GLOBAL JOURNAL OF PURE AND APPLIED SCIENCES VOL. 9, NO.4, SEPTEMBER 2003: 517 - 522
 ISSN 1118-0579

A COMPARATIVE STUDY OF THE STARCH PASTING PROPERTIES OF UNPROCESSED AND PROCESSED CASSAVA (MANIHOT ESCULENTA) PLANTAIN (MUSA PARADISIACA) AND BANANA (MUSA SAPIENTUM) FLOURS

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(Received 14 June 2002; Revision accepted 9 January 2003)

ABSTRACT

Pasting properties (gelatinization temperature, gelatinization time, viscosity, ease of cooking and starch stability) of cassava, plantain and banana flours have been found to be affected by processing. Roasting and boiling, reduced peak viscosities drastically. Boiling reduced the peak viscosity of cassava from 1575 to 65Bu, decreases which ranged from 335 to 105Bu and 165 to 105Bu were also observed for banana and plantain respectively. Gelatinization temperature decreased with steeping time but increased with time of boiling while gelatinization time increased with steeping time from 21 to 23mins, 25 to 28mins and 25.3 to 35.5mins for cassava, plantain and banana respectively. Steeping also increased viscosity on cooling to 50^{0}C for plantain and banana only. All boiled samples had unstable starches while steeping enhanced the stability of banana and plantain flours but reduced the stability of cassava flour

Key words: Pasting properties, cassava, plantain and banana.

INTRODUCTION

Cassava *(Manihot esculenta)* plantain (musa paradisiaca) and banana (*Musa sapientum)* are indigenous to Africa. In Nigeria they are planted and used for different purposes and form an important source of carbohydrate in the diet.

Being very rich in starch (90% of the dry matter) cassava is mainly used in traditional human foods after more or less elaborate processing. It is estimated that about 70% of the total cassava harvested is processed into garri (a fried product prepared from pealed and grated cassava root) Ngoddy, (1977). Lafun (fermented cassava root flour), foufou (fermented cassava root paste) are very popular in the Western and Eastern States of Nigeria respectively. In Nigeria banana is essentially used as a fruit when ripe, in recent times unripe banana is used as a starch source in porridge as a weaning food for babies. Banana with its natural flavour retained could also be prepared into dehydrated products. Plantain is a versatile crop in the many popular delicacies and snacks. However, while the snacks and delicacies may be widespread throughout the country, it is only in the more humid regions that it is a major staple food. Though plantain is produced throughout the year, the major harvest comes between October and February.

Plantains are known to have an advantage over other starchy staple foods like yam, cassava or cocoyam where labour is an important factor of production as a result of its high energy returns per unit of labour. Therefore they are sources of the cheapest carbohydrate foods in terms of cost per hectare, per toune and per calorie (Ohazi, 1996).

Nutritionally, plantain is a good source of carbohydrate and is also rich in pro-vitamin A (carotene). Gastro intestinal disorders like diarrhea and vomiting can be treated with plantain. Plantain is also used as a carbohydrate source for diabetic patients. Water extracts of the roasted peel of plantain is used by the Efiks in Cross River State of Nigeria in place of 'akang' as a tenderizer of fluted pumpkin leaves during the cooking of the popular 'Otong' (Okro/ pumpkim soup). Roasted peel and stalk of plantain are also used for washing pots and cutlery. plantain leaves are used by some communities as wrappers for food. In the Cross River State of Nigeria, the Efiks use plantain leaves as wrappers for 'ekoki' (grated corn meal) and 'ayan ekpang' (grated cocoyam meal).

Published information on studies involving plantain is rather scarce and fragmentary.

In plant organisms, the storage carbohydrate is starch. Starch granules exhibit some orderly orientation and are completely insoluble in cold water and inaccessible to the

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plant metabolic enzymes. Food processing destroys starch structure, for instance, when starch is heated it undergoes an irreversible disorder transition called gelatinization causing starch granules to swell to a size several times its original size (Olkku and Rha, (1978), Mate, Quaetaert, Meerdink and Van't Reit 1998). The swelling temperature is influenced by a variety of factors including pH, pretreatment, heating rate and presence of salts and sugars (Deman, 1990). Heating starch suspension above a critical temperature leads to a tangential swelling of the amorphous region of the granules (Oates, 1997). It is worthy to note that within a starch preparation, the granules are not equally susceptible to enzymatic degradation of the manner amylose absorb to the granule (Oates and Powell, 1996), Giraut and Koop (1995)).

Steeping increases acidic content of samples, but the key functional property influenced by soaking is available carbohydrate, which is reduced (Anthony, et al, 1996), Khokhor, et al (1996).

The objective of this study was to analyze and compare the effect of the afore mentioned processing methods on the pasting properties of cassava, plantain and banana flours and to evaluate the extent to which a particular processing method can be used to enhance product utilization to both processor and consumer.

MATERIALS AND METHODS

Food processing techniques

The cassava (Manihot esculenta), unripe plantain (Musa paradisiaca) and unripe banana (musa sapientum) used were obtained from a farm in Etomkpe village, Akpabuyo Local Government Area of Cross River State. The plantain and banana were cut off from the stalk while the cassava tubers were washed with water to remove sand and dirt. They were all stored separately on benches in the laboratory.

Sample preparation

Samples used were carefully selected.
Each was divided into four proportions for flour production.

Control sample

The first lot was hand peeled, sliced into chips, and dried at 60^{0}C for 24 hours in an oven. The dried samples were individually ground into flour using a Kenwood, portable mill, sieved through a 300µm and stored individually in labeled air tight containers.

Steeped samples

In the second lot, chips of each sample were steeped in water at room temperature for 6hrs, 12hrs and 24hrs. At the end of each steep the chips were drip dried, oven dried at 60^{0}C for 24hrs and stored as described earlier in labeled airtight containers.

Boiled samples

The third portion was sliced into chips and placed in boiling water for 5,10 and 30 minutes respectively. Each was drained and oven dried as reported earlier and stored in labeled airtight containers.

Roasted samples

Samples of banana, plantain and cassava sliced into chips were individually placed in an oven at 165^{0}C for 2hrs. After roasting they were cooled and dried as described earlier and stored in labeled airtight containers.

Starch pasting properties

Brabender Amylograph (Mazurs, Schoch and Kite, 1957) was used. Starch slurry of 10% w/v concentration was prepared in distilled water and a total volume of 450cm^3 was obtained. The slurry was transferred into the Amylograph bowl and the head of the instrument slowly lowered into the bowl. The water value on the cooling system was turned on and the thermo regulator set at 30^{0}C as starting temperature with the recording chart pen at zero position. The slurry was allowed to heat to 30^{0}C. This took about 2minutes. The slurry was now heated to 95^{0}C and maintained at that temperature for 30 minutes. The temperature was then lowered to 50^{0}C for another 30minutes. The pasting (gelatinization) temperature was determined as the temperature in which the initial viscosity of the slurry increased. Peak viscosity which is the maximum viscosity attained during heating to 95^{0}C and viscosity after 30 minutes holding at 95^{0}C and gelatinization time which is the time in minutes from zero time to time increase in viscosity occurred were all determined.

RESULTS AND DISCUSSION

Pasting properties

The pasting properties of cassava, plantain and banana which include pasting temperature, gelatinization time, and viscosity, ease of cooking and starch stability were affected by the three methods of processing used.

Pasting (gelatinization) temperature

The pasting properties of cassava, plantain and banana as shown in Table 1

Table 1

Brabender amylograph pasting properties of processed cassava, plantain and bannana slurry

SAMPLE	Processing Method	Duration (Mins)	Gelatinization Temp (Tg)^{0}C	Gelatinization Time (Mg) Mins	Time to Reach peak viscosity (Mn) Mins	peak viscosity During Heat to 95^{0}c(Vp)	Viscosity after 30 mins holding at 95^{0}c(vr)	Viscocity on cooling to 50^{0}c(ve)	Ease of cooking (Min)	Starch Stability (Vp-Vr)
	Raw flour (control)	0	63	21.0	27.8	1575	330	595	5.2	1245
	Roasted	120	66	21.5	25.5	430	35	80	4.0	369
	Steeped	360	68	21.5	27.0	690	210	380	5.5	480
CASSAVA	Steeped	720	66	22.0	27.0	620	50	130	5.0	570
	Steeped	1440	64	23.0	27.0	670	88	180	4.0	582
	Boiled	5	50	13.5	42.0	35	25	45	28.5	10
	Boiled	10	53	18.5	43.0	10	5	150	24.5	5
	Boiled	30	54	14.5	37.0	5	110	354	22.5	-45
	Raw flour (control)		81	33.3	67.0	165	230	280	33.7	-65
	Roasted	120	76	29.0	43.0	175	145	205	14.0	30
	Steeped	360	76	25.0	34.5	545	240	405	9.5	305
PLANTAIN	Steeped	720	74	28.7	36.7	690	365	685	8.0	325
	Steeped	1440	72	28.0	35.0	905	455	870	7.0	450
	Boiled	5	67	22.0	56.5	205	240	425	34.5	-35
	Boiled	10	68	24.8	70.0	195	245	430	45.2	-50
	Boiled	30	69	23.0	43.0	105	140	425	20.0	-35
	Raw flour (control)		76	29.0	43.0	335	180	250	14.0	155
	Roasted	120	77	29.0	52.0	83	165	270	23.0	-82
	Steeped	360	76	25.3	31.5	690	240	405	6.2	450
	Steeped	720	71	33.0	43.5	905	485	745	10.5	480
BANANA	Steeped	1440	73	35.5	36.5	990	490	765	11.0	500
	Boiled	5	55	18.5	41.0	135	175	250	22.5	-45
	Boiled	10	55	17.0	48.0	130	145	245	31.0	-15
	Boiled	30	68	18.0	42.0	105	155	285	54.0	-50

- show the pasting temperature ranging between 63°C and 81°C with cassava having the lowest value of 63°C and plantain the highest value of 81°C, while Banana had a value of 76°C. Roasted samples had pasting temperature in the order cassava, < plantain < banana. Pasting temperature range for the steeped samples were 66-68°C (cassava), 70 to 76°C (plantain) and 71 to 76°C (banana) while the boiled samples had temperature range of 50 to 54°C, 64 to 68°C and 55 to 68°C for cassava, plantain and banana respectively.

The higher pasting (gelatinization) temperature of plantain followed by banana suggests that the crystalline size and association within their granules are of a higher order of magnitude than that in cassava starch. (Hoover, 1996). The observed reduction in gelatinization temperature due to processing was a direct indication of the rate at which each resultant flour could loose birefringence characteristic of its starch fraction (Singh, Voraputhaporn, Rao and Jambunathan, 1989). Possibly gelatinization temperature is an index of the temperature level at which the carbohydrate fraction of the food system affects its thickening power, in other words, water binding capacity is most effective from about such a temperature (Iwuoha and Kalu, 1995). This view agrees with the report made by Faboya and Asagbra (1990) that the starches with high pasting, (gelatinization) temperature have low (hot-paste) viscosities.

Gelatinization time

The gelatinization time was observed to be 21.0, 33.3 and 29.0 minutes for the control starches of cassava, plantain and banana respectively as shown in table 1. ... r. All processing methods led to reductions in gelatinization time for the samples with the exception of cassava, which exhibited an increased gelatinization time with steeping. For all three samples, the boiled flours had the lowest gelatinization time. This is probably due to the pregelatinization of the starch during processing.

Viscosity

Processing had diverse effect on the time the three samples attained their peak viscosities. Steeping slightly lowered this time from 27.8 to 27.0 minutes irrespective of steeping time while boiling led to high increase in the time it was attained (from 27.8 to 42.0 minutes) as shown in Table 1. This effect was pronounced in the case of boiled banana and plantain flours from 34.5 to 70.0 and 31.5 to 72.0 minutes for boiled plantain and banana flours respectively.

Processing had a very significant effect on the hot paste peak viscosity of a slurry of the three samples in two distinct manners (by increasing or decreasing) as shown in the Brabender viscograph. The control sample of cassava had the highest peak viscosity of 1575Bu compared to 335Bu and 1 65Bu for banana and plantain respectively. This high viscosity of cassava (1575Bu) was greatly reduced to 670Bu by steeping for 1440 minutes and 10Bu by boiling for 10 minutes compared to high increases from 165-905Bu and 335 to 990Bu for 1440 minutes for steeped plantain and banana flours respectively. Raw plantain and banana. boiled cassava, plantain and banana and roasted plantain and banana showed no appreciable or distinct peak viscosity on the Brabender viscosity chart; this also explains the effects of processing on the three samples. The results on viscosities of processed and unprocessed samples show that the significant differences are due to granule type which have effect on the hot paste peak viscosity of samples. On the other hand, peak viscosity is a function of gelatinization (pasting) temperature, the lower the pasting temperature, the higher the viscosity and vice versa. This is in agreement with observation made by Faboya and Asagbra (1990) that starches with high pasting temperature had low (hot paste) viscosities while studying the physicochemical properties of starches from some Nigerian cultivars of white yam. The observed changes in viscosities due to processing also agrees with the report made by Iwuoha and Kalu (1995) for processed (steeped, boiled and roasted) cocoyam flours.

Ease of cooking

Cassava was observed to be the easiest to cook with a cooking time of 5.2 minutes (as shown in table 1 followed by banana with a cooking time of 14.0 minutes and plantain the hardest to cook, 33.7 minutes. The method of processing had varying effects on the three samples. Steeping reduced appreciably the cooking time of all the flours though the effect was more on plantain and banana. An average of 75.8 per cent decrease was observed for plantain, while 34.0 and 33.0 percent decreases were obtained for banana and cassava respectively.

Starch stability

Cassava exhibited the highest starch stability of 1245Bu followed by banana 155Bu. while plantain had the most unstable starch of – 65Bu. Steeping led to a decrease in stability of cassava starch from 1245 to 480Bu, while increases of 65 to 450Bu and 155 to 500Bu were observed for plantain and banana starches respectively, as shown in table 1. Boiling drastically reduced the starch stability of all three samples rendering plantain and banana starches highly unstable with a fluctuating effect on stability of cassava starch.

CONCLUSION

Processing decreased all pasting properties of cassava except cooking time, reducing peak viscosity of cassava from 1515 to 10Bu for 10 minutes boiled sample. Steeping increased the viscosities of plantain and banana flours from 165 to 905 Bu and 335 to 90Bu for 1440 minutes. Ease of cooking also increased and starch stabilities increased from –65 to 450 Bu and 155 to 50 Bu for plantain and banana flours respectively.

This study shows that processing of cassava, plantain and banana led to modification in pasting properties probably due to the degree of interaction between and among protein/starch chains (Hoover, 1996) and porosity of starch granules. Since the use of food ingredients is based on their functionality (Pour-EL, 1981), it is therefore necessary to adopt processing methods, which enhance the functionality of the food substances for effective utilization.

Flours with relativély high diastatic activity and low paste viscosity produce dense pudding-like structures and are therefore not suitable for bread making. Unprocessed plantain and banana starches with low hot paste viscosities and unstable paste which do not favour bread making, could be improved by steeping other factors being equal. Thus steeping could be used to enhance pasting properties of plantain and banana, by increasing their hot paste viscosities, stabilities and subsequently reducing gelatinization temperature and time thus increasing the ease of cooking. The technological implication of the above mentioned effects is that less energy will be expanded when the carbohydrate source is being employed as a thickener or gelling agent (Iwuoha and Kalu, 1995). Boiling and roasting enhanced cold paste viscosity and could therefore be used for starch products or preparations which need stirring into paste in cold water for example 'break fast' meals and laundry starch. Boiling increased water and oil absorption capacities of all the samples. This is advantageous since this parameter determines the situations that involve water binding (Aguilera, Rossi, Hiche and Chichester, 1980). Food substances which absorb more water are highly preferred by the consumers and processors (Khokhar, Frias, Price, Fenwick and Hedley, 1996). Wolf (1970) in his work showed that this property enables bakers to add more water to doughs and improve handling characteristics. Soaking and boiling are also effective methods of improving the quality of food products due to the removal of some anti nutritional factors (Khokhor, Frias, Price and Hedley, 1996). Boiling also led to significant reduction in carbohydrate (amylose) contents.

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