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Effect of Particle Size on the Functional, Pasting and Textural Properties of Gari Produced from Fresh Cassava Roots and Dry Chips

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ABSTRACT

Three varieties of cassava roots were processed into gari from fresh roots and dry chips. The effect of particle size on the functional, pasting and textural properties was also evaluated. The results obtained for the functional properties showed that water absorption capacity ranged from 3.90 to 6.07ml/g, loose bulk density 0.42 to 0.53g/ml, packed bulk density 0.52 to 0.62g/ml and swelling index 2.77 to 4.63.Water absorption capacity, packed bulk density and swelling index all decreased with decreased in particle size. Pasting properties showed that final viscosity ranged from 126.50 to 331.42RVU, peak viscosity 119.67 to 322.67RVU, breakdown 30.92 to 177.67RVU, peak time 4.73 to 6.47RVU, trough 70.92 to 239.17RVU and pasting temperature 81.50 to 88.95^{0}C respectively. Textural properties showed that gel strength and gel consistency ranged from 1.44 to 1.93Seconds and 8.12 to 9.46cm. Final Viscosity showed highest in gari from dry chips of 98/2101 and this indicated that the sample is good for making sticky 'eba'. Gari from dry chips of 97/4779 with particle size >40µm had the highest peak viscosity value with lowest energy requirement for processing while gari made from fresh roots of 98/0067 with particle size 20µm had the height swelling index of 4.63 volume increase hence, produced the best quality gari in terms of swelling. Particle size caused a significant difference (p<0.05) in peak viscosity, trough, breakdown viscosity, final viscosity, setback viscosity, peak time, pasting temperature, gel consistency, swelling index and water absorption capacity of the samples analyzed and this demonstrated that separation of gari into different particle size range during gari processing will have a significant effect on its handling, end product quality characteristics and consumers acceptability.

***Keywords**: Functional Properties, Gari, Particle Size, Pasting and Textural Properties.*

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I. INTRODUCTION

Cassava (*Manihot esculenta Crantz*) is a very popular high energy root crop consumed in the tropics and many regions of the developing world including Nigeria. Cassava roots are highly perishable and a lot of post-harvest losses often occur during storage [1]. Cassava roots are processed into different products before consumption in order to detoxify, modify or to minimize wastage after harvesting. Several products are derived from processed cassava roots; prominent amongst these products is gari. Gari is eaten by almost everybody in the eastern part of Nigeria and hence its popularity. Gari is a starchy staple with high dietary energy and it is consumed by both young and old in almost all parts of Nigeria and many African countries [2].

Processing of cassava roots into gari consist of peeling, washing and grating followed by fermentation and dewatering in a jute bag for at least forty-eight hours and finally toasting. Storability of gari for more than three months in homesteads has been a problem in the country [3]. This low shelf life has been attributed to relatively high moisture content of traditionally processed gari and its exposed surface area [3]. Cassava chips store better than gari because chips have smaller exposed surface area. Report has shown that gari of acceptable chemical and sensory quality can be processed from dried cassava chips [4]. Pasting properties is an important index in determining quality gari during and after its reconstitution with hot water. The important component of pasting properties of starch is associated with a cohesive paste and has been reported to be significantly present in domestic products such as pounded yam, which requires high setback, high viscosity and high paste stability [5].

The quality of any gari is judged by the end users by its colour, degree of coarseness, moisture, taste, swelling capacity, HCN content and perhaps particle size. Several studies have been conducted on the pasting properties of gari but nothing has been reported as it affects particle size. Particle sizes have been reported to affect several functional characteristics of cowpea flours [6]. Though that of gari have been studied but its effect on the functional, pasting and textural properties of gari are scarcely reported hence this study.

This study was undertaken to determine the effect of particle size on the functional, pasting and textural properties of gari made from chips and fresh roots of selected varieties of cassava.

II. MATERIAL AND METHODS

2.1 Source of Raw Material and Sample Preparation

The cassava varieties (97/4779, 98/2101 and 98/0067) were harvested from Ebonyi State Agricultural Department Programme Farm, Onu – Ebonyi Izzi, Ebonyi State. The gari from the dry chips and fresh roots of cassava were processed using the method described by Ekwu and Ehirim [1].

2.2 Particle Size Analysis:

One hundred gramme of gari was placed on the topmost sieve of an Endicott sieve shaker and was vibrated for 10min. Siftings of 20, 40 and > 40µm were collected separately and used for the analysis.

2.3 Functional Properties:

The method described by Onwuka [7] was adopted with some modification for the analysis of water absorption Capacity. One hundred gramme of gari was weighed into a conical graduated centrifuge tube. Using a waring whirl mixer, the gari sample was thoroughly mixed with 10ml distilled water for 30 minutes. It was allowed to stand for 30 minutes at room temperature and then centrifuged at 5,000rpm for 30 minutes. The volume of free water was read directly from the graduated centrifuge tube. The water absorption capacity is expressed as amount of water absorbed (ml) ÷ weight of sample (g). A known amount of the sample (6 g) was weighed into a 10ml measuring cylinder. The bottom of the cylinder was gently tapped for five minutes from a height of 5cm. The bulk density was taken as the mass per unit volume of the sample. Calculation:
Bulk density (g/ml) = Weight of the sample / Volume of the sample after tapping. Loose bulk density was done before tapping the cylinder. The method described by Okaka *et al.* [6] was used in determining the swelling index. One gramme of each gari was placed in a separate measuring cylinder and 10cm^3 distilled water was added to each of them. The cylinder was allowed to stand at room temperature (28±2^{o}C) for 30 minutes. The volume of gari prior to the addition of water (A) and after standing when water was added (B) was noted, from which the percent volume change of the gari sample was calculated as (B-A÷ A) × 100.

2.4 Pasting Characteristics:

Pasting Characteristics were determined according to the procedure described by New Scientific [8]. Pasting properties were determined with a Rapid Visco Analyzer (model RVA+, Newport Scientific Australia). About 2.5g of gari samples were weighed into a dried empty canister and then 25ml of distilled water was dispensed into the canister containing the sample. The solution was thoroughly mixed and the canister was well fitted into the RVA as recommended. The slurry was heated from 50^{o}C to 95^{o}C with a holding time of 2mins followed by cooling to 50^{o}C with 2mins holding time. The rate of heating and cooling was at a constant rate of 11.25^{o}C per minute. Peak viscosity, trough, breakdown, final viscosity, setback, peak time and pasting temperature were read from the pasting profile with the aid of thermocline for windows software connected to a computer [8].

2.5 Textural Properties:

Gel strength was evaluated with the use of a penetrometer (Staphone - Seta Ltd. Surrey - England). A cylindrical metallic probe with a cross sectional diameter of 40mm was attached to the penetrometer. The probe was made to penetrate through the paste which is cylindrical (40mm diameter x 40mm height) in shape. The paste was prepared from gari sample with a calculated weight of gari solid (based on total weight of material i.e. gari and water) at 20% solid concentration in water (w/v dry basis). The time taken the probe to penetrate the sample was read.
Gel Consistency:

The consistency of the gari was determined using Adam’s consistometer. The gari was poured into the boiled water and stirred. It then cooled to 50^{o}C. The concentration of the paste was 10% total solids (w/v, dry basis) [9]. The cooled paste was poured into the Adam’s consistometer cup, which was then raised and the extent of flow was read after 30 Seconds [10].

2.6 Statistical Analysis:

Completely randomized design was employed in this study while data generated were analyzed using analysis of variance [11]. The means were separated using Fishers least significant difference [12].

III. RESULTS AND DISCUSSION

3.1 Effect of Particle Size on Functional Properties

The results of effect of particle size on the functional properties of gari from fresh cassava roots and dry chips were shown in Table 1. Water absorption capacities (WAC) of gari obtained ranged from 3.90 to 6.07ml/g. The gari from variety, 98/0067 processed from dry chips with particle size 20µm had the highest value while the sample from 98/2101 processed from fresh roots with particle size >40µm had the lowest value. The high WAC observed in variety 98/0067 from dry chips with particle size 20µm may be attributed to loose structure of the starch polymers while low value observed in gari from 98/2101 processed from fresh roots with particle size >40µm indicates the compactness of its molecular structure [13]. The WAC of the gari samples generally decreases with decrease in the particle size. Particle size significantly ($p < 0.05$) affect WAC of the samples in each variety irrespective of the processing method used.

Table 1: Effect of Particle Size on the Functional Properties of Gari.

Cassava Varieties	Processing methods	Particle Size (µm)	WAC (ml/g)	LBD (g/ml)	PBD (g/ml)	Swelling Index
98/2101	FG	20	5.67^{b}	0.51^{b}	0.55^{de}	3.44^{f}
		40	5.45^{cd}	0.50^{bc}	0.53^{ef}	3.17^{g}
		>40	3.90j	0.44^{fg}	0.53^{ef}	2.80^{h}
	DG	20	5.90^{a}	0.50^{bc}	0.62^{bc}	4.13^{c}
		40	5.10^{ef}	0.47^{e}	0.64^{ab}	3.73^{e}
		>40	3.93^{j}	0.43^{gh}	0.61^{c}	3.10^{g}
97/4779	FG	20	4.90^{g}	0.51^{b}	0.53^{ef}	4.03^{c}
		40	4.68^{h}	0.48^{de}	0.52^{f}	3.85^{de}
		>40	4.33^{i}	0.45^{f}	0.52^{f}	3.00^{g}
	DG	20	5.47^{c}	0.49^{cd}	0.65^{a}	4.00^{c}
		40	5.27^{de}	0.47^{e}	0.61^{c}	3.85^{de}
		>40	4.03^{j}	0.43^{gh}	0.60^{c}	2.77^{h}
98/0067	FG	20	5.90a	0.53^{a}	0.56^{d}	4.63^{a}
		40	5.60^{bc}	0.50^{bc}	0.57^{d}	4.15^{c}
		>40	5.07^{ef}	0.43^{gh}	0.53^{ef}	3.40^{f}
	DG	20	6.07^{a}	0.51^{b}	0.61^{c}	4.43^{b}
		40	5.70^{b}	0.48^{de}	0.62^{bc}	3.75^{e}
		>40	4.97^{fg}	0.42^{h}	0.64^{ab}	3.12^{g}
F-LSD			0.198	0.017	0.028	0.173

Means not followed by the same superscript in a column are significantly different ($p<0.05$).
FG - Gari produced from fresh cassava roots.
DG - Gari produced from dried cassava chips. WAC - Water absorption capacities of the gari.
LBD - Loose bulk densities of the gari. PBD - packed bulk densities of the gari.

Values of loose bulk densities (LBD) and packed bulk densities of gari obtained ranged from 0.42 to 0.53g/ml and 0.52 to 0.65g/ml respectively. These values are below the values recorded for gari produced in Delta, Edo and Cross River [14]. LBD of the gari samples increased as particle size increases. These low bulk densities could be of importance in handling operations like stirring of gari paste in the preparation of *eba*. Statistically, particle size significantly ($p<0.05$) affected the LBD of all the varieties except the 98/2101 processed from fresh roots. This may be attributed to varietal effect and processing method used. The packed density analyzed shown no definite trends of either increasing or decreasing with particle size. In gari from dry chips of 98/0067, packed density increased with decrease in particle size while other sample behaved differentially. This variation may be attributed to varietal effect which could not resist the overriding force used in packing of the gari.

Swelling index value of the gari analyzed ranged from 2.77 to 4.63. Sample of 98/0067(FG) with particle size 20µm had the highest value while that of 98/4779 (DG) with the particle size >40µm had the lowest value. Swelling index of the gari samples was affected by its particle size as they decreased with decrease in particle size. The higher the swelling index, the lower the associative forces [15]. This implies that the decrease in the swelling index of gari as particle size decreases could be attributed to the higher associative forces associated with compactness of smaller particles. Statistically, the swelling index of the samples as affected by particle size differs significantly ($p<0.05$) in all samples.

3.2 Effect of Particle Size on the Pasting Properties of Gari

The results effect of particle size on the pasting properties of gari samples are shown in Table 2. Pasting properties are used in determining the behaviour of starch during cooking and cooling operation hence could be an important determinant for any food suitability for industrial processing. Peak viscosity is the highest value of viscosity a cooked starchy paste like gari can attain during or soon after heating operation. The values of peak viscosity obtained in this study ranged from 119.67RVU to 322.67RVU. The gari from dry chips of 97/4779 with particle size >40µm had highest value while 20µm gari made from dry chips of 97/4779 had the lowest value .This result indicated that peak viscosity is more particle size dependent than cassava variety. Statistically, the peak viscosity of the samples are significantly affected by it particle size.

Trough is the minimum viscosity value in the constant temperature of the RVA profile and measure the ability of paste to withstand breakdown during cooling [16]. The values of trough ranged from 70.92 to 239.17RVU. Trough values of gari made from dry chips of 98/2010 was highest in particle size >40µm. The trough of gari samples increased with decrease in particle size for gari from dry chips of 97/4779, while the one made from 97/4779 (FG) increased with decrease in particle size (20 to 40µm) and then decreased with decrease in particle size (40 to >40µm). Values of trough of gari from 98/2101 decreased with decrease in particle size (20 to 40µm) and then increased with decrease in particle size (40 to >40µm). This may be attributed to varietal effect of the cassava and the processing method used in the preparation of the samples. Statistically, the trough of gari samples analyzed were significantly affected ($p<0.05$) by particle size.

Table 2: Effect of Particle Size on the Pasting Properties of Gari.

Cassava Varieties	Processing Methods	Particle Size (µm)	PV RVU	TV RVU	BD RVU	FV RVU	SB RVU	Peak Time	P. Temp
98/2101	FG	20	197.33^{e}	158.92^{d}	38.43^{j}	249.25^{e}	90.33^{f}	5.13^{ef}	88.20^{b}
		40	166.25^{h}	115.67^{f}	50.58^{d}	293.33^{c}	177.67^{a}	6.07^{b}	84.20^{d}
		>40	194.25^{f}	148.75^{e}	45.50^{g}	237.58^{g}	88.83^{g}	5.00^{gh}	87.45^{c}
	DG	20	259.50^{c}	189.75^{b}	69.75^{c}	282.17^{d}	92.42^{d}	5.07^{fg}	87.45^{c}
		40	135.08^{i}	98.00^{h}	37.08^{k}	160.17^{i}	62.17^{i}	4.93^{h}	88.95^{a}
		>40	278.17^{b}	239.17^{a}	39.00^{i}	331.42^{a}	92.25^{e}	5.20^{de}	84.10^{d}
97/4779	FG	20	133.50^{j}	85.08^{j}	48.42^{f}	145.25^{j}	60.17^{j}	6.00^{b}	83.65^{d}
		40	236.36^{d}	99.33^{g}	137.50^{b}	137.42^{k}	38.08^{i}	4.73^{i}	81.50^{f}
		>40	128.50^{k}	87.42^{i}	41.08^{h}	186.42^{h}	99.00^{c}	6.47^{a}	83.60^{d}
	DG	20	119.67^{l}	70.90^{k}	48.75^{e}	126.50^{l}	55.58^{k}	5.75^{c}	83.60^{d}
		40	189.93^{g}	158.92^{d}	30.92^{l}	245.67^{f}	86.75^{h}	5.27^{d}	88.30^{ab}
		>40	322.67^{a}	160.58^{c}	160.08^{a}	299.42^{b}	138.83^{b}	4.67^{i}	82.55^{e}
F-LSD			0.125	0.349	0.119	0.742	0.168	0.119	0.725

Means not followed by the same superscript in a column are significantly different at ($p<0.05$).

FG- Gari produced from fresh cassava roots. DG- Gari produced from dried cassava chips.

PV- Peak viscosity, SB- Setback viscosity, TV- Trough, BD- Breakdown, FV- Final viscosity and P.Temp-Pasting temperature.

The breakdown of viscosity of the gari samples ranged from 30.92 RVU to 162.08 RVU. The gari made from dry chips of 97/4779 with particle size >40µm had the highest value of all compared while the one with particle size of 40µm of same variety from dry chips had least value. The higher the breakdown in viscosity, the lower the ability of the sample to withstand the stress it undergoes during heating operations. Hence the gari made from dry chips of 97/4779 with particle size 40µm will be able to withstand more heating and shear stress than others. The breakdown of gari made from both fresh roots of 98/2101 and 97/4779 all increased with decrease in particle size (20 to 40µm) and then decreased with decrease in particle size (40 to >40µm) while the one made from dry chips decreased with decrease in particle size (20 to 40µm) and then increased with decrease in particle size (40 to >40µm). This variation in trend may be attributed to different processing methods. It was significantly affected ($p<0.05$) by particle size and the processing methods used.

Setback viscosity is the viscosity after cooling a cooked food material to 50^{o}C. It is an indication of how stable a cooked paste is after cooling. Values of setback viscosity ranged from 38.08RVU for gari made from fresh roots of 97/4779 (40µm) to 177.67RVU for gari made from fresh roots 98/2101(40µm). The high setback value of gari from particle size made from fresh roots of 98/2101(40µm) indicates that its paste would have a low stability against retrogradation while low setback value of gari made from fresh roots of 97/4779 (40µm) would show highest degree of paste stability after cooking if used in processing. This indicated that varietal effect and processing methods used may have contributed to the variation more than particle size effect.

Peak time is the time it takes a paste to be cooked and corresponds to the time at which the maximum viscosity develops during or soon after cooking. The peak time of gari paste obtained from the dried chips and fresh roots of cassava varieties ranged from 4.73 to 6.47min.These values are in line with what Etudaiye *et al.* [17] obtained for *fufu* flour. Gari processed from fresh roots of 97/4779 with the particle size, 40µm had the lowest value while the gari sample from dry chips of 97/4779(FG) with particle size, >40µm had the highest value. The peak time of the sample processed from dry chips of 97/4779 decreased with decrease in particle sizes while others indicated no definite trend of either increasing or decreasing. Statistically particle size significantly affected ($p<0.05$) the peak time of the *eba* studied in all the varieties and processing methods.

Pasting temperature is the temperature required for starchy food like gari to form a viscous paste *eba* during cooking. The pasting temperature obtained ranged from 81.50 to 88.95^{o}C and these values were greater than a previous report by Etudaiye *et al.* [17]. This may be attributed to differences in processing methods such as fermentation process, gratification, sieving processes which these samples were subjected to. However, pasting temperature was affected by particle size as well as processing methods. High pasting temperature value is an indication for ease of formation of paste and this implies that gari made from dry chips of 98/2101 with particle size (40µm) formed paste *eba* before any other gari studied.

3.3 Effect of Particle Size on the Gel Strength and Gel Consistency of Gari:

The gel strength of the gari ranged from 1.44 to 1.93Sec (Table 3). These results are in agreement with Osuji who studied the cohesiveness of *fufu* and concluded that cooling of cooked paste affected the firmness of the paste [18]. Gari produced from dry chips of 97/4779 with particle size 20µm had highest value while the one from fresh roots of 98/2101 with particle size 20µm had lowest value. Its values decreased with decrease in particle size for gari processed from dry chips of 98/2101 while other gari samples increased with decrease in particle size and then increased except for 97/4779 (FG) which decreased with decrease in particle size (20µm to 40µm) and then increased from 40µm to >40µm. This may be attributed to the particle size nature, varietals effect and processing method used which affected cooling rate of the gari paste. High value of gel strength in gari from 97/4779(DG) with particle size 20µm indicated its ability to form strong *eba* and would be mostly preferred by processors and consumers. Statistically, gel strength of the gari made from dry chips of 98/2101 was not significantly affected ($p<0.05$) by its particle size.

Table 3: Effect of Particle Size on the Gel Strength and Gel Consistency of Gari.

Cassava Varieties	Processing Methods	Particles Size (µm)	Gel Strength (Sec)	Gel Consistency (cm)
98/21011	FG	20	1.44^{j}	9.18^{d}
		40	1.88^{ab}	8.33^{g}
		>40	1.82^{bcd}	8.12^{i}
	DG	20	1.66^{fgh}	8.75^{e}
		40	1.70^{efg}	8.22^{h}
		>40	1.70^{ef}	8.45^{f}
97/4779	FG	20	1.77^{cde}	9.35^{b}
		40	1.62^{ghi}	9.25^{c}
		>40	1.86^{abc}	9.45^{a}
	DG	20	1.93^{a}	8.75^{e}
		40	1.68^{efg}	8.77^{e}
		>40	1.53^{ij}	9.46^{a}
F-LSD			0.0997	0.041

Means not followed by the same superscript in a column are significantly different at ($P<0.05$).

Gel consistency of the gari samples ranged from 8.12 to 9.46cm (Table 3). The gari from fresh roots of 98/2101 with particle size >40µm had the lowest value while the one from dry chips of 97/4779 with particle size >40μm had highest value. This shows that gari made from 97/4779 with particle size >40μm exhibited highest resistance to flow. The gel consistency of gari samples decreased with decrease in particle size for gari from fresh roots of 98/2101, while the one made from 97/4779 (FG) decreased with decrease in particle size (20 to 40μm) and then increased with decrease in particle size (40 to >40μm). This implies that a thickening effect was produced with particle size as gel becomes more viscous with increase in particle size. The results obtained are similar to the one reported by Adeyemi and Beckley in their study on *Ogi* fermentation [10]. The gel consistency of the sample processed from dry chips of 97/4779 increased with decrease in particle sizes while the one made from 98/2101(DG) decreased with decrease in particle size (20 to 40μm) and then increased with decrease in particle size (40 to >40μm). The differences may be as a result of varietal effect and processing method used. Statistically, the gel consistency of gari samples are significantly affected ($p<0.05$) by particle size.

IV. CONCLUSION

Final Viscosity showed highest in gari from dry chips of 98/2101 and this indicated that the sample would be good for making sticky '*eba'* while gari from dry chips of 97/4779 with particle size > 40μm had the highest peak viscosity value with lowest energy requirement for processing hence, is recommended for industrial use. However, gari made from fresh roots of 98/0067 with particle size 20μm had the highest swelling index of 4.63 volume increase hence produced the best quality gari in terms of swelling. Particle sizes of gari samples analyzed affected its functional, pasting and textural properties and this demonstrated that separation of gari into different particle size range during gari processing will have a significant effect on its handling, end product quality characteristics and consumers acceptability.

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