Available online at https://asric.africa/natural-sciences
ASRIC Journal on Natural Sciences Vol 4(1) (2024) 19-23

Effect of Thermal Processing on The Functional and Pasting Properties of Mucuna Flagellipes Flour

Uchechukwu Lawrencia Igwesi[1], and Nkemjika Nnedinso Umerah[2]

Department of Food Science and Technology, Enugu State University of Science and Technology.
* Lawrenciauchechukwu@gmail.com
Department of Food Science and Technology, Enugu State University of Science and Technology, Nigeria. nkemumerah@yahoo.com

Received 15 March 2024; revised 16 April 2024; accepted 21 May 2024

Abstract

Mucuna flagellipes is an underutilized legume that is wildly grown especially, in Eastern part of Nigeria. The study evaluated the effects of thermal processing on the functional and rheological properties of *Mucuna flagellipes* flours. The *Mucuna flagellipes* seeds were sorted, cleaned and divided into four equal lots of 0.5kg each. They were processed into A -raw, B -boiled, C -roasted and D -autoclaved. The samples were analysed for functional and pasting properties using standard methods. The functional properties of the flours showed that the bulk density ranged from 0.85 – 2.79 g/cm^3, 3.42 – 6.68 % water absorption capacity, 4.09 – 6.58 % oil absorption capacity, 16.47 – 64.85 % emulsification capacity, 16.47 – 64.85 % least gelation concentration, 5.26 – 15.61 % swelling capacity, respectively. The pasting properties of the *Mucuna flagellipes* flours also showed that the peak viscosity, trough viscosity, breakdown viscosity, set back viscosity, final viscosity, peak time and pasting temperature ranged from 14.49 – 65.69 RVU, 45.91 – 89.57 RVU, 43.77 – 98.34 RVU, 11.76 – 52.57 RVU, 19.51 – 117.18 RVU, 7.68 – 11.75 min and 85.90-98.81 ^{0}C, respectively. The study showed that the thermally processed *Mucuna flagellipes* flours could be used as nutritional supplements and functional ingredients in the preparation of a wide range of foods.

Keywords: *Mucuna flagellipes*, rheology, functional, underutilized.

Introduction

Mucuna is a genus of 100 acknowledged species of climbing vines and shrubs of the family *Fabaceae* found worldwide in the woodlands of tropical areas and are in great demand as food, livestock feed and pharmaceutically valued products (FAO, 2011). Among the species is *Mucuna flagellipes.* legume that belong to the subfamily *Papilonaceae* that comprises pods covered with brownish dense whisker-like hairs called trichomes, irritating when in contact with the skin or eyes. Each pod may contain 1 to 3 seeds with a hard coating which is whitish when fresh and immature but turns black when mature and dry. It is the most widely cultivated among the numerous varieties of *Mucuna* family, it is known as “Ox-eyed bean” or “Hamburger seed” and popularly called “Ukpo” by the Igbos, “Kararra” by the Hausas and “Yerepe” by the Yorubas (Obi and Okoye, 2017)

The functional properties are the fundamental physicochemical properties that reflects the complex interaction between the composition, structure molecular conformation and physicochemical properties of food components together with the nature of environment which are associated and measured. (Siddiq, 2009, Singh et al., 2005).

Pasting properties are functional properties which relate to the ability of a food item to act in paste-like manner (Otegbayo et al.., 2006). According to Wang and Copeland (2013), Starch granules when heated become hydrated, swell, and are transformed into a paste. The granule structure collapses due to melting of crystallites, unwinding of double helices and breaking down of hydrogen bonds. These changes are collectively referred to as starch gelatinization which is accompanied by the loss of characteristic birefringence of intact granules. On cooling, the disaggregated starch chains retrograde gradually into partially ordered structures that differ from those in native granules (Asouzu and Umerah, 2020). The pasting properties that are commonly evaluated in food products include the peak viscosity, trough, breakdown, setback, and final viscosities, pasting time and temperature, respectively.

The trust of this work is the determine the effect of thermal processing on the functional and pasting properties of *mucuna flagellipes* flour.

Materials and Methods

Mature dried *Mucuna flagellipes* seeds that were used for the study were purchased from Ogbete Main Market Enugu, Enugu State, Nigeria. The seeds were sorted and the damaged seeds discarded, cleaned and divided into four equal portions of 500g each. Three portions were subjected to different processing treatments (boiling, roasting and autoclaving) while the fourth batch was processed raw.

Preparation of Raw *Mucuna flagellipes* seed flour

The raw *Mucuna flagellipes* flour were prepared according to the method described by Udensi et al (2021). During preparation, five hundred grammes (500g) of *Mucuna flagellipes* seeds which were free from extraneous materials were cleaned with 1.5liters of potable water and dehulled manually followed by winnowing to remove the hulls. The dehulled seeds were spread on trays and dried in a hot air oven (Model DHA 9101 ISA) at 60 ^{O}C for 6 h with occasional turning of the seeds at intervals of 30 min to ensure uniform drying. The dried seeds were milled in an attrition mill and sieved through a 500micron mesh sieve. The flour produced were packaged in an airtight plastic container, labeled and kept in a cool dry place until needed for analysis.

Preparation of Boiled *Mucuna flagellipes* seed flour

The boiled *Mucuna flagellipes* flour were prepared according to the method described by Enwere (1998). During preparation, five hundred grammes (500g) of *Mucuna flagellipes* seeds which are free from extraneous materials were washed with 1.5 liters of potable water and dehulled manually followed by winnowing to remove the hulls. The dehulled seeds were boiled with 2 liters of potable water in a hotplate at 100C for 30 min. The boiled seeds were drained, spread on the trays and dried in hot air oven (Model DHA 9101 ISA) at 60 ^{O}C for 8 h with occasional turning of the seeds at intervals of 30 min to ensure uniform drying. The dried seeds were milled in an attrition mill and sieved through a 500micron mesh sieve. The flour produced were packaged in an airtight plastic container, labeled and kept in a cool dry place until needed for analysis.

Preparation of Roasted *Mucuna flagellipes* seed flour

The roasted *Mucuna flagellipes* flour were prepared according to the method described by Enwere (1998). During preparation, five hundred grammes (500g) of *Mucuna flagellipes* seeds which are free from extraneous materials were cleaned with 1.5 liters of potable water and dehulled manually followed by winnowing to remove the hulls. The dehulled seeds were rinsed, spread on the trays and roasted in an oven (Model DHG 9101 ISA) at 240 ^{0}C for 40 min with occasional stirring of the seeds at intervals of 5 min to ensure uniform roasting. The dried seeds were milled in an attrition mill and sieved through a 500micron mesh sieve. The flour produced were packaged in an airtight plastic container, labeled and kept in a cool dry place until needed for analysis.

Preparation of Autoclaved *Mucuna flagellipes* seed flour

The autoclaved *Mucuna flagellipes* flour were prepared according to the method described by Udensi et al. (2021). During preparation, five hundred grammes (500g) of the seeds which were free from extraneous materials were cleaned with 1.5 liters of potable water and dehulled manually followed by winnowing to remove the hulls. The dehulled seeds were placed in a beaker and autoclaved at a temperature of 121 ^{O}C and pressure of 6 atmospheres for 40 min in an autoclave (Model 75HG, Britain, UK). The autoclaved seeds were dried in a hot air oven (Model DHG 9101 ISA) at 60 ^{O}C for 6 h. The dried seeds were milled in an attrition mill and sieved through a 500micron mesh sieve.

Results

Table 1. Functional Properties of Raw and Processed *Mucuna flagellipes* flours

Functional Properties	Raw	Boiled	Roasted	Autoclaved
Bulk density (g/ml)	2.79^{a} ±0.07	0.85^{d} ±0.03	1.87^{c} ±0.03	1.92^{b} ±0.00
WAC(g/m2)	6.68^{a} ±0.03	4.65^{c} ±0.09	3.42^{d} ±0.11	5.53^{b} ±0.00
OAC (ml)	6.58^{a} ±0.01	4.73^{b} ±0.13	4.38^{c} ±0.00	4.09^{d} ±0.04
Emulsification Capacity	64.85^{a} ±0.00	42.67^{c} ±0.10	16.47^{d} ±0.01	57.32^{b} ±0.04
Least Gel. Capacity	15.61^{a} ±0.01	5.26^{d} ±0.00	14.03^{b}±0.01	8.14^{c} ±0.01
Swelling Capacity(g)	156.24^{a} ±0.13	100.87^{d} ±0.01	140.02^{b} ±0.07	134.01^{c} ±0.13

Values are mean ± SD of triplicate determinations. Means within the same row with different letters are Means within the same row with different letters are significantly different at p<0.05.

Table 2. Pasting Properties of Processed *Mucuna flagellipes* flours

Flour Samples	Raw	Boiled	Roasted	Autoclaved
Peak Viscosity (RVU)	14.49^{d}+0.03	32.00^{b}+0.03	23.33^{c}+0.03	65.69 ^{a}+0.00
Trough Viscosity (RVU)	45.91^{d}+0.03	70.11^{b}+0.03	59.45^{c}+0.08	89.57^{a}+0.03
Breakdown Viscosity (RVU)	13 .92^{c}+0.03	35.60 ^{b}+0.03	11.76^{d}+0.03	52.57 ^{a}+0.02
Setback Viscosity (RVU)	117.18 ^{a}+0.03	47.09^{b}+0.03	20.44^{c}+0.03	19.51^{d}+0.06
Final Viscosity (RVU)	98.34 ^{a}+0.03	79.09 ^{c}+0.03	43.77^{d}+0.03	83.87^{b}+0.07
Peaktime (Mins)	6.81^{c}+0.03	7.68^{d}+0.03	11.75 ^{a}+0.03	9.41^{b}+0.01
Pasting Temp. (°C)	57.66^{d}+0.03	88.43^{b}+0.03	70.50^{c}+0.03	89.95^{a}+0.00

Values are mean ± SD of triplicate determinations. Means within the same column with different letters are significantly different (p<0.05). PV=Peak Viscosity, TV=Trough Value, BV=Breakdown Value, FV=Final Viscosity, SV=Setback Viscosity, PTi=Pasting Time, PTe=Pasting Temperature, RVU=Rapid Visco Unit.

Discussions

The results of the functional properties of thermal processed *Mucana flagellipes* flour is shown above. The bulk density of the raw *Mucuna flagellipes* flour was 2.79g/cm^3 and that of the processed samples ranged from 0.85 to 1.92g/cm^3. The control samples (sample A) had significantly the highest bulk density of 2.79g/cm^3 compared to the autoclaved, roasted, and boiled that had 1.92, 1.87 and 0.85 respectively. The lowest bulk density (0.85g/cm^3) was recorded for boiled *Mucuna flagellipes* flours. The reduction in bulk density of boiled samples observed in this study is in agreement with the work of Akubor (2017) who reported that boiling and autoclaving lead to decrease in bulk density of foods. The low level of bulk density observed in the boiled and autoclaved sample is an indication that they will require simple packaging materials as Umerah et al. (2020) observed that bulk density is used to determine the packaging requirement and material handling in the processed of food products. The water absorption capacity of the raw *Mucuna flagellipes* flour was 6.68% . the processed samples ranged from 3.42 to 5.53% with the roasted sample having the least value (3.42%), while the autoclaved sample had the highest value (5.53%).All the treatments decreased the water absorption capacity of *Mucuna flagellipes* flour, boiling exerted a greater effect. Water absorption capacity represent the ability of a product to absorb water when there is shortage of water (Asouzu and Umerah, 2020). The decrease could be as a result of decrease in carbohydrate level as opposed to increase in the protein level. The oil absorption capacity of the raw *Mucuna flagellipes* flour was 6.58% and that of the processed samples ranged from 4.09% to 4.73%. The result showed that the boiled and roasted *Mucuna flagellipes* flours had higher (4.73% and 4.38%) than the samples processed by autoclaved (4.09%) treatment when compared with the raw sample which had the highest (6.58%) oil absorption capacity. Oil absorption capacity (OAC) is significant because it improves the mouthfeel of food and preserves flavor (Asouzu et al., 2020).The least gelation concentration of the raw *Mucuna flagellipes* flour was 15.61% and that of the processed samples ranged from 5.26% to 14.03% with the boiled sample having the least value (5.26%) while the roasted sample had the highest value (14.03%). Least gelation concentration is a measure of the minimum amount of blends of flour that needed to form gel or paste in a measured volume of water (Adebowale et al., 2005).

The peak viscosity of the processed sample ranged from 23.33 to 65.69 RVU and that of the raw sample was 14.49 RVU. Peak viscosity indicates the water holding capacity of starch and is often correlated with the final product quality. Peak viscosity is also the maximum viscosity developed during the pasting period. Peak viscosity is the ability of starch to form paste during cooking (Umerah et al., 2020). As the temperature increased during pasting, the starch granules swell and increase the viscosity of the paste until the peak value is reached. The low peak viscosity of boiled and roasted sample is of interest as gruel /porridge made from low peak viscosity sample will produce a soft consistent gruel during cooking and give room for more food which will provide nutrient and energy as oppose to autoclaved sample with high peak viscosity. The peak time of the raw *Mucuna flagellipes* flour was 6.81 min and that of the processed samples ranged from 7.68 to 11.75 min with the roasted sample having the highest value (11.75 min), while the boiled sample had the least value (7.68 min). The peak time is the time taken to attain the peak viscosity. Porridge with lower peak time will cook faster than the one with high peak time (Umerah et al., 2020). Boiled and autoclaved sample will cook faster than the roasted sample. The pasting temperature of the raw *Mucuna flagellipes* flour was 57.66 ^{O}C and that of the processed samples ranged from 70.50 to 89.95 ^{O}C. The result showed that all the processing treatments used in this study increased the pasting temperature of the *Mucuna flagellipes* flour. Pasting temperature is the temperature at which the porridge form gel (Umerah et al.., 2020). The high pasting temperature of the processed samples will not be suitable for food products that require low gel strength and elasticity. The trough viscosity of the processed samples ranged from 59.45 to 89.57 RVU and that of the raw sample was 45.91 RVU. The result showed that all the processing treatments increased the trough viscosity of *Mucuna* flagellipes flour samples. Therefore, to produce flour with low trough viscosity or hot paste stability, roasting and boiling treatments could be used to process the *Mucuna flagellipes* flour. The final viscosity of the processed samples ranged from 43.77 to 83.87 RVU and that of the raw *Mucuna flagellipes* flour was 98.34 RVU. The final viscosity is an indication of the ability of the starch-based food to form a viscous paste or gel after cooking and cooling (Otegbayo et al., 2006). The result showed that all the processing treatment employed had a decreased the final viscosity of the *Mucuna flagellipes* flour.

Conclusion

The processed samples have good functional properties which suggest that thermally processed *Mucuna flagellipes* flours may be used as functional ingredients in the production of some baked products. Generally, all the processing treatments decreased the functional properties of the flours.

The result of the pasting properties showed that the processing treatment used reduced gelatinization temperature thereby shortening the cooking time. These values are needful as modern techniques aimed at making production much cost-effective and in determining the ability of a sample to form a gel during processing.

Thermally processed *Mucuna flagellipes* flours have improved functional and rheological properties and can be utilized as functional ingredients.

Funding Agency: Tertiary Education Trust Fund (TETFund).
Funding Name: Tertiary Education Trust Fund (TETFund).
Grant Number: ESPOLY/CR/PF/276/VOL. II/1

References Cited

Akubor, P. I. (2017). Effect of Processing Methods on the Chemical Composition and Functional Properties of Pigeon Pea Seed. *Innovare Journal of Food Science; 5(4): 16-19.*

Asouzu, A. I., Oly-Alawuba and Umerah, N. N**.** (2020). Functional Properties and Chemical Composition of Composite Flour Made from Cooking Banana (Musa Paradisiaca) and Yellow Maize (Zea Mays). Research Journal of Food and Nutrition. 4 (2); 2020, PP 6-12, ISSN 2637-5583.

Asouzu, A. I. and Umerah, N. N**.** (2020). Rheology and acceptance of pap (*Zea mays)* enriched with *Jatropha carcus* leaves to improve iron status in children. *Asian Journal of Biochemistry, Genetics and Molecular Biology, 3*(2), 35-47. https://doi.org/10.9734/ajbgmb/2020/v3i230083

Enwere, N. J. (1998). "Foods of Plant Origin," Afro-Orbis Publications Limited, University of Nigeria, Nsukka, PP 194-199.

FAO (2011). *State of Food and Agriculture*. Rome, Italy: Food and Agriculture Organization in Developing Countries. Pp200-205.

Obi, C. D. and Okoye, J. I. (2017). Effects of Boiling and Autoclaving on the Chemical Composition and Functional Properties of *Mucuna flagellipes* Seed Flours. *International Journal of innovative food, nutrition and sustainable Agriculture*,5(2): 18-24.

Olorunda, A.O. (2000). Recent Advances in Postharvest Technologies of Banana and Plantain in Africa. *Proceedings of the First International Conference on Banana and Plantain for Africa,* Kampala, Uganda. *Published by the International Society for Horticultural Science (ISHS), Acta Horticulturae; Pp. 517-597*

Onimawo, I. A. and Akubor, P. I. (2012). Food Chemistry Integrated Approach with Biochemical Background. 2nd edn. Joytal Printing Press, Agbowo, Ibadan, Nigeria. Pp. 22-44.

Otegbayo, B.O., Aina, J.O. and Asiedu, R. (2006. Effect of storage on the pasting characteristics of yam starches. In: OAT Ebuehi (ed). Reforms in the food industry for meeting future challenges in Africa. *Proceedings of the 30th Annual Conference/General Meeting of the Nigerian Institute of Food Science and Technology, Sheraton Hotel and Towers and ASCON Conference Centre, Badagry, Lagos State, Nigeria. Pp. 187-188.*

Sanni, S.A. and Eniola, S.A. (2004). Sensory characteristics of plantain-wheat biscuits. In: G.O. Adegoke, L.O., Sanni, K.O., Falade, J. and Uzo-Peters, P.I. (Eds). *Proceedings of the 28th Annual Conference/AGM Nigerian Institute of Food Science and Technology, University of Ibadan, Ibadan, Nigeria. Pp. 152-153.*

Siddiq, M., Nasir, M. R., Ravi, D. D.K. and Butt, S.M. (2009). The Effect of Defatted Maize Germ Addition on Functional and Textural Properties of Wheat Flour. *International Journal of Food Properties*,12:860-870.

Singh, K.K, Datta, S., Fakrudin, B. and Goswami, T.K. (2005). Thermal Properties of Cumin Seed. *Journal of Food Engineering, 45:181-187*

Udensi, E.A. Oselebe, H.O. and Iweala, O.O. (2021). The Investigation of Chemical Composition and Functional Properties of Water Yam (Dioscorea alata): Effect of Varietal Differences. *Pakistan Journal of Nutrition*,7: 342-344.

Umerah, N.N. Oly-Alawuba, N.M., Asouzu, A. I. and Udeh-Oluah, C.G. (2020). Rheology and Functional Properties of Complementary Food Made from Maize (Zea mays) Supplemented with Crayfish (Euastacus spp) and Carrot (Daucus carota) Flour. *Asian Journal of Biotechnology and Genetic Engineering*.3(1): 41-48.

Wang, S.J. and Copeland, L. (2013). Molecular Disassembly of Starch During Gelatinization and its Effect on Starch Digestibility: a review. *Food Function, 4: 1564-1580.*