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Effect of Some Processing Factors Affecting the Yield and Quality of Oil Expression from Pumpkin Seeds

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ABSTRACT
Pumpkin is a cultivar of squash plants, with the thick shell containing the pulp seeds. Pumpkin seeds are typically rather flat and asymmetrically oval. The seeds are gotten from the fruit of the pumpkin itself, which contains oil and percentage of water. The health benefits of pumpkin seeds are attributed to the macro and micro nutrients constituent compositions. The health benefits of pumpkin seeds are attributed to the macro and micro nutrients constituent compositions. An investigation was made into the effects of some processing factors on the yield of oil expressed from pumpkin seeds. The mechanical expression was carried out using a mini laboratory oil press. The processing parameter that was fixed is heating time of 30 minutes. While the varied factors were moisture content (15, 17 and 19%) and heating temperature (70, 90 and 110^{0}C). The oil yields were higher from samples when heated at 110^{0}C temperature and moisture content of 19%. The results of the analysis of variance revealed that temperature significantly influenced the oil yield of pumpkin seeds. The physicochemical analysis of the oil shows that the oil is edible with a saponification value of 157.84 mg/g, Iodine value of 105.15g/100g, Peroxide value of 1.53m/mol/kg, specific gravity of 0.924kg/m^3 and Free fatty acid of 4.84mg/KOH/g. Data obtained from this evaluation can be used as parameters for the design and fabrication of several expelling machine for the expression of oil from pumpkin seeds.
KEY WORDS: Processing factors, Physiochemical , Yield, Pumpkin seed, Expression

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I. INTRODUCTION

Pumpkin is a cultivar of squash plants, most commonly of *curcubitapepo* that is round, with smooth slightly ribbed skin and deep yellow to orange coloration. The thick shell contains the pulp seeds. Pumpkin seeds are typically rather flat and asymmetrically oval and light green in colour and may have white outer hull. The seeds are gotten from the fruit of the pumpkin itself, which contains oil and percentage of water. The seed are dried at 40 to 60^{o}C until it reaches the final moisture content of 8 to 10% (Bavec *et al*., 2002b). The pumpkin seed is valued in regards to nutritional points. Several studies have reported the chemical composition and oil characteristics of the pumpkin seed from different origins and varieties. The four fatty acids presented in significant quantities in pumpkin seeds are palmitic, stearic, oleic and linoleic acids (Stevenson *et al*., 2005). The pumpkin seed is a good source of Potassium, Phosphorus and Magnesium. It also contains moderately amounts of other trace elements/minerals (calcium, sodium, manganese, iron, zinc and copper) and these elements make pumpkin seed valuable for food supplements (Lazos, 1986). Raw or roasted pumpkin seeds are valuable for food supplement used as a snack food for human consumption in many culture all over the world. The kernels of pumpkin seeds have been utilized as flavor enhancers in gravies and soups, and used in cooking, baking and ground meat formulations as a nutrient supplement and a functional agent (El-Adawy and Adaha, 2001). They possess valuable dietary and medicinal qualities. The health benefits of pumpkin seeds are attributed to the macro and micro nutrients constituent compositions. They are a rich natural source of proteins, triterpenes, lignans, phytosterols, poly unsaturated fatty acids, anti-oxidative phenolic compounds, carotenoids, tocopherols and minerals (Fu *et al.,* 2006). Pumpkin seed oil is one of the most nutritional oils available and it is an excellent source of fatty acid, anti-oxidants, vitamins and sterols (Idouraine *et al.,* 1996). It contains Omega-3 and Omega-6 fatty acid, which are known to promote energy levels, brain function, vitality and overall health. It is thick oil pressed from roasted pumpkin seeds, appears red or green in colour depending on the oil layer thickness and container properties. It is often praised as a "super hero ingredient" in skin care due to the essential fatty acids. Vegetable oils are essential in meeting global nutritional demands and are utilized for many food and other industrial purposes. Despite the broad range of sources of vegetable oils, the world consumption is dominated by soybean, rapeseed, palm and sunflower oils with 31.6, 30.5, 15.5 and 8.6 million tons consumed per year. These conventional sources of vegetable oils no longer meet the ever increasing demands of domestic and industrial sectors (Idouraine *et al*., 1996).

Previous studies on pumpkin had focused on its medicinal uses and nutritional aspect of the plant (Fu *et al.*, 2006).With the current trend of replacing polyunsaturated vegetable oils with those containing high amounts of monosaturated acid. It is highly imperative to undertake a study on the effect of some processing factors; such as applied pressure, pressing time, moisture content and heating temperature on the yield of oil expressed from pumpkin seed. To characterize the pumpkin seed oil in terms of quality parameters such as Iodine, Free Fatty Acid (FFA), Specific gravity, Saponification and Peroxide values.

II. MATERIALS AND METHODS

2.1 Experimental plan

Experiments were carried out to determine the processing factors such as moisture content, heating temperature, heating time, applied pressure and pressing time.

The material and equipment used in the study were pumpkin seeds, conical flask, funnel, stainless steel cans with lids, DHG-9053. Electrically heated thermostatic blast dry box (oven), laboratory oil press, digital weighing balance, centrifuge, sieve shaker and attrition mill (premier model A1)

The pumpkin fruits were obtained from Sabo market in Ikorodu, Lagos state, Nigeria. The pumpkin fruits were cut to remove the pods in them. The pods were then dried and cracked manually to reveal the seeds in them. The dried and cleaned seeds were not pressed whole due to the fact that oil expression is more effective if the seeds are in smaller particles (Eromosele, *et al.,* 1994). The clean seeds were milled and sieved using 0.09mm and 0.18mm aperture sieve to separate into fine and coarse particle sizes. The oil yield for the fine particles were then determined following some procedural techniques. The initial moisture content of pumpkin seeds sample used for the experiment was determined using the method suggested by ASABE (1998) for oil seeds. Pumpkin seeds sample of 50g was weighed accurately and then dried in an oven at 130^0C for 6 hours (ASABE 1998). The aluminum dish containing the sample was removed from the oven and transferred into desiccators for cooling for 10 minutes. The loss in weight was noted and the moisture content was calculated on wet basis as in equation 1(Odunukan *et al.*, 2013).

$$\text{Moisture content, \% wb} = \frac{W_2 - W_3 X\ 100}{W_2 - W_1} \quad (1)$$

Where

W_1=initial weight of empty can, g

W_2=weight of can +sample weight before drying, g

W_3=final weight of sample +can, g

The experimental samples were prepared at different moisture levels for the experiment. In order to obtain the desired moisture level in the sample, calculated amount of water was added to the sample and the samples were thoroughly mixed and sealed in polythene bags. The bags were kept in a refrigerator at about 5-10^0C for conditioning for 48hours to enable the seed absorb water and were allowed to equilibrate in the ambient for 4 hours as prescribed by Odunukan, *et al.* 2016. Calculation of the amount of water added to achieve the required moisture content of the seeds on conditioning was based on equation 2 (Akinoso, 2006).

$$Q=\frac{A(b-a)}{100-b} \quad (2)$$

where :

A=initial mass of sample, g

a =initial moisture content of sample, %wb

b = final moisture content of sample, %wb

Q =mass of water to be added, g

The actual percentage (%) moisture content after this conditioning was determined and recorded.

2.2 Oil Extraction Using Laboratory Oil Press

The samples were conditioned to 15, 17, and 19% moisture level and were heated to 70, 90 and 110^0C temperatures respectively in the oven for 30 minutes as reported by Adejumo *et al.* 2013. Thereafter, the sample were wrapped with cheese cloth and then transferred into the pressing cylinder of the laboratory oil press. A piece of wire mesh wrapped with cheese cloth was placed at the bottom of the cell to act as filter during the expression. The press consists of a lever arm with a drum attached to the end of the arm. Known weights were added to the drum to generate the required pressures. A metal disc was placed in the cylinder to distribute the pressure from the pressing arm evenly on the sample. Applied pressure was varied at 274.3, 476.3 and 648.5 kPa and the pressing time was varied at 10, 20, and 30 minutes. The expressed oil was measured using measuring cylinder. The oil expressed was a mixture of oil and water. The oil was separated using a centrifuge. The difference in weight of the unexpressed and expressed oil were recorded as the oil yield (Eromosele *et al.*,1996). The percentage oil yield of the sample would be calculated as follows:

$$Yy = \frac{W_1-W_2}{W_1} \times 100\% \quad (3)$$

Where Yy=Total oil yield (%)
W_1=Weight of un-pressed sample (kg)
W_2=Weight of sample after expression (kg)

2.3 Quality Parameters Determination

2.3.1 Determination of Saponification value

Two (2) grams of the pumpkin seed oil was weighed into a conical flask, 20ml of the solvent (ethanol) was added to dissolve the oil, 50ml of ethanolic KOH was added to the content of the beaker, it was heated on a hot plate for exactly 2minutes. It was removed from hot plate and was allowed to cool at room temperature, 2 to 4 drops of phenolphthalein indicator was added and was titrated to pink end point using 0.1N HCl, A blank (B) test was also done, titre values for both sample and blank were recorded. The saponification value was determined as given in equation 4(Farooq *et al.,* 2006).

$$SV\ (mg/KOH/g) = \frac{(V - B) \times N \times 56.1}{W} \qquad (4)$$

Where
SV: Saponification Value
V: Titre value/volume of 0.1N HCl consumed for sample titration
S : Titre value/volume of 0.1N HCl consumed for sample titration
56.1: Molecular weight of KOH
W: Weight of sample in g

2.3.2 Determination of Free Fatty Acid

1g of the pumpkin seed oil was weighed into a conical flask, 20ml of the solvent mixture was added to the sample, 0.2ml of phenolphthalein indicator solution was added and titrated while shaking with 0.1N KOH till pink colour appears and persist for at least 10seconds. A blank titration was also carried out. The free fatty Acid was calculated as given in equation 5 (Farooq *et al.,* 2006).

$$\%\ FFA\ (\text{as Oleic Acid}) = \frac{(V - B) \times N \times 28.21}{W} \qquad (5)$$

Where
V = Volume of titre (KOH) consumed for sample
B = Volume of titre consumed for blank
N = Normality of titration (KOH)
W = Weight of sample
28.21 = Value from the molecular weight of Oleic acid (28.21g/mol) after being multiplied by 100 followed by dividing with 1000 (converting weight to mg) in order to convert result to %.

2.3.3 Determination of Peroxide Value

5g of oil sample was weighed into a conical flask, 30ml of solvent mixture glacial acetic acid chloroform was added in the ratio 3:2 respectively and 0.5ml saturated potassium iodide (KI) solution was added and mixed, the vessel was allowed to stand for 5minutes in the dark, 30ml of distilled water was added, 1ml starch indicator was also added, it was titrated immediately with 0.01N sodium thiosulfate solution until yellow colour was discharged, a blank titrate was also done. (Eromosele *et al.,*1994)

$$\text{Peroxide Value (meq. peroxide/kg)} = \frac{(V_1 - V_2) \times N \times 1000}{W} \qquad (6)$$

V_1 = volume of $Na_2S_2O_3$ consumed for sample
V_2 = volume of $Na_2S_2O_3$ for blank
W= weight of the sample in g
N = normality of the sodium thiosulphate

2.3.4 Determination of Iodine Value

100mg (0.1g) of pumpkin seeds oil was weighed into an iodine flask.A dispensing device was used, 10ml of chloroform was added and was shaken to dissolve the sample, A blank titrate was done with only 10ml chloroform and10ml of Wij. The flask was covered with a stopper and the flask was kept in the dark for 30minutes. After 30minutes, 8ml of 10% Potassium Iodine (KI) solution was added; 100ml of distilled water was also added in order to rinse down through the neck of the flask. The mixture was titrated immediately with 0.1N$Na_2S_2O_3$ until the aqueous layer began to lighten. 2ml starch solution was also added and titration continued until the blue colour of the aqueous solution began to disappear, the iodine flask was covered with a stopper and it was shaken vigorously to extract any iodine remaining in the chloroform layer, When the end point (colourless) appear to have reached, it was shaken again and 2 drops of starch solution was added to verify that no more blue colour was formed in the aqueous layer, the burette reading then was recorded. The Iodine value of the oil was calculated as given in equation 7 (Esuoso *et al.*, 1998).

$$\text{Iodine Value} = \frac{\text{ml Na2S203 consumed for blank} - \text{ml Na2S203 consumed for sample} \times N \times 12.69}{\text{Weight of sample in g}} \quad (7)$$

N = Normality of $Na_2S_2O_3$

2.3.5 Determination of Specific Gravity

At 100ml of specific gravity bottle was cleaned and dried in a dry air oven and cooled in a dessicator. The weight of the specific gravity bottle was taken and recorded as W_1 and the specific gravity bottle was filled with distilled water. The weight of the bottle and the content was measured and recorded as W_2 and the water in the bottle was poured out and the bottle was allowed to dry. The specific gravity bottle was again filled with pumpkin seed oil. The weight of the specific gravity bottle and oil was taken and recorded as W_3. The specific gravity of the oil was then calculated as given in equation 8 (Ibrahim and Onwualu, 2005).

$$\text{Specific gravity} = \frac{\text{Weight of oil}}{\text{Weight of equal volume of water}} \quad (8)$$

III. RESULTS AND DISCUSSION

The experimental design used was factorial experiment which allowed the effects between and within the parameters tested. The result obtained from the experiment was analyzed using f-test Analysis of variance (ANOVA) for easy testing of hypothesis to determine the significance level of the moisture content applied pressure, heating temperature and pressing time of the oil obtained from the pumpkin

The processing factors considered in this study were based on past projects. The experiments were carried out at various levels of processing factors investigated. The experiments were replicated thrice and the mean values and oil yields were calculated and recorded.

Table 1: Oil yield at Various Processing Levels

Moisture Content(%)	Temperature(^{0}C)	Pressure(kPa)	Time(Min)	Oil yield(%)
15	70	274.3	10	18.21
17	70	274.3	10	15.01
19	70	274.3	10	12.20
15	90	274.3	10	20.30
17	90	274.3	10	20.61
19	90	274.3	10	23.00
15	110	274.3	10	21.30
17	110	274.3	10	19.50
19	110	274.3	10	23.24
15	70	476.3	20	20.30
17	70	476.3	20	24.50
19	70	476.3	20	32.10
15	90	476.3	20	29.50
17	90	476.3	20	24.40
19	90	476.3	20	24.70
15	110	476.3	20	25.51
17	110	476.3	20	27.30
19	110	476.3	20	30.10
15	70	648.5	30	30.30
17	70	648.5	30	32.50
19	70	648.5	30	32.40
17	90	648.5	30	31.30
19	90	648.5	30	36.24
15	110	648.5	30	40.10
17	110	648.5	30	42.10
19	110	648.5	30	30.41

15	90	648.5	30	35.10

Table 2 : Chemical Properties of Pumpkin oil

Parameters	Mean value	FAO/WHO Specification
Saponification value(mgKOH/g)	157.84	181.4±2.60
Free fatty acid value(mgKOH/g)	4.84	5.78-7.28
Iodine value (g/100g)	105.15	80-106
Specific gravity(g/cm^3)	0.924	0.9-1.16
Peroxide value(m/mol/kg)	1.53	10

Table 3: Experimental variables

Processing factors and level used in the experiment

Factors	Minimum	Maximum
Moisture content (%)	15	19
Temperature (^{o}c)	70	110
Pressure (kpa)	274.3	648.5
Pressing time (mins)	10	30

Table 4 :Summary of Analysis of Variance (ANOVA)

Source of variation	Df	F Value	P Value Prob>F	Remark
Model	6	0.034	<0.0001	Significant
Moisture content	2	0.0260	0.8432	Not Significant
Temperature	2	0.0718	0.4312	Not Significant
Pressure	2	0.0242	0.1135	Not Significant
Pressing Time	2	0.0234	0.3241	Not Significant
Moisture Content *Temperature	4	0.0397	0.0216	Significant
Moisture Content *Time*Temperature	8	0.00807	0.0321	Significant
Error	36	0.39227	0.6721	Not significant

The oil from pumpkin seeds were expressed using laboratory oil press and some quality parameters of the expressed oil were analyzed. Table 1 shows the oil yield obtained from the pumpkin seed which ranged from 12.20-42.10%. The highest yield of oil was obtained from sample at19% moisture content, temperature of 110^{o}C, applied pressure of 648.5kPa and at 30 minutes pressing time. The highest value (42.1%) obtained in the study falls within the range of value (40-50%) of pumpkin seed oil reported by Bavec *etal.*(2002b)

Table 2 depicts the chemical composition of the pumpkin seed oil obtained from the study.It can be observed from the study that the Peroxide value of the pumpkin oil was 1.53m/mg which is below 10meq/oxygen/kg for edible oils. This value is within the permitted level of not more than 10meq/oxygen/kg oil value recommended by FAO/WHO, 2009 for edible oil. High oxidative stability is possible when peroxide value is less than 10.00mg peroxide/kg, hence, the oil will be resistant to oxidation during storage. This depicts that the oil is fresh and could be stored for a long period of time without getting rancid. The value obtained is of nutritional interest and it suggests that it could be utilized as edible oil.

The magnitude of saponification value gives an idea about the average molecular weight of the fat and oil. The higher the molecular weight of the fat, the smaller is its saponification value (Israel, 2018). This is to say saponification values are inversely related to average molecular weight of the fatty acids in the oil fractions. The oil fractions with saponification values of 200mgKOH/g and above had been reported to possess low molecular weight fatty acids (Israel, 2018). The saponification value reported in this study is 157.84 mgKOH/g. This value is comparable to 158.40mgKOH/g saponification value reported by Akubugwo *et al.* (2008) in their study. 157.84mgKOH/g saponification value recorded in this study is an indication that the oil is of lower molecular weight and this implies that the saponification value of the oil is high. This is an indication that the oil has potential for use in the industry (Amoo *et al.,* 2004). The oil can be used for soap production and in making other cosmetic products such as shampoo.

Free fatty acid obtained from the oil was 4.84mgKOH/g and this is below the (5.78 – 7.28mgKOH/g) range of values prescribed by FAO/WHO standard for edible oil. This could be attributed to presence of natural antioxidants in the seeds such as vitamins A and C as well as other possible phytochemical like flavonoids. Free fatty acid as reported by Ajayi (2009) has the ability to stimulate oxidative deterioration of oils by enzymatic and chemical oxidation to form off-flavour component. Low free fatty acid of the pumpkin oil indicates that the oil could be stored for a long time without spoilage through oxidative rancidity and could find application as edible oil (Aremu *et al.*,2006a). High acid value in oil shows that the oil may not be suitable for use in cooking (edibility) but however be useful in the production of paint, liquid soaps and shampoos(Aremu *et al.*,2006a). Iodine value of the pumpkin oil reported in this study was 105.15g/100, this values falls within the range of (80-106kg/100g) as recommended by WHO/FAO for edible oil. Iodine value measures the degree of unsaturation of a particular vegetable oil. The greater the iodine value, the more unsaturation of the oil and the higher its susceptibility to oxidation and the lower the iodine value, the longer the shelf life of the oil (Hamilton, 1999).The Iodine value (105.15gI_2/100g) obtained in this study which is less than 115.15gI_2/100g suggests that it is a non- drying oil, therefore, non drying oils are not suitable for ink and paint productions due to their non-drying characteristics but may be useful in the manufacture of soaps (Hamilton, 1999).

The specific gravity was 0.924 this value falls within the range of (0.9-1.16kg/m^3) prescribed by FAO/WHO for vegetable oils. The oil is less dense than water and would be useful in cream production as it will make the oil flow and spread easily on the skin (Oyeleke *et al*., 2012b). The value of the specific gravity obtained is comparable with 0.91g/cm^3 reported by Nwabanne (2012) for fluted pumpkin seed.

Table 4 shows the summary of Analysis of Variance (ANOVA) performed on data obtained from the experiment. This result indicated that the model was significant ($P<0.05$) and the interactions between moisture content and temperature and the interaction of temperature, time and moisture content had significant ($P<0.05$) effect on the yield of pumpkin oil, while moisture content, pressure, temperature and pressing time had no significant ($P>0.05$) effect on the oil yield.

IV. CONCLUSION

The following conclusions were drawn from the study:

I. The effect of applied pressure, pressing time, temperature and moisture content on oil expressed from pumpkin seed was investigated.

II. Pumpkin seed pre-heated at 110^{0}C after 30 minutes pressing time and an applied pressure of 648.5kPa had the highest oil yield of 42.1%.

III. The Analysis of variance performed on data indicated that the model was significant ($p<0.05$) and the interaction between the moisture content and temperature and the interaction of temperature, time and moisture content had significant ($p<0.05$) effect on the yield of pumpkin oil.

IV. Some quality parameters were investigated, it was observed that the low Peroxide value obtained in the study depicts that the oil is fresh and could be stored for a long period of time without getting rancid.

V. A Saponification value of 157.84mgKOH/g was reported in the study. This is an indication that the oil is of lower molecular weight and therefore could be utilized in soap making and shampoo products.

VI. Free fatty acid of the pumpkin oil was 4.84mgKOH/g, this indicates that the oil could be stored for a long time without spoilage through oxidative rancidity and could be used as edible oil.

VII. The value for Iodine oil (105.15gI_2/100g) was obtained for the oil in the study suggests that it is a non drying oil. It is not suitable for ink and paint productions but could find application as an ingredient in the manufacture of soap.

VIII. The specific gravity of the pumpkin seed oil is 0.924g/cm^3, this suggests that the oil is less dense than water (1.0g/cm^3) and would be useful in cream production.

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