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Cottage Processing of Black Plum (*Vitex doniana*) into Juice in Katsina State, North-Western Part of Nigeria

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Abstract
Black plum (Vitex doniana) is among the perishable fruits which if not processed would get contaminated by microorganisms. The equipment such as extractor, filter press, pasteurization pot and a capping machine were fabricated for processing black plum fruits into juice. The processing of fruits into juice started with sorting, washing, extraction, filtration, pasteurization, bottling and capping. The juice yield, capacity and efficiency of the extractor were found to be 75.8%,1.56kg/min and 92.2% respectively. Pasteurization temperature which ranges from 36^{O}C to 90^{O}Caffected the proximate composition and pH of the juice. The increase in pasteurization temperature showed an increase in crude protein, crude fibre, ash and pH while other parameters such as carbohydrate, moisture and fat change differently. The research showed that variation in pasteurization temperature affects the proximate composition of black plum juice. Attaining a temperature of 60^{O}C was recommended for black plum juice pasteurization.
Keywords: Black plum, Extractor, Juice, Processing and Proximate.

INTRODUCTION

Black plum (*Vitex doniana*) belongs to the family of verbenaceae. It is medium size deciduous forest tree found in the coastal woodlands, riverine and lowland forests reaching up to grassland. The tree can reach up to 18m high. The fruit is oblong and less than 3cm long. It is green when unripened, turning purplish-black on ripening and with a starchy black flesh. It has good taste when consumed raw. The fruits can be processed into juice (Agbede and Ibitoye, 2007).

The *Vitex doniana* tree can easily be found in the northwestern part of Nigeria (Katsina, Kaduna, Kano, Zamfara, Kebbi and Sokoto States) and some part of north-central (James, 2002). It is known by various tribal names in Nigeria such as *Dinya* (Hausa), *Ejiji* (Igala) and *Olih* (Etsako).The fruit is a drupe consisting of a thin exocarp, the edible mesocarp (pulp), and a thick woody endocarp. According to Vunchi *et al.*, (2011) majority of fruits have high carbohydrate content although the fruit type, environment and maturity level are key determinants. A ripen fruit usually contains edible pulp up to 18-25%, by weight, of the fruit. Due to the high sugar content, the fruits may serve as raw materials for the preparation of several beverages (James, 2002). While other fruits such as pears, apples, peaches, strawberries, loganberries and raspberries have been processed into syrups and juices(Ayub *et al.*, 2010; Sulaiman *et al.*, 2016),there is no sufficient literature on the cottage production of *Vitex doniana* fruit juice in Katsina State even though tonnage quantity of the fruits is harvested annually in the state. Hence the purpose of this study was to determine the physicochemical and nutritional information of *Vitex doniana* fruit juice and also to investigate the performance characteristics of the fabricated juice extractor.

MATERIALS AND METHODS

Study location

At Ibrahim Shehu Shema Centre for Renewable Energy Research of the Umaru Musa Yar'adua University Katsina, Katsina State, Nigeria, an electrically operated *Vitex doniana* fruit juice extractor was designed and fabricated along with other unit operation equipment such as filter press, pasteurizer, sorting table, water bath, capping machine and stove, under a project titled "EU grant project on sustainable development of farm agro-forestry and fuel wood conservation system in North-West Katsina, Katsina State." The fabricated juice processing line was used for this study.

Juice Extractor

The extractor consists of hopper, drum, mesh sieve, crushing roller, auger, main shaft, pulley, juice outlet, fiber outlet, frame and support. It is powered by a 3hp electric motor. The hopper is directly above the drum and was made of stainless steel material. The rotating shaft is fitted with a crushing roller. The mesh sieve covers the auger and they are both situated inside the pulping section of the machine. The shaft of the crushing roller is directly attached to the pulley and power is transmitted from 3hp electric motor through belt transmission to drive the shaft. The auger shaft is connected to the crushing roller shaft via a gear train. All the components were made of stainless steel material except the frame which was made from mild steel as seen in figure 1 below.

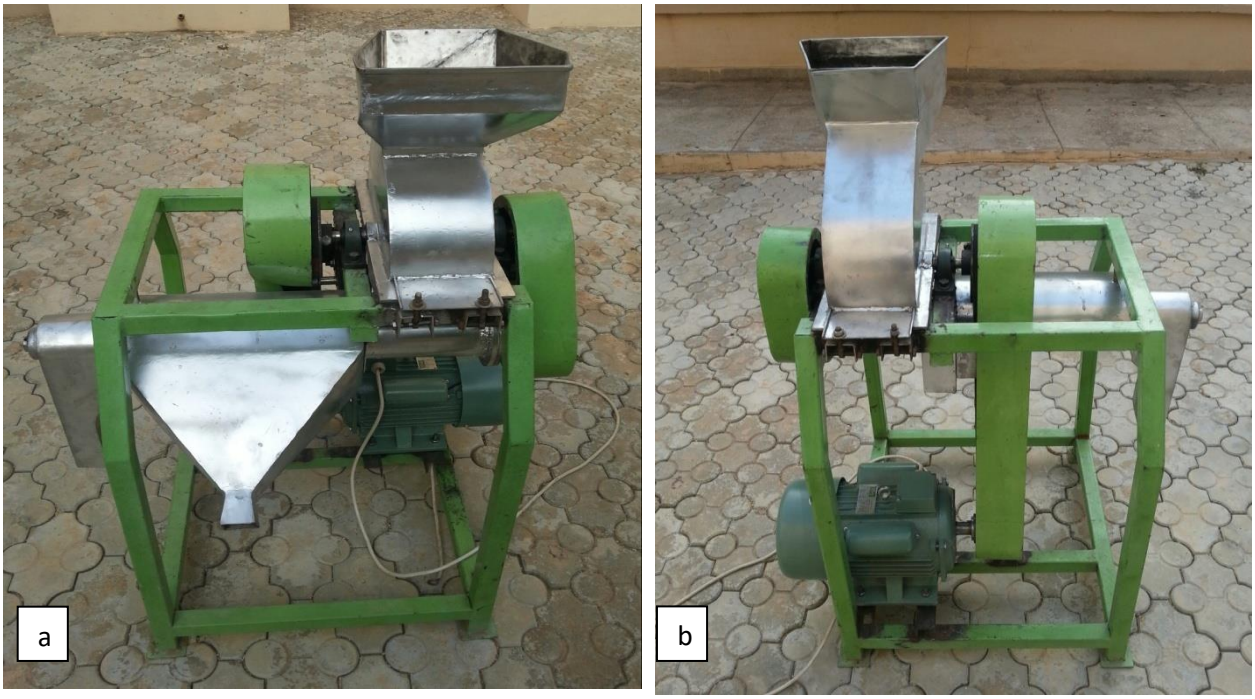

Figure1: Picture showing (a) Front view of the juice extractor (b) Rear view of the juice extractor

Operation of the juice extractor

In operation, the fruit is introduced through the hopper into the crusher inside which is the rotating shaft attached with a grooved roller. Extraction takes place inside the crusher by mastication through crushing roller and maceration by the auger inside the pulping section as the shaft is powered by the electric motor. The juice extracted is sieved by the mesh sieve and collected from the juice outlet while the residual products (fiber and process waste) are collected separately at the fiber outlet.

Sample collection and processing

Fresh samples of *Vitex doniana* fruits were procured from the local markets within the Batsari Local Government in Katsina State of Nigeria, 9.5kg of the fruit sample was obtained after sorting and subsequent washing, this amount was charged into the extractor together with a definite quantity of water and the extracted juice was obtained. The juice extracted was filtered through a muslin cloth filter, and the filtered juice was then pasteurized. The juice samples were taken at various pasteurization temperatures, and finally, the samples obtained were taken to a laboratory for analysis.

Performance of the machine

The performance of the machine was evaluated by determining the percentage yield of juice per kg of the fruit, juice extraction capacity (kg/hr) and juice extraction efficiency (%). The following equations were employed as used by Olaniyan, 2010;

$J_Y = \frac{100W_{JE}}{W_{JE}+W_{RW}}$ ..... Equation 1

$J_E = \frac{100W_{JE}}{XW_{FS}}$ ..... Equation 2

$E_L = \frac{\{W_{FS}-(W_{JE}+W_{RW})\}}{W_{FS}}$ ..... Equation 3

$J_{EC} = \frac{100W_{JE}}{t}$ .....Equation 4

$X = \frac{(W_{JE}+W_{JC})}{W_{FS}}$ .....Equation 5

X value was determined by taking the ratio of the sum of masses of juice extracted and juice in chaff to the mass of the feedstock fed into the machine.

Where:

J_Y = Juice yield, J_E = Juice extraction efficiency

E_L = Juice extraction loss, J_{EC} = Juice extraction capacity of the machine

W_{JE} = Weight of juice extracted in kg, W_{RW} = Weight of the residual waste in kg

W_{FS} = Weight of black plum and water fed in kg, W_{JC} = Weight of the juice in the chaff

X = Juice constant of the black plum in decimal.

RESULTS

The juice extraction capacity of the machine was 1.56kg/min while the percentage performance of the machine can be seen in Table 1 below;

Table 1:Showing the performance and yield of the extractor

Sample performance parameters	Performance (%)
J_Y	75.8%
J_E	92.2%
E_L	3.8%

The proximate composition of the black plum at the pasteurization temperature range of 36 to 90 ^{O}C can be seen in table 2. The highest value of carbohydrate, crude protein and ash were obtained at 80 ^{O}C, 36 ^{O}C and 80 ^{O}C respectively. While the lowest values obtained for carbohydrate, crude protein and ash were at temperature of 70 ^{O}C, 90 ^{O}C and 36 ^{O}C respectively.

Table 2: Proximate analysis of the extracted juice at different temperature

Parameters	36 ^{O}C	60^{O}C	70^{O}C	80^{O}C	90^{O}C
Carbohydrate	4.27	2.78	0.82	5.22	3.19
Crude fat (%)	0.30	0.20	0.15	0.20	0.15
Crude protein (%)	1.93	1.40	1.23	0.88	0.70
Moisture (%)	92.24	94.26	96.36	92.16	94.44
Ash (%)	0.80	0.86	0.92	0.94	0.92
Crude fibre (%)	0.46	0.50	0.52	0.60	0.60
pH	5.92	6.10	6.19	6.27	6.26
Viscosity (shear stress dynes/cm^2)	37.903	38.174	37.644	37.871	37.870

The concentration of carbohydrates is highest at 80 ^{O}C with 5.22%, followed by 36 ^{O}C (4.27%), 90 ^{O}C (3.19%), 60 ^{O}C (2.78%) and the least was 0.82% at 70 ^{O}C as seen in figure 2.

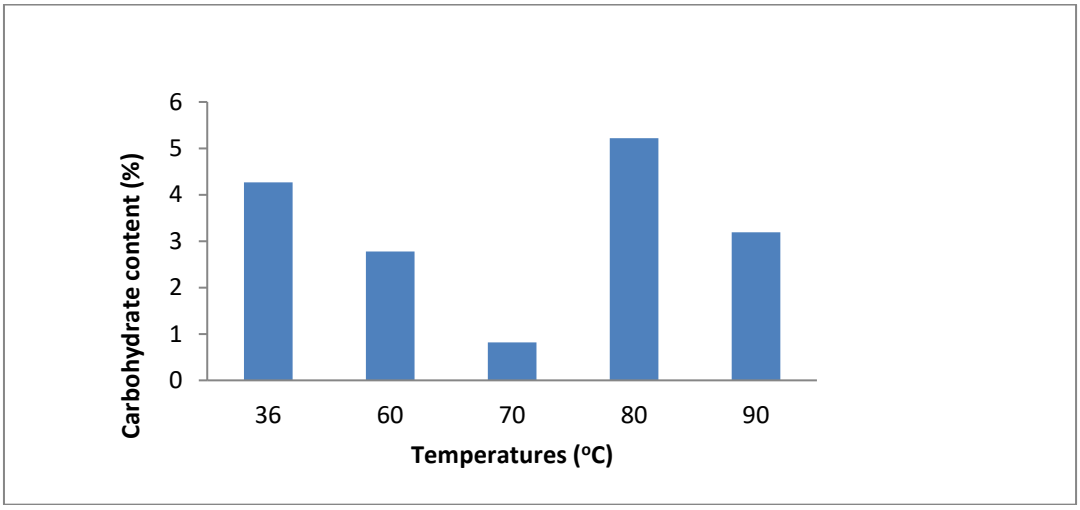

Figure 2:Effect of pasteurization temperature on carbohydrate content of black plum juice

The concentration of fat was low in all the samples ranging from 0.15 – 0.30%.

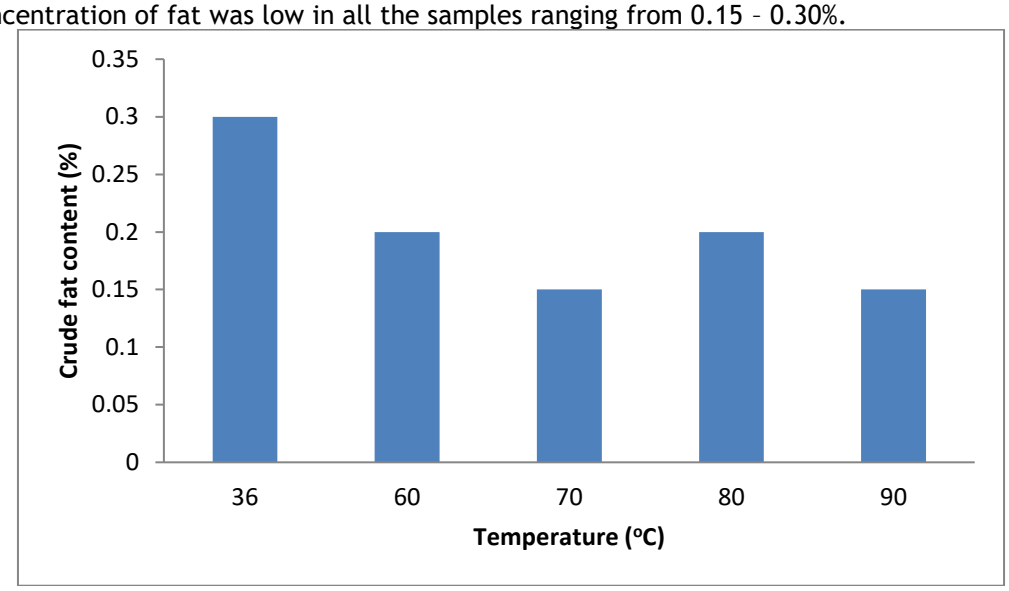

Figure 3: Effect of pasteurization temperature on Crude fat content of black plum juice

The protein concentration decreases due to the increasing temperature of pasteurization. The low concentration of protein ranges between 0.70 - 1.93%.

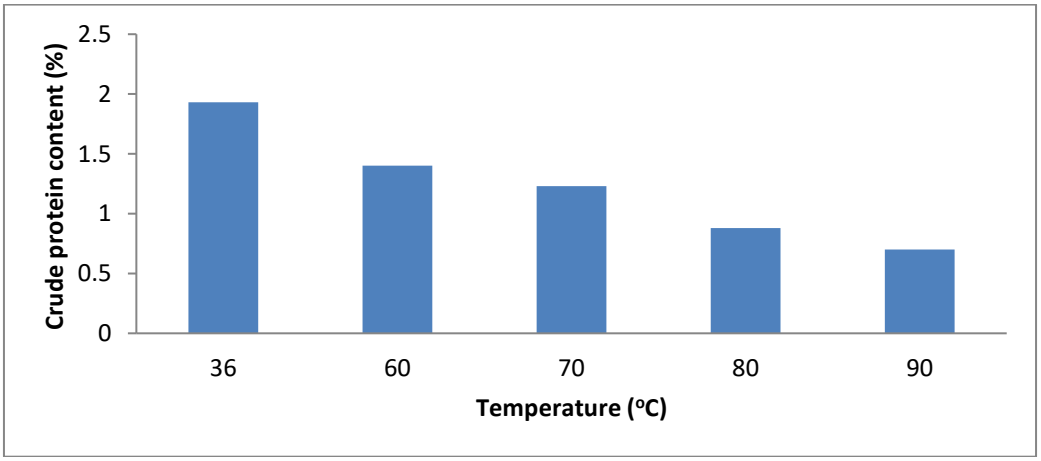

Figure 4: Effect of pasteurization temperature on Crude protein content of black plum juice

The ash content increases with increasing temperature from 0.80% to 0.94% up to 80 ^{O}C before it begins to decline to 0.92% at 90 ^{O}C.

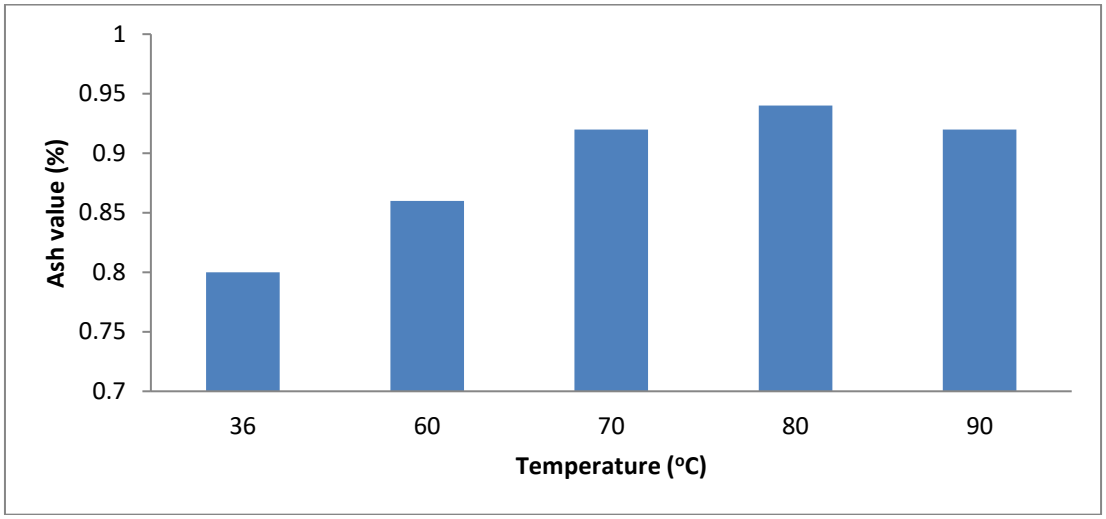

Figure 5: Effect of pasteurization temperature on Ash content of black plum juice

The crude fiber content increased with an increasing pasteurization temperature. The value rises from 0.46 to 0.6%.

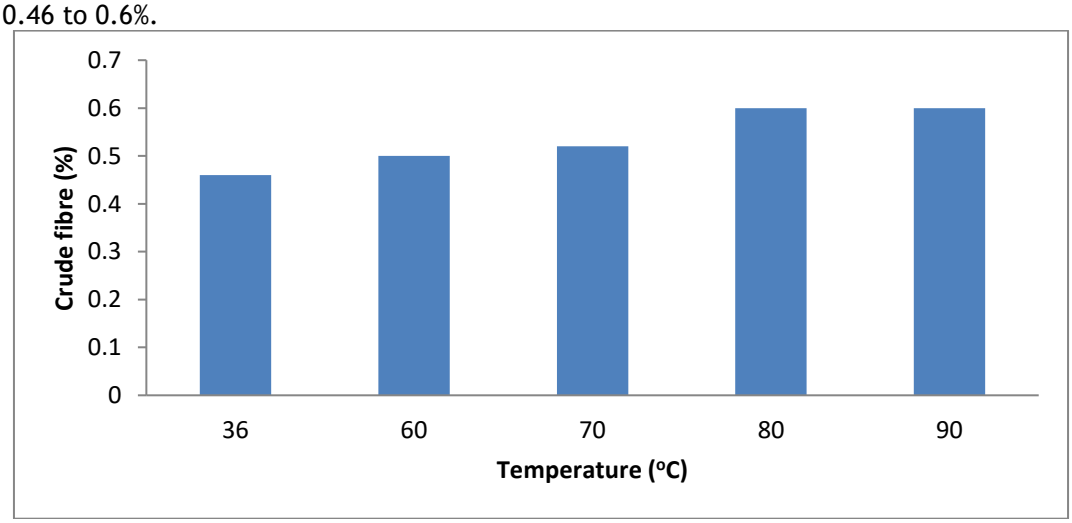

Figure 6: Effect of pasteurization temperature on Crude fiber content of black plum juice

The high moisture contents ranges between 92.16 and 96.36%.

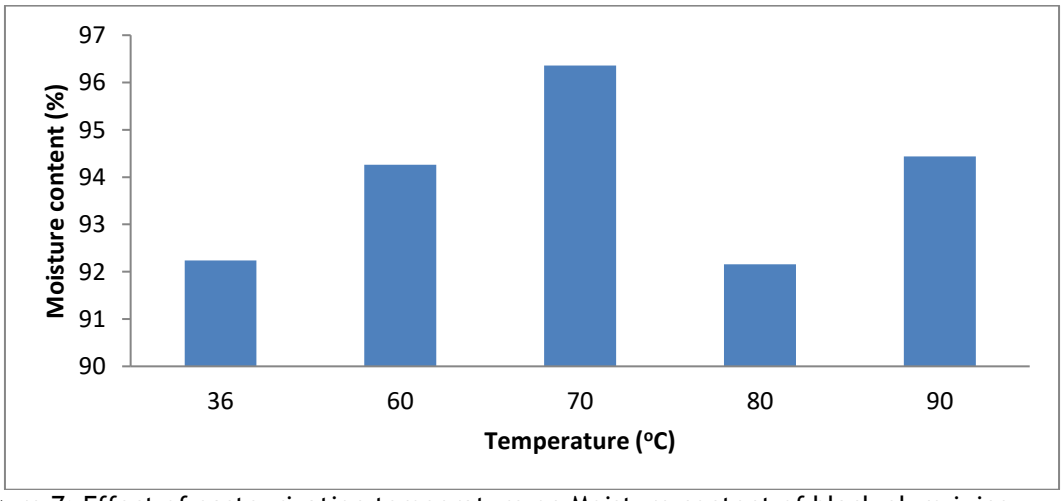

Figure 7: Effect of pasteurization temperature on Moisture content of black plum juice

In our findings, the pH increases with the increase in pasteurization temperature. The pH ranges from 5.92 - 6.27.

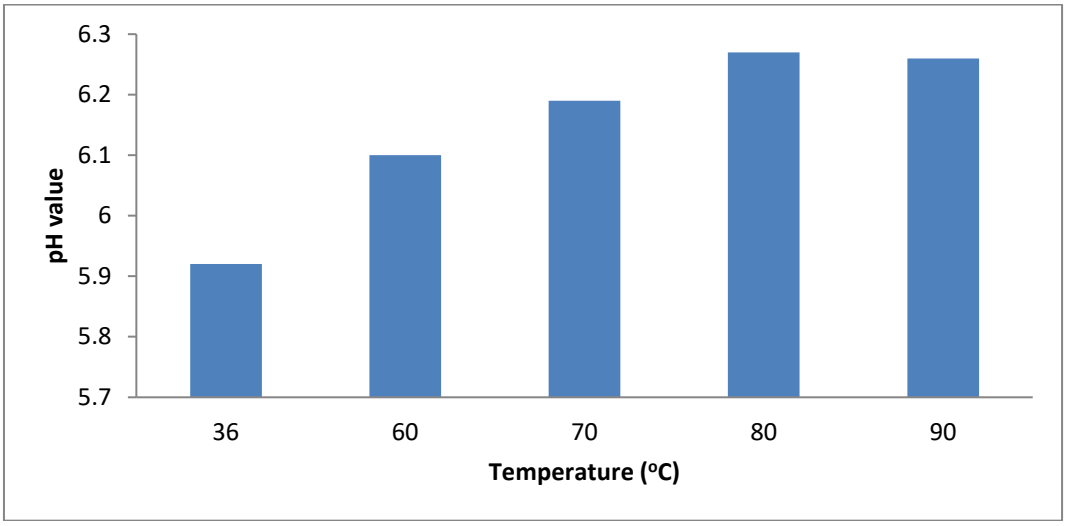

Figure 8: Effect of pasteurization temperature on pH of black plum juice

The viscosity ranges between 37.644 – 38.174 shear stress dynes/cm^2. The viscosity decreased as the temperature increased from 60 to 90 ^{O}C.

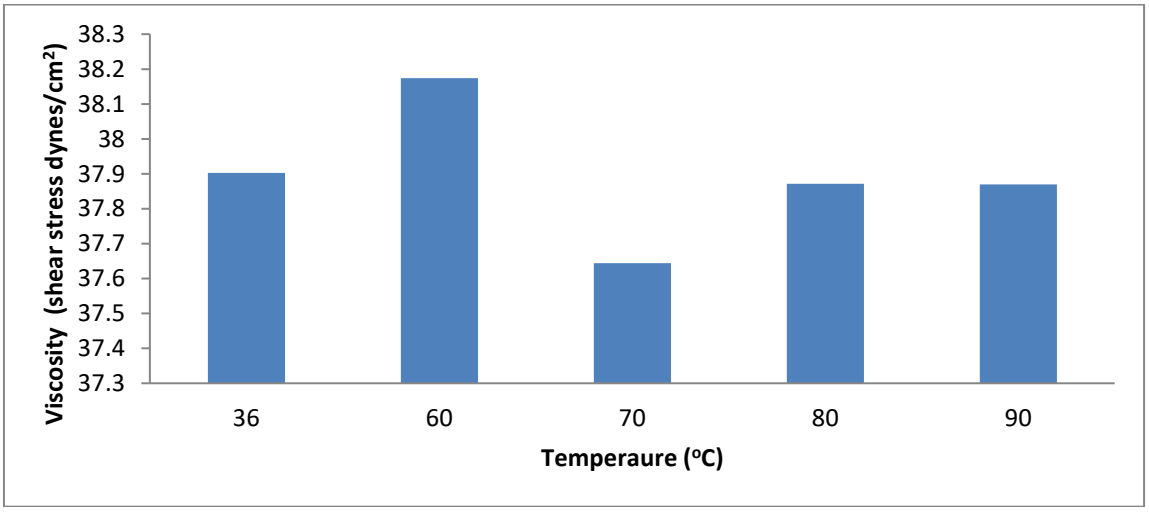

Figure 9: Effect of pasteurization temperature on Viscosity of black plum juice

DISCUSSION

The concentration of carbohydrates is highest at 80 ^{O}C with 5.22%, followed by 36 ^{O}C(4.27%), 90 ^{O}C (3.19%), 60^{O}C (2.78%) and the least was 0.82% at 70^{O}C. Vunchi *et al.*, (2011) on analyzing the powdered form of *Vitex doniana* reported 28.4% carbohydrate content, while Nnamani *et al.*, (2009) found 67% carbohydrate content from the leaves of *Vitex doniana*. Therefore, environmental conditions and fruit type might be the responsible for the low carbohydrate values obtained in this study, and also the study analyzed the juice form of *Vitex doniana* as against the pulp powder and leaves of the plant that gave the higher values as compared above.

The concentration of fat was low in all the samples ranging from 0.15 – 0.30%. The low concentration of fat which is common in fruits is similar to the studies by Mary *et al.*,(2015) and Agbebde and Ibitoye,(2007) who reported 0.4% and 3.0% respectively of crude fat. And the decreasing trend of the crude fat with temperature maybe due to the thermal effect on the juice.

The protein concentration is higher in our findings compared to 0.05% of apple juice reported by Ekanem and Ekanem,(2018). Additionally, Ozioma *et al.*(2013) reported lower values of protein for *Ananus comosus* 0.39%, *Annona muricata* 0.51%, *Malus domestica* 0.29% and *Irvingia gabonensis* 0.61% and similar values of *Musa paradisiaca* 1.25%, *Psidium guajava* 1.28%, *Carica papaya* 0.82% and *Citus sinensis* 0.87% compared to our findings.

The values obtained for ash contents were higher than those reported by Ozioma *et al.*,(2013) for *Musa paradisiaca* (0.30%), *Carica papaya* (0.27%) and *Malus domestica* (0.50%).

The increase in ash due to an increase in pasteurization temperature is in agreement with Kumar *etal.*,(2017). The ash content indicates the concentration of various mineral elements that accelerate growth and development.

The highest fiber content value obtained is close to 0.58% obtained by Vunchi *et al.*, (2007) for *Vitex doniana* pulp powder. Again, Ozioma *et al.*, (2013) reported similar value for the fiber content of *Ananus comosus*.

The changes in water content due to temperature could be attributed to the evaporation (Toledo, 2007), dehydration and hydrolysis leading to synthesis or evaporation of water molecules (Singh *et al*. 2012). Although this study focused on *Vitex doniana* juice, James (2002) investigated the physicochemical properties of *Vitex Doniana* syrup and reported moisture content of 67.9%.The high moisture content which is typical of a matured and ripped fruit is to serve as a medium for metabolic activities.

In our findings, the pH increases with the increase in pasteurization temperature. This is in disagreement with the work of Kumar*et al.*,(2017) and Okafor *et al.*,(2017). The pH ranges from 5.92 - 6.27. The increase in pH is due to the release of more hydroxide ions. At 90 ^{O}C the pH began to drop because the hydrogen ions were more than the hydroxide ions.

The viscosity decreased as the temperature increased from 60 to 90 ^{O}C. This is similar to the report of Juszczak *et al.*, (2010) when increase in temperature of beetroot juice from 10-60 ^{O}C resulted in decrease in viscosity of the juice.

CONCLUSION

Black plum (*Vitex doniana*) is among the perishable fruits which if not processed would get contaminated by microorganisms. With the simple operated machine set-up presented in this study, *Vitex doniana* fruits can now be processed into juice that can last for a long time and add more economic values to the fruit. The juice yield obtained was 75.8% whereas the extraction capacity and extraction efficiency were 1.56kg/min and 92.2% respectively. The study has also indicated some nutritional benefits of *Vitex doniana* fruit juice and found best pasteurization temperature for cottage production of *Vitex doniana* fruit juice in Katsina State to be 60^{O}C.

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