Specific gravity was determined from the measurements of the dry density bottle size 25 mL which was weighed accurately using a digital balance accurate to 0.001 g. The bottle was filled with distilled water and weighed again. It was then dried and filled with oil and weighed. This was carried out in triplicates for each sample. Specific gravity was obtained from Equation (4):

$$Specific\ gravity = \frac{W_{b+o} - W_b}{W_{b+w} - W_b} \tag{4}$$

Where, W_{b+o} is the mass of density bottle filled with oil, g; W_{b+w} is the mass of density bottle filled with water, g; W_b is the mass of empty density bottle, g.

2.3 Statistical analysis

All the experiments were conducted in triplicates and the means ± standard deviation of values are reported in this study. A one way analysis of variance was performed at a significant level of 0.05 and treatment means were separated using a Waller Duncan *K*-ratio to determine treatment effects. All statistical analyses were done with SAS statistical software (SAS Institute, Cary, NC, USA).

3 Results and discussion

3.1 Seed weight composition

A summary of the weights of pumpkin fruits and the corresponding seed weight extracted is shown in Table 1.

Table 1 Pumpkin fruit weight and seed weight

Pumpkin type[a]	Average of three pumpkin fruits weight/kg	Average seed weight/kg	Percentage weight of seed to fresh pumpkin
Japanese	3.80 a ± 0.13	0.104 ab± 0.003	2.74 b ± 0.109
Green Kabocha	3.03a ± 0.42	0.144 a ± 0.012	4.77 a ± 0.583
Butternut	3.07 a ± 0.74	0.094 b ± 0.038	3.06 b ± 0.898

Note: [a] Pumpkin varieties with different letters within columns are significantly different ($P \leqslant 0.05$) according to a Waller-Duncan K-ratio test.

Green Kabocha yielded higher average seed weight composition compared to the Japanese and the butternut types. It was observed that the quantity of seeds in the pumpkin fruit is dependent on the shape, size and variety of pumpkin as the seed distribution patterns differ accordingly. A summary of the parameters of pumpkin seed oil obtained after carrying out the physichemical and statistical analysis is shown in Table 2.

Table 2 Results for different parameters as determined in the experiment

Oil property	Pumpkin variety[a]		
	Japanese	G. Kabocha	Butternut
Oil content (%)	35.67 a ±1.65	30.12 b ±0.70	34.76 a ±0.48
Acid value (mg KOH/g)	2.24 b ±0.00	3.35 a ±0.01	3.74 a ±0.64
Iodine value (mg I_2/100 g)	8.82 a ±0.27	8.43 b ±0.10	8.87 a ±0.10
Specific gravity	0.917 a ± 0.006	0.912 a ±0.001	0.913 a ± 0.001
Refractive index	1.470 b ± 0.000	1.469 c ±0.000	1.471 a±0.000

Note: [a] Pumpkin varieties with different letters within rows are significantly different ($P \leqslant 0.05$) according to a Waller-Duncan K-ratio test.

3.2 Oil content

There was a significant difference in the oil content of the pumpkins as shown in Table 2, i.e., $P<0.05$ implying that the oil content of pumpkin seeds is dependent on the variety of pumpkin. In comparison to the oil content of other seeds/fruits, the pumpkin seed oil was higher than soybeans oil (19%–21%) as well as cotton seed (15%–20%) as reported by reference [14]. It also has higher oil content among some crops within the *Curcubitacae* family such as egusi (30%), sesowane (24.8%), wrewre (27.5%), tsama (24.8%) and the desert melon variety (28%)[15], and to some of the 12 pumpkin varieties cultivated in Iowa (10.9%–30.9%)[9]. It is worth mentioning that the oil content in the current study is higher than that reported by reference [16] in a study on *Curcubita maxima* (27.83%). This may imply that factors such as environment, weather, and agricultural practices to mention but a few have an impact on oil content. Nevertheless, the oil content in this study (35.67%–30.12%) were lower when compared with the oil content of rubber seed (68%), coconut (60%) and castor seed (67.7%) as reported by reference [14]. Also it is lower than the oil content from *Curcubita Pepo* (52.8%) and *Curcubita maxima* (55.8%) in the study by reference [15]. Oil contents of agricultural materials provide information on whether it is justifiable to process industrially from a given seed/fruit. According to reference [16], any seed containing greater than 17% of oil is considered to be an oil seed; as such a pumpkin seed conforms and can be utilized for industrial vegetable oil processing.

3.3 Acid value

There was a significant difference in the acid value of the pumpkin seed oil from the different pumpkin varieties as shown in Table 2, i.e., $P<0.05$ implying that the acid value is dependent on the type of pumpkin. This indicates that the oil of the Japanese type pumpkin requires less refining and hence is safer for human consumption compared to those of Green Kabocha and Butternut. Oil from Green Kabocha and Butternut requires further processing such as refining to remove the free fatty acids before human consumption. Also the result suggests that oil from the Butternut type is more likely to undergo deterioration due to its higher acid value. The acid value in this study is higher than that by Alfawaz (2004)[6] on *Curcubita maxima* (0.53). Consequently it is lower than that for *Curcubita pepo* (62.6 mg KOH) and *Curcubita maxima* (12.6 mg KOH) as reported by Bwade et al.[16]. In comparison to other seed crops, the pumpkin seed oil acid value in this study is lower than the acid value of soybean 9.86 mg KOH[18] and coconut oil (6.36 mg KOH) as reported by Obasi et al.[19]. Also the acid value in this study is lower than that of cotton seed (5.75 mg KOH) as reported by Onimawo and Obasi et al.[18, 19].

3.4 Iodine value

There was a significant difference in the iodine value of different pumpkin seed oil varieties as shown in Table 2, i.e. $P\leqslant 0.05$ implying that iodine value of pumpkin seed oil depends on the type of pumpkin. The iodine value in this study is lower compared to that by reference [16]. The iodine values in this study are lower than the iodine value for soy bean oil (132.7 g I_2/100g)[20], the refined (87.72 g I_2/100 g) and the unrefined castor oil (84.8 g I_2/100 g) reported by reference [21]. In the study by Alfawaz[6], the iodine value of pumpkin seed oil from *Curcubita maxima* was as high as 105.12 g I_2/100 g and which is higher than the iodine values obtained in this study and that by reference [16] of *Curcubita maxima* (16 g I_2/100 g) and *Curcubita pepo* (15.8 g I_2/100 g). The low iodine value implies non-drying of the oil and it also suggests that the oil contains few unsaturated bonds and therefore has a low susceptibility to oxidative rancidity. Due to its non-drying properties as suggested by the result, pumpkin seed oil is not a good fit for use in ink and paint industry.

3.5 Refractive index

There is no significant difference in the refractive indices of the different pumpkin seed oil varieties, i.e. $P>0.05$ as in Table 2. This implies that the refractive index of pumpkin seed oil is not dependent on the pumpkin variety ($P>0.05$), i.e. all types yielded nearly similar refractive indices 1.470, 1,469 and 1.471 for types 1, 2 and 3, respectively. The refractive indices obtained in this study do not differ from those of other oils, i.e. according to reference [21], the refractive index of cotton seed oil was 1.464 and that of soy bean oil was 1.474 as reported by Alfawaz[6].

3.6 Specific gravity

Correspondingly the effects of variety were not significant on the specific gravity of pumpkin seed oil. The specific gravity in this study does not differ from those of other vegetable oils, i.e. cotton seed oil, 0.92[21], soy bean oil, 0.926[20,23]. The results in this study suggest that pumpkin seed oil is less dense than water. The determination of the density of vegetable oils is essential in the design of unit processes such as distillation, heat exchangers, piping, and reactors.

4 Conclusions

In this study, pumpkin seed oil was quantified and characterized as an alternative vegetable oil for consumption. The study found that the oil content of pumpkin seed (30%-35%) was higher than that of soybeans (19%– 21%) as well as cotton seed (15%–20%) but lower in acid value than soybean (9.86 mg KOH) and coconut oil (6.36 mg KOH). Furthermore, the iodine values in this study are lower than those of the soy bean oil (132.7 g I_2/100 g), the refined (87.72 g I_2/100 g) and the unrefined castor oil (84.8 g I_2/100 g), but higher than that of coconut oil (10.99 g I_2/100 g). It can therefore be concluded that pumpkin seed oil is comparable to other vegetable oils and is good for human consumption. What remains is a focused study to commercialize the production of pumpkin seeds for oil production.

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