Original Research Article

Effect of watermelon rind (*Citrullus lanatus)* addition on the functional, pasting and microbiological quality of sorghum based *mumu*

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AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration between all authors. Author STG designed the study, performed the statistical analysis, managed the analyses of the study, wrote the protocol and wrote the first draft of the manuscript. Author SAA supervised the work. Author COA managed some of the literature searches. All authors read and approved the final manuscript.

Article information

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ABSTRACT

The effect of watermelon rind powder addition on the functional, pasting and microbiological quality of Sorghum based *mumu* was evaluated. Sorghum-based *mumu* was prepared from composite flours of 85:15, 75:15, 70:15 and 65:15% roasted sorghum flour and roasted partially defatted groundnut flour respectively and included with 0, 10, 15 and 20% watermelon rind powder respectively which were known as sample A, B, C and D accordingly. Subsequently, the functional, pasting properties and microbial quality was assessed. Functional properties values; Bulk density (0.89 to 0.80mg/100g), reconstitution index (4.99 to 4.89) and swelling index (2.35 to 2.20) decreased significantly ($p < 0.05$) with increase in watermelon powder addition while water absorption (10.36 to 10.97g/g), oil absorption (10.33 to 10.79) and foam capacities (12.46 to 13.85%) increased with increase in watermelon rind powder. The pasting properties; peak (302.22 to 292.44 RVU), trough (156.44 to 150.00 RVU) and Final viscosities (412.69 to 400.76RVU), and breakdown (149.95 to 140.59RVU) decreased significantly ($p < 0.05$) with increased in watermelon rind powder while setback viscosity (101.05 to 115.59RVU), pasting temperature (59.32 to 62.02^{o}C) and pasting time (4.93 to 5.13mins) increased. Microbial analysis revealed the following ranges: Total viable count, $0.5x10^{2}$ to$1.0x10^{2}$ cfu/g, fungi count of $6.1x10^{1}$- $9.9x10^{1}$ cfu/g and no coliform was detected. Overall, addition of watermelon rind powder showed good functional, pasting and microbiological qualities of sorghum based *mumu.*

Keywords: mumu, sorghum, watermelon rind, pasting

1. INTRODUCTION

Mumu is a Nigerian cereal-based food product processed from roasted sorghum, millet or maize and consumed particularly by *Tiv* people (adults and children). *Mumu* is in powdered form and can be reconstituted in cold water with sugar to taste. It can be eaten at any time of the day and served as

energy giving food. The class of people that consume *mumu* are mostly low income groups that cannot afford animal protein, therefore there is need to enrich *mumu* with plant proteins [1]
Sorghum, one of the cereals for production of *mumu* is rich in carbohydrate but low in protein and other micronutrients [2]. *Mumu* food product has gained a lot of attention among the over four million *Tiv* people and hence, the need to supplement it with locally available sources [3].

Groundnut also called Peanut is a legume crop that belongs to the family of Fabaceae, genus Arachis, and botanically named as *Arachis hypogaea.* Groundnuts are consumed in many forms such as boiled peanuts, peanut oil, peanut butter, roasted peanuts, and added peanut meal in snack food, energy bars and candies [4]. Groundnut, which is a rich source of protein and essential amino acids, can help in preventing malnutrition [5]. Blending of sorghum with groundnut will result in *mumu* with high protein content but low in micronutrient content [2].

Watermelon (Citrullus lantus) rind is the greenish outer covering of the fleshy, succulent sweet pulp and is usually wasted after consumption of the pulp. Watermelon rind is a good source of vitamins such as vitamin (A, C, B6, B2 and B3) and minerals such as (phosphorous, calcium, sodium,iron and zinc) [6]. Watermelon is also high in citrulline, an amino acid the body make use of to make another amino acid, arginine (used in the urea cycle to remove ammonia Cal from the body) [7]. The research by Gbaa *et al.*, [8] has shown that blending sorghum/groundnut *mumu* with watermelon rind powder had significantly improve the nutritional value of the product in terms of its macro and micronutrients content thereby improving the nutritional status of the consumers.

When starch-based foods are heated in an aqueous environment, they undergo a series of changes known as gelatinization and pasting. These are two of the most important properties that has effect on quality and aesthetic concerns in the food industry, since they affect texture and digestibility as well as the end use of starchy foods [9]. The functional properties of a food material affect how it interacts with other food components and determines its application and end use. Therefore, food items with good functional properties can be easily incorporated into other foods and will yield good quality and acceptable end products [10]. Pasting characteristic measures the viscosity of flours over a range of temperature and pressure and are used for predicting the ability of flour to form a paste when subjected to heat application in the presence of water [10] [11].

The aim of this study therefore is to determine how the addition of watermelon rind powder will affect the functional, pasting and microbiological quality of the *mumu* product.

2. MATERIAL AND METHODS

2.1 Sources of raw materials

Yellow sorghum (*Sorghum bicolor*) and Groundnut (*Arachis hypogaea)* were purchased from Wurukum Market, Makurdi. Locally available fresh watermelon free from physical disorder was purchased from railway market, Makurdi and the rinds were collected after the flesh has been separated.

2.2 Samples Preparation

2.2.1 Preparation of roasted sorghum flour

Roasted sorghum flour was prepared according to the method described by Ingbian and Adegoke [1] with slight modification, without fermentation of the grains. Sorghum grains were sorted and winnowed to remove grain stalk, sticks and remaining husk. The grains were further subjected to visual screening to remove foreign particles such as stones. This was followed by washing with water to remove dust, soil particles and any over floats. Damaged, diseased or discolored grains as well as immature or sprouted grains were discarded. Cleaned sorghum grains were oven roasted at 150°C for 60min.The roasted grains were kept under silica gel to avoid moisture re-absorption until when required for milling and mixing for formulation of blends. A hammer mill was used to mill the roasted grains and a sieve of 0.5mm was attached to collect the milled product.

2.2.2 Preparation of roasted partially defatted groundnut flour

Roasted defatted groundnut flour was prepared by the method described by Adjou *et al*., [12] with modification that the cake was milled into flour. The groundnuts were sorted to get rid of foreign matter, and roasted at 150^{o}C for about 6-8 minutes and then allowed to cool and the bran was removed and milled to obtain fine flour. To extract oil from groundnut flour, hot water extraction method was used. The flour was pressed in the mortal and pounded gently with addition of hot water till the oil was collected by pressing in muslin cloth. It was shaped and deep fried to form cake. The cake was cooled and milled into flour.

2.2.3 Preparation of watermelon rind powder

Watermelon rind powder was prepared as describe by Lee-Hoon and Norhidayal [13] Watermelon (*Citrullus lanatus*) rind was separated from washed fresh fruits manually with a stainless knife. The rind was cut into small pieces before drying in a hot air oven at 50^{o}C for 24 h. The only modification was that freshly cut watermelon rind of 8 mm thickness were placed on aluminium foil in hot air oven at constant air velocity (0.8 m/s). The dried slices of watermelon rind were then ground in a laboratory mill and further sieved through a 0.5 sieve screen to fine powder and kept in an airtight plastic container and stored in a cool dry place prior to use as shown in figure 1.

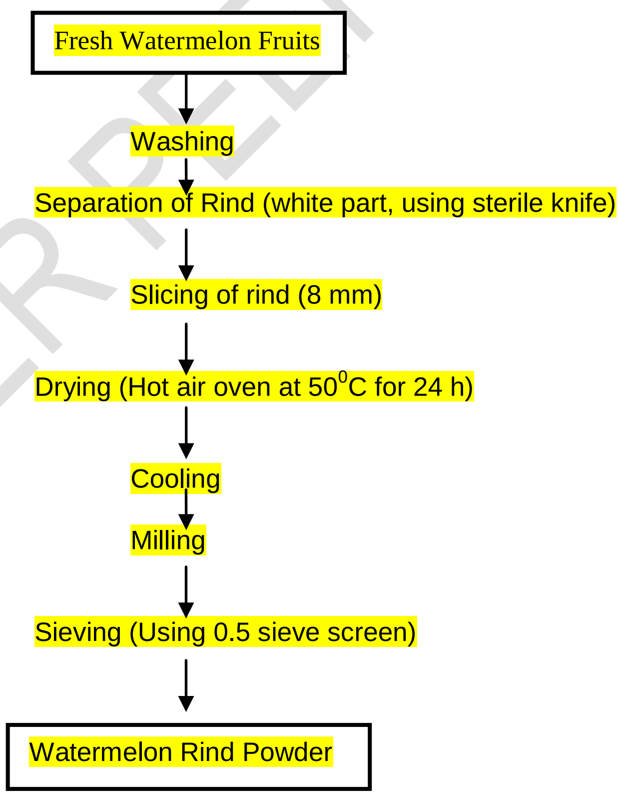

Fig. 1: Process flow diagram for watermelon rind powder.
Sources: Lee-Hoon and Norhidayah [13].

2.2.4 Formulation of blends

Four blends, A, B, C and D were formulated using different ratios; Sample A was comprising 85% roasted sorghum flour, 15% roasted defatted groundnut flour and 0% watermelon rind powder which served as the control; sample B comprising 75% roasted sorghum flour, 15% roasted defatted groundnut flour and 10% watermelon rind powder; sample C comprising 70% roasted sorghum flour, 15% roasted defatted groundnut flour and 15% watermelon rind powder and sample D comprising 65% roasted sorghum flour, 15% roasted defatted groundnut flour and 20% watermelon rind powder.

Table 1: Formulation of blends from roasted sorghum flour, roasted defatted groundnut flour, and watermelon rind powder.

Sample	% Roasted sorghum flour	% Roasted groundnut flour	% watermelon rind powder
A	85	15	0
B	75	15	10
C	70	15	15
D	65	15	20

Source: Gbaa *et al.,* [8]

2.2.5 Preparation of *mumu* Product

The resulting *mumu* from four blends A, B, C and D were prepared by reconstitution of powdered form *mumu* in cold water with desired consistency and sugar added to taste

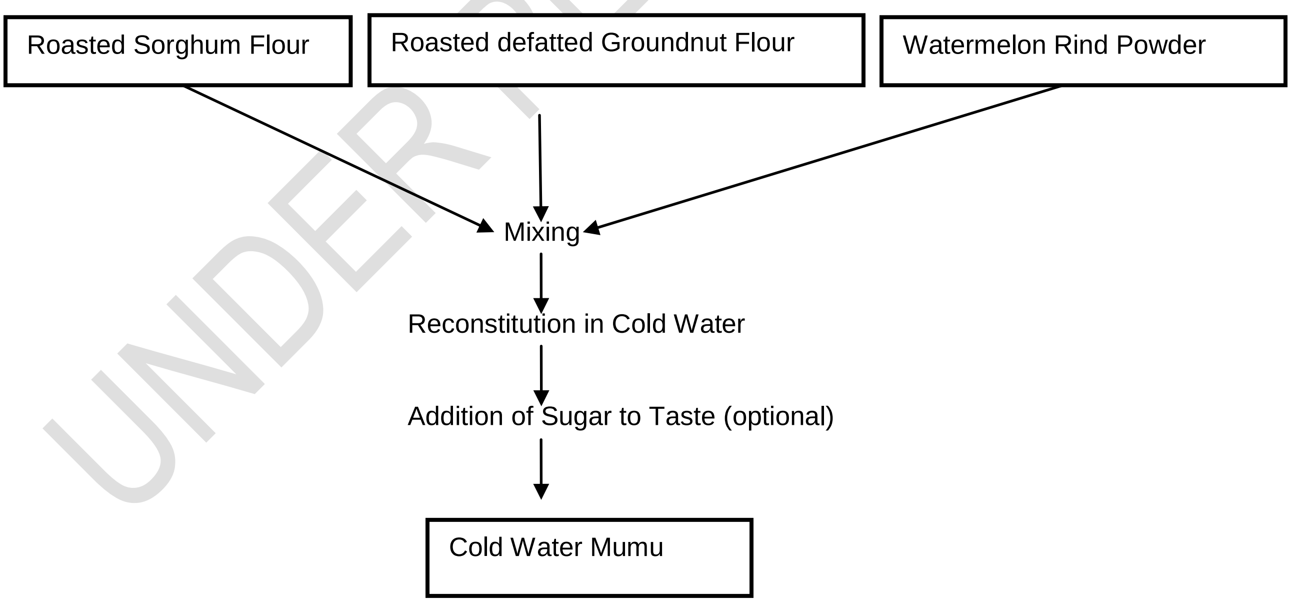

Figure 2: Flow diagram for the production of cold water *mumu*.
Source: (Ingbian and Adegoke, [3]

2.3 Determination of functional properties of *mumu*

2.3.1 Determination of bulk density

Bulk density was determined by method described by Onwuka [14] 10ml capacity graduated measuring cylinder and filled gently with each sample. The bottom of the cylinder was gently tapped on a laboratory bench several times until there was no further diminution of the sample level. Bulk density was calculated as shown below

$$Bulk\ Density = \frac{Weight\ of\ sample\ (g)}{Volume\ of\ the\ sample\ (ml)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

2.3. 2 Determination of water and oil absorption capacity

The oil and water absorption capacity was determined according to the method of Onwuka [14]. 1 g of sample was added to distilled water in 10ml distilled water/vegetable oil in a conical flask. The mixture was allowed to stand for 30 minutes at room temperature and then transferred into a graduated centrifuge tube. It was centrifuge at 500rpm for 30 minutes. The volume of water/oil absorbed (total volume-free volume) was multiplied by the density of water absorbed or retained per gram of sample.

$$\text{Water/oil absoption capacity (g/100g)} = \frac{Density\ of\ wateror\ oil\ X\ Volume\ of\ Water\ or\ oil\ absorbed}{Weight\ os\ Sample} \ldots\ldots\ (2)$$

2.3.3 Determination of foaming capacity (FC)

The foaming capacity of the four blends was determined as described by Onwuka [14]. Two grams (2 g) of flour sample was blended with 100ml distilled water in a blender and the suspension was whipped at 1600rpm for 5 minutes. The mixture was poured into a 250 ml measuring cylinder and the volume was recorded after 30 seconds.

$$Foaming\ Capacity = \frac{volume\ after\ whipping - volume\ before\ whipping}{Volume\ before\ whipping}\ X\ 100\% \ \ldots\ldots \quad (3)$$

2.3.4 Determination of swelling index (SI)

The method as described by Onwuka [14] was used in the determination of the swelling index. One gram (1 g) of the flour sample was weighed into 10ml graduate cylinder. Five milliliters (5 ml) of distilled water was carefully added and the volume occupied by the sample was recorded. The sample was allowed stand undisturbed in water for one hour (1 h) and the volume occupied after swelling was recorded and calculated as:

$$Swelling\ index = \frac{Change\ in\ Volume\ of\ sample}{Original\ Volume\ of\ Sample} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (4)$$

2.3.5 Determination of reconstitution Index (RI)

The reconstitution index of the flour sample was determined according to method described by Onwuka [14] Five grams (5 g) of the flour sample was dissolved in 50 ml of boiling water. The mixture was agitated for 90 seconds and was transferred into a 50ml graduated cylinder and the volume of the sediment was recorded after settling for 30minutes.

$$Reconstitution\ index = \frac{Volume\ of\ sediment}{Weight\ of\ Sample} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

2.4 Determination of pasting properties of *mumu*

Pasting properties of *mumu* samples were determined according to AACC [15] using the rapid visco analyser (RVA). The composite flour sample (3.5 g) was weighed and dispensed into the test canister. Distilled water (25.0 ml) was thereafter dispensed into the canister (14 % moisture basis). The visco analyser was switched on and the pasting performance of the flour was automatically recorded on the graduated sheet of the instrument.

2.5 Microbial analysis

2.5. 1 Determination of total viable count (TVC)

The total viable count was determined according to the method of [16]. The samples were inoculated using nutrient agar after the serial dilution of the samples had been obtained with 1 g of each sample. Pour plate method was used. The colony count was done after 24 h of incubation at 37^{o}C using a colony counter and the number of colonies calculated using the following method.

$$TVC\ (CFU\ /\ g)\ =\ \frac{Number\ of\ colonies\ x\ Original\ concentration)}{(Dilution\ factor\ x\ volume\ of\ inoculums).}\quad \ldots\ldots\ldots\ldots\ldots\ldots\ (6)$$

CFU = Colony Forming Unit

2.5.2 Determination of total mould count (MC):

The mould count was determined using the method described by Prescott *et al*. [16]. After the serial dilution of the samples, they were inoculated using Sabauroud Dextrose Agar (SDA). Pour plate method was used. The colony count was done after 72 hours on incubation at 37^{o}C using a colony counter and the number of colonies calculated using the following method:

$$Mould\ count\ (CFU/g)\ =\ \frac{Number\ of\ colonies\ x\ Original\ concentration)}{(Dilution\ factor\ x\ volume\ of\ inoculums).}\ \ldots\ldots\ (7)$$

CFU = Colony Forming Unit.

2.5.3 Determination of total coliform count

The coliform was determine by the method describe by Prescott *et al.,*[16]. After the serial dilution of the samples, they were inoculated using Maconkey Agar. Pour plate method was used. The colony count was done after 72 hours on incubation at 37^{o}C using a colony counter.

2.6 Statistical analysis

Data obtained was subjected to Analysis of Variance (ANOVA) followed by Tukey's Least Significant Difference(LSD) test to compare treatment means; differences was considered significant at 95% (P≤0.05) (SPSS Version 21 software).

3. RESULTS AND DISCUSSION

3.1 Effect of Watermelon rind powder (WRP) addition on functional properties of sorghum based *mumu*

Table 2 shows the effect of WRP addition on the functional properties of sorghum based *mumu.* The bulk density of the samples decreased significantly (P<0.05) as addition of watermelon rind powder increase. Sample A had the highest bulk density (0.89 g/ml). The values obtained were lower than values (0.97-0.92 g/ml) for corn starch/sorghum flour and (0.98-0.96 g/ml) for sorghum/African yam bean flour reported by Okoye *et a*l., [17] and Okoye et al., [18] respectively. The bulk density of flours is important as it affects mixing, packaging, and transportation. Nutritionally, low bulk density is advantageous because it engenders consumption of more quantity of the lighter food item and this translates into more nutrients for the consumer [19].

Water absorption capacity of *mumu* samples showed significant (p≤0.05) increased as the watermelon rind powder addition increases. The values ranged from 12.36 to 13.31 g/g. Similar increased in the water absorption capacity of cowpea- water yam flour, cassava- sorghum flour meals, cocoyam-soybean-crayfish flour blends has been reported by Otunnola and Afolayan, [20], Oti and Akobundu [21]; Perez and Perez [22] respectively. The increased in water absorption capacity could be due to high water absorption capacity of WRP which is in agreement with finding by Olaitan et al., [23]. And on the other hand the difference in protein concentrations and the degree of interaction of such proteins with water [24]. Increase in water absorption capacity improves the structural matrix for holding water, sugars and other components [25]. According to Onyerekua and Adeyeye [26] high water absorption capacity is desirable for the improvement of mouth feel and viscosity reduction in food product.

The oil absorption capacity of the *mumu* samples showed significant (p≤ 0.05) increased as the level of watermelon rind powder addition increases. The values ranged from 10.31 to 10.97 g/g. The possible explanation of this may be due to dilution factor by fibre from addition of high fibre watermelon rind powder. Wang et al [27] reported that oil absorption capacity of cereals increases with increased in fibre. Apart from that, increased OAC means that the food material has high hydrophobic proteins; the more hydrophobic proteins demonstrate superior binding of lipids [28].

There was significant decreased (p<0.05) in the values of reconstitution index as addition of watermelon powder increases. The values ranged from 4.99 – 4.87. Although the samples easily reconstituted, the decrease in reconstitution index was an indication that increasing the content of the WRP in the *mumu* blends increases water absorption capacity which in turn improves the reconstitution ability of the *mumu* blends. Similar observations had been reported by Adebowale *et al.,*[29], Adegunwa *et al.,* [30].

The *mumu* samples decreased significantly (p≥0.05) in swelling capacity as the level of WRP addition increased. The values of the swelling index ranged from 2.55 to 2.20. Sample A has the highest swelling index of 2.35. This is in agreement with values (2.48 – 2.30g/ml) obtained by Akajiaku *et al.,* [31] in sorghum/wheat noodles. The result could be due to increase in protein content of the food product since Wang *et al.,*[32] reported that increasing amount of protein could inhibit the starch granules from swelling.

The foaming capacity increased significantly (p<0.05) with increased WRP addition in the *mumu* blends. The values ranged from 12.46 to 13.85%. This result is higher than the values obtained from wheat/ groundnut protein concentrate flour (5.25 – 9.20%) recorded by Ocheme *et al*., [10]. The observed foaming capacity increased could be as a result of increased protein content since since addition of watermelon rind powder has been reported to increase protein content of *mumu* [13]. Brou *et al.,* [33] also reported that foaming capacity is positively correlated with protein content.

Table 2: Effects of WRP addition on functional properties of sorghum based *mumu*

Samples	Bulk density (g/ml)	WAC (g/g)	OAC (g/g)	Reconstitution index	Swelling index	Foam capacity (%)
A	0.89^{a}±0.00	12.36^{d}±0.04	10.33^{d}±0.01	4.99^{a}±0.01	2.35^{a}±0.01	12.46^{d}±0.11
B	0.88^{b}±0.00	12.70^{c}±0.02	10.69^{c}±0.03	4.90^{b}±0.01	2.23^{b}±0.01	13.05^{c}±0.01
C	0.87^{c}±0.00	13.10^{b}±0.01	10.91^{b}±0.01	4.89^{c}±0.01	2.20^{c}±0.01	13.69^{b}±0.01
D	0.80^{d}±0.00	13.31^{a}±0.01	10.97^{a}±0.01	4.87^{d}±0.01	2.20^{cd}±0.01	13.85^{a}±0.05
LSD	0.001	0.043	0.031	0.013	0.015	0.020

Values are shown as mean ± standard deviation of replicates. Mean values followed by different superscript in a Column are significantly different (P<0.05).

***Key**:*

A = (85% Roasted sorghum, 15% roasted defatted groundnut), B = (75% Roasted sorghum, 15% Roasted defatted groundnut, 10% Watermelon rind powder), C = (70% Roasted sorghum, 15% Roasted defatted groundnut, 15% Watermelon rind powder), D= (65% Roasted sorghum, 15% roasted defatted groundnut, 20% Watermelon rind powder) LSD = Least Significant Different.

3.2 Effect of WRP addition on the pasting properties of sorghum based *mumu*

Table 3 shows effect of watermelon rind powder addition on the pasting properties of sorghum-based *mumu*. Peak viscosity is the maximum viscosity developed during or soon after the heating portion. It is the index of the ability of starch to swell freely before their physical breakdown [29] [34]. Peak viscosity decreased significantly ($p<0.05$) from 302.22 to 292.44 RVU as the level of WRP addition increased. Peak viscosity has been reported to be correlated with water binding capacity of starch which takes place at equilibrium point between swelling which causes an increase in viscosity while rupturing and realignment cause its reduction [35]. According to Osungbaro [36], high peak viscosity is an indication of high starch content. High peak viscosity values noted in the study is of processing advantage and has been reported to be significant in the preparation of stiff dough products made from cereal flours [37]

Trough viscosity is the maximum viscosity value in the constant temperature phase of the rapids visco analyzer pasting profile. In simple terms, trough viscosity is the point at which the viscosity reaches its maximum during either heating or cooling processes. It measures the ability of the paste to withstand breakdown during cooling [22]. Trough viscosity significantly ($P<0.05$) decreased as level of addition of WRP increases. The values ranged from 156.44 to 150.00 RVU. This result is similar to the range obtained (80.30 to 117 RVU) of Ofada rice [37] and 80 to 159RVU of African yam bean and brown cowpea seeds composite flour [38] but lower than trough viscosity values (820 to 536 RVU) of wheat and groundnut concentrate flour blends [10]. The significant high trough viscosity obtained in this study indicates the tendency of the *mumu* samples to break during cooking.

The breakdown viscosity is an index of the stability of the starch and a measure of the ease with which the swollen granules can be disintegrated [39]. There was significant ($P<0.05$) difference in breakdown viscosity. The values ranged between 149.95 to 140.59RVU. Sample A had the highest breakdown viscosity. The result of this study is similar the range 32.00-151.00 RVU for cereal grains reported by Adebayo, [40] and higher than values 2.38-126.59 RVU for acha, defatted soy bean and groundnut flour [41]. The higher the breakdown viscosity, the lower the ability of starch in the flour samples to withstand heating and shear stress while lower breakdown value indicates that the starch in question possess cross-linking properties [42].

Final viscosity is commonly used to define the quality of particular starch-based flour since it indicates the ability of the flour to form a viscous paste after cooking and cooling. It also gives a measure of the resistance of the paste to shear force during stirring [29] [43]. There was significant ($P<0.05$) decreased in final viscosity as level of addition of watermelon rind powder increases. The values ranged from 412.69 to 400.76 RVU. Sample A has the highest Final Viscosity. The final viscosity values obtained in this study are higher than 190.3 to 261 RVU reported for Ofada rice variety [37]. This result indicates that the final viscosities are important in determining the ability of the sample materials to form gel during processing [44]

The set back value of the food indicates the tendency of starch granules to retrograde on cooling [19]. There was significant ($P<0.05$) difference in the setback viscosity of the *mumu* samples as addition of watermelon rind powder increased. The setback value of the blends ranged between 115.59 to 101.05 RVU. The result of this research is similar to the range 115.37 to 139.49 RVU observed for cassava starch/mushroom [45]. Higher setback results indicate lower retrogradation during cooling of products [46]. When starch is heated in the presence of water and subsequently cooled, the disrupted amylose and amylopectin chains can gradually re-associate into a different ordered structure in a process termed retrogradation. Starch retrogradation is usually accompanied by a series of physical changes such as increased viscosity and turbidity of pastes, gel formation, exudation of water [47]

Pasting temperature is the temperature at which the first detectable increase in viscosity is measured and it is the index characterized by the initial change due to swelling of starch [48]. There was significant ($P<0.05$) increased in pasting temperature as inclusion of watermelon rind powder increases. The values ranged from 59.32 to 62.02 ^{o}C. The result obtained in this study is lower than range of 81.43 to 83.29 ^{0}C for cassava starch/mushroom [45]. A high pasting temperature usually indicates the flour has high water absorption capacity [48]. Therefore observed lower pasting temperature of sample A could be as the result of low water absorption capacity of the blend.

Pasting time is the measure of the cooking time [49]. There was significant ($P<0.05$) increased in pasting time as inclusion of watermelon powder increases. The pasting time ranged from 4.93 to 5.13min. The result is similar to the values 4.79 to 5.75min for cassava starch/mushroom observed by Ojo *et al*., [45]. The result indicates that sample A with pasting temperature of 4.93minutes requires shorter time to cook compare to sample D with pasting time of 5.13.

Table 3: Effect of WRP addition on the pasting properties of sorghum based *mumu*

Samples	Peak Viscosity (RVU)	Trough viscosity (RVU)	Breakdown (RVU)	Final viscosity (RVU)	Setback viscosity (RVU)	Pasting temperature (°C)	Pasting time (mins)
A	$302.22^{a}\pm0.11$	$156.44^{a}\pm0.40$	$149.95^{a}\pm0.05$	$412.69^{a}\pm0.52$	$101.05^{d}\pm1.04$	$59.32^{d}\pm0.01$	$4.93^{d}\pm0.00$
B	$300.06^{b}\pm0.03$	$155.11^{b}\pm0.88$	$146.04^{b}\pm0.95$	$411.17^{b}\pm0.93$	$108.10^{c}\pm0.01$	$59.86^{c}\pm0.01$	$4.99^{c}\pm0.01$
C	$298.33^{c}\pm0.01$	$151.04^{c}\pm0.06$	$141.14^{c}\pm0.95$	$402.04^{c}\pm0.05$	$111.59^{b}\pm0.50$	$59.99^{b}\pm0.01$	$5.01^{b}\pm0.01$
D	$292.44^{d}\pm0.55$	$150.00^{d}\pm0.00$	$140.59^{c}d\pm0.50$	$400.76^{d}\pm0.58$	$115.59^{a}\pm0.50$	$62.02^{a}\pm0.02$	$5.13^{a}\pm0.01$
LSD	0.528	0.907	1.347	1.142	1.184	0.017	0.012

Values are shown as mean ± standard deviation of replicates. Mean values followed by different superscript in a Column are significantly different (P<0.05).
Key: A = (85% Roasted sorghum, 15% roasted defatted groundnut), B = (75% Roasted sorghum, 15% Roasted defatted groundnut, 10% Watermelon rind powder), C = (70% Roasted sorghum, 15% Roasted defatted groundnut, 15% Watermelon rind powder), D= (65% Roasted sorghum, 15% roasted defatted groundnut, 20% Watermelon rind powder) LSD = Least Significant Different.

3.3 Microbiological quality of sorghum based *mumu*

The microbial examination of the products revealed different values for total viable count and fungi count as shown in Table 4. The total viable count ranged from 5.00 to 1.0×10^{2} cfu/g, while the fungi count ranged between 61 to 99 cfu/g. The contamination could have occurred during cooling and before packaging. Fungi such as yeast are commonly present as contaminants in cereals and can probably be attributed to the low value of the pH which creates ideal conditions for yeast growth [50]. The presence of micro flora may also be due to availability of more nutrients for microbial proliferation and enhanced metabolic activities [51]. However, the samples had low levels of bacteria and mould growth. No coliform was detected. The microbial counts were within the permissible limit set by the Standard Organization of Nigeria, which states that the counts of aerobic bacterial must not exceed 100 cfu/g. Thus the consumption of these products may not be fraught by the danger of contacting any food borne disease.

Table 4: Microbiological quality of Sorghum based *mumu*

Samples	Total Viable count (cfu/g)	Total mould count (cfu/g)	Total coliform count (cfu/g)
A	1.0×10^{2}	63	NG
B	0.9×10^{2}	88	NG
C	0.5×10^{2}	61	NG
D	1.0×10^{2}	99	NG

Values are shown as mean ± standard deviation of replicates. Mean values followed by different superscript in a Column are significantly different (P<0.05).
Key: A = (85% Roasted sorghum, 15% roasted defatted groundnut), B = (75% Roasted sorghum, 15% Roasted defatted groundnut, 10% Watermelon rind powder), C = (70% Roasted sorghum, 15% Roasted defatted groundnut, 15% Watermelon rind powder), D= (65% Roasted sorghum, 15% roasted defatted groundnut, 20% Watermelon rind powder) LSD = Least Significant Different, NG =No Growth

Conclusion

Addition of watermelon powder to sorghum based *mumu* produced good effect on the functional and pasting properties as well microbial safety of the product. Bulk density, swelling index and reconstitution of the *mumu* reduced significantly ($p < .05$) with increasing level of watermelon rind powder while, water absorption, oil absorption and form capacities increased. Peak time, peak, trough, breakdown, final, viscosities of the flour blends decreased with increase percentage of watermelon rind inclusion while the setback viscosity, pasting temperature and pasting time increased. The *mumu* samples blends had low levels of bacteria and mould growth. No coliform was detected Thus the consumption of these products may not be fraught by the danger of contacting any food borne disease.

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