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Full Length Research Paper

A NOTE ON THE LOSS OF RESISTANT STARCH FROM CASSAVA DURING TRADITIONAL PROCESSING INTO FOOD

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ABSTRACT

Resistant starch (RS), a prebiotic and functional food fiber wasrecently reported to be significantly lost during the traditional processing of cassava into food.This study was done to evaluate the role of different unit operations employed in cassava processing in this loss. The cassava variety, TMS 30555 was processed into three types of foods, *fufu*, *garri* and *abacha* and concentration of RS determined at intervals/after the different unit operations. RS was determined using the resistant starch assay kit of Megazyme International, Ireland. Soaking or dewatering, usually accompanied by fermentation operations were responsible for the highest rates of loss of RS. Sieving and washing also contributed towards significant losses. The unit operations, boiling and frying and culinary operations involving the application of heat resulted in increases in concentrations of RS in the foods. These principles can be exploited in developing processing techniques that will enable the retention of more RS in cassava based foods.

Key words:Cassava; processing;fermentation; resistant starch

INTRODUCTION

Resistant starch is defined as that fraction of starch which escapes digestion in the small intestine and passes into the large intestine where it is fermented by gut microflora. Resistant starch (RS) has been shown to have beneficial effects on insulin sensitivity and fatty acid (FA) metabolism in both healthy individuals and those with metabolic syndrome (Johnston *et al*., 2010; Maki *et al*., 2012; Robertson *et al*., 2012). These properties make RS an important prebiotic and functional fiber, which its consumption in the regular diet can be exploited in the prevention and management of chronic non communicable diseases. On this basis, several nutritionists including the American Dietetic Association (2008) have recommended the consumption of adequate amounts of dietary fiber from a variety of plant foods.

RS has been reported to occur naturally in starchy foods such as potato, corn and rice and recently at about96.9 g/kg in cassava (Moongngarm, 2013). Cassava would therefore, serve as a good source of RS in the diet, particularly in the developing countries where it constitutes the most affordable source of food carbohydrate.

However, Ogbo and Okafor (2015) have reported that processing using traditional methods can significantly reduce the RS content of cassava. In threeNigerian cassava based foods;*fufu*, *garri* and *abacha*studied by these authors, RS was reduced respectively, by 70.4 %, 52.8 %and 35.9 %. Unfortunately, the majority of methods employed in the processing of cassava remain traditional in many parts of the world. For example, other foods such as *attieke*, *chicouangue*, in tropical Africa, *mpondu* and *sago*in India, *tapai* and *getu* in Indonesia, *farinha de mandioca* and *tapioca* in Brazil and *bammy* in Jamaica are still produced using these methods(Olasupo*et al*., 2010; FAO, 1998). Even though the methods for the processing of these foods may seem to vary in different parts of the world, they are composed of similar unit operations. These operations include washing, size reduction and shredding, soaking, dewatering, fermentation, boiling and drying.

Food processing, depending on the unit operations involved is known to affect beneficially or adversely, the concentrations of RS in food. The objective of this study therefore, is to determine the role of the different unit operations employed in cassava processing on RS loss. A better understanding of these principles may be exploited in developing processing techniques that will enable the better retention of RS in cassava based foods.

MATERIALS AND METHODS

Cassava variety

The improved cassava variety, Tropical Manihot Species (TMS30555), identified by the International Institute for Tropical Agriculture (IITA),Ubiaja field, Edo State,Nigeria wasused for this study. Cassava roots were harvested from nine-month old plants.

Traditional processing of cassava roots into foods

Three processing methods considered representative of most traditional cassava processing methods adopted in different parts of the world were chosen for this study. These were processing into:*fufu*, wet mash of fermented fresh cassava tubers;*garri*, granular flour with a sticky sour fermented flavorand *abacha* or shredded cassava made from sun drying of boiled and fermentedcassava.

Processing cassava roots into *fufu*

The method described by Ogbo (2006) was adopted. Briefly, cassava roots were peeled, washed and cut into pieces of approximately 10 cm length X 5cm diameter. Retting was performed by completely submerging approximately 1.5 kg of the cassava pieces in 2 L of tap water, contained in 4L plastic buckets at room temperature(28°C) for four days.The retted roots, determined by softness to touch were hand pulverized, wet sieved and dewatered in a clean sack.Culinary preparation of the sieved mash was done by boiling the mash in water for a total of approximately 1h and then pounding into a dough-like consistency.

Processing cassava roots into *garri*

Cassava roots were peeled, washed and grated into a mash. Mash weighing approximately 5 kg was stuffed into a clean jute sack and dewatered using a mechanical press located near our laboratory. Dewatering and accompanying spontaneous fermentation were carried out at room temperature (28°C) for 72 h. The dewatered and caked mash was broken up using a coarse sieve (about 2 X 2 mm openings) and then, fried into *garri* granules. Frying was done in a shallow cast-iron pan over an open wood fire. The sieved cassava mash was spread thinly in the pan in 2-3 kg batches. A piece of calabash was used to stir the mash constantly while pressing it against the hot surface of the pan until frying was completed (Oluwole*et al*., 2004). Culinary preparation was done by stirring granules in hot water into paste.

Processing cassava roots into *abacha*

The traditional method of processing cassava roots into *abacha*was performed as follows; cassava roots were washed, boiled for 10min., peeled and sliced using a hand held shredder. The slices were soaked in water for 48 hours, then washed, drained and spread on mats to sun-dry. The apertures of the shredder used during this work yielded slices of about 0.4 mm thickness when dry.

Determination of resistant (RS)/ Effect of different processing unit operations

Samples were taken at different intervals and operations during the processing of the various foodsand prepared as follows;Cassava tubers were diced, and the various processed samples of foods broken up as appropriate and then dried in the oven (Gallenkamp) at 50ºC, until they attained less than 150 g/kg moisture (AOAC, 967.03, 2005). The dried samples were subsequently ground up using a hand operated grinder,to pass a 40 mm meshsieve.Samples were stored in desiccators at 4ºC during the period of the experiment.

Resistant starch was determined using a kit assay (K-RSTAR, Megazyme Bray, Co. Wicklow, Ireland). This kit follows the protocols of AOAC method 2002.02 procedures explicated by Niba and Hoffman (2003). Samples (100±0.5mg) prepared as already described were incubated with pancreatic α-amylase (0.01 mg/L) solution containing amyloglucosidase (AMG) for 16 h at 37°C with constant shaking. After hydrolysis, samples were washed thrice with ethanol (v/v, 99% and 50%). The separated pellet from supernatant was further digested with 2 M KOH. Digested pellet and supernatant were separately incubated with AMG. Glucose released was measured using a glucose oxidase-peroxidase (GOPOD) reagent kit (K-GLOX, Megazyme Bray, Co. Wicklow, Ireland) by absorbance at 510 nm against the reagent blank. The glucose content of the supernatant and digested pellet were used in calculation of Resistant Starch (RS) by applying the factor of 0.9.

Determination of total cyanide content of cassava foods

Total cyanides in dried processed food samples were analyzedspectrophotometrically (Jenway 6405UV/Vis) using the picrate paper method of Bradbury *et al*. (1999).

Statistical Analysis of data

All measurements were done in triplicate and data expressed as mean values ± standard deviation.Determination of the statistical significance of changes in RS content due to the different unit operations employed in cassava processing was performed by comparison of mean RS before and after each operation using the one tailed t-Test. Unequal sample variances were assumed(Microsoft Excel).

RESULTS AND DISCUSSION

Total cyanide content of cassava based foods

Average HCN in the foods were 5.0, 8.0 and 1.1 mg/kgrespectively, for *fufu*, *garri* and *abacha*.These values fall within the tolerance level (10 mg/kg) recommended by the FAO/WHO (1991).

Effect of processing into *fufu* on RS content of cassava

All the processing operationsof cassava into the wet mash of *fufu*resulted in decreases in its RS content. However, the culinary preparation of *fufu* resulted in asignificant increase (p = 0.024)in RS. Calculations from data obtained during this study show that at the point of consumption, *fufu*would have lost 68.4 % of RS originally present in the tuber (Table 1).

The major unit operations involved in *fufu* production are size reduction, soaking or steeping, fermentation and sieving/washing. Observations during this study show that soaking/fermentation werethe most important operations among these, with respect to loss of RS content. At the end of 84 h of this operation cassava had lost 66.7 % RS (Table 1).The fermentation, which occurs during the retting of cassava is spontaneous and involves a multiplicity of microorganisms, which include *Bacillus*and*Clostridium* species, yeasts andthe Lactic acid bacteria (LAB). These organisms producevarious enzymes including the plant cell wall-lysing enzymes, pectin methylesterase and pectatelyase, which their simultaneous activity leads to the softening of the tuber (Brauman*et al*., 1996). Softening of the tubers is probably a major mechanism for the loss of RS present in cassava. Softening makes RS accessiblefor digestion by microbial genera including theLAB, which are involved in the fermentation of cassava. These organisms have been shown to possess the ability to ferment RS (Haydersah*et al*., 2012). Decreases in RS concentration following fermentation have also been observed in other foods such assorghum flour (AbdElmoneim, *et al*., 2004) and legume based fermented foods (Yadav*et al*., 2007).

Table 1: Resistant starch content of cassava after different operations of processing into *fufu*

Operations during *fufu* processing	Mean RS (g/kg) in *fufu* during processing by traditional method
Cassava tuber	69.7 ± 0.9^a
Soaking/Fermentation:	
24 h	51.3 ± 3.3^b
48 h	50.1 ± 3.0^b
72 h	37.3 ± 1.5^c
84 h	23.2 ± 1.7^d
Sieving of wet mash	17.7 ± 4.0^e
Culinary preparation	22.0 ± 6.4^f

Means with different suffixes are significantly different at $p < 0.05$

The unit operation of size reduction was not expected to have any effect in its own capacity on RS since this process was immediately followed by soaking/fermentation. However, it increased surface area available on the tubers for biochemical and microbiological changes during the subsequent processes.

Sieving is performed by dispersing the retted roots in a basket held in clean water contained in a basin.A sieve cloth is subsequently used to remove excess water from this to obtain the wet mash. The sieving operation can therefore be considered to be combined with washing. A significant quantity of RS (Table 1) was lost during sieving because of the general loss of starch suspended in water during the removal of excess water.

Effect of processing into *garri* on RS content of cassava

At the end of processing as described in this paper,*garri* granulescan be eaten without further cooking. Most *garri*, however, is prepared for eating by adding to hot water and stirring to make a stiff paste or porridge, which is then eaten with soup or stew. Culinary preparation was notobserved to alter RS content of this food.

Two operations were observed to play key roles in RS losses during the processing of *garri*. Grating, which can be considered as a drastic size reduction process enhanced both microbial and biochemical activities resulting in significant loss of about 25 % of RS in the tuber. Loss of RS due to fermentation was similar in degree and apparently followed similar mechanisms as earlier described for *fufu.* Further loss of starch generally, would have also been enhanced by dewatering(Table 2).

Table 2: Resistant starch content of cassava after different operations of processing into *garri*

Operations during *garri* processing	Mean RS (g/kg) in *garri* during processing by traditional method
Cassava tuber	69.7 ± 0.9[a]
Cassava grating	52.1 ± 1.0[b]
Dewatering/Fermentation:	
24 h	37.4 ± 1.2[c]
48 h	30.5 ± 1.5[d]
72 h	24.5 ± 0.5[e]
Frying into granules/Cooling	42.6 ± 1.2[f]
Paste prepared by stirring in hot water	42.8± 2.9[g]

Means with different suffixes are significantly different at $p < 0.05$

The operation of frying during *garri* production resulted in an increase in the RS of the product (Table 2). This is as a result of the formation of some type 3 (RS3), also called retrograded starch during frying and subsequent cooling. Two important processes, heat-gelatinization of starch and drying are achieved during frying. Gelatinization leads to partial solubilization, which increases the availability of starch for digestion by amylolytic enzymes. However, upon cooling, starch, particularly, amylose, undergoes a relative slowre-association process commonly termed retrogradation. During this process, starch molecules re-associate as double helices and can form tightly packed structures stabilized by hydrogen bonding (Eerlingen and Delcour, 1995). This is a common process by which RS type 3 (RS3) is formed in foods.

Drying constitutes essentially, the removal of moisture. Zeleznak and Hoseney (1986) in studies on wheat have reported that the moisture content of a starch gel determines the extent to which that starch will retrograde, with maximum crystallinityoccurring in gels of 500-600 g/kg starch. Drying during the frying of *garri* may thereforehave an inhibitory effect on retrogradation and the corresponding formation of resistant starch.

Effect of processing into *abacha* on RS content of cassava

No change is expected in the RS of *abacha* during culinary preparation, which usually involves the soaking in water for a few minutes to soften the shreds. *Abacha* may also be eaten as snack with nuts such as palm kernel.

Processing of cassava into *abacha* resulted in the least loss, 34.2 % of RS relative to the tuber, when compared with *fufu* and *garri*. The major operations involved in *abacha* processing are size reduction in the form of shredding, boiling, soaking and fermentation as well as washing.Commencement of processing with boiling of the tubers, which increases RS content available in the tuber,may be considered advantageous (Table 3).Boiling is a process well known to play significant roles in the formation or depletion of RS in foods depending on how it is applied. Boiling will induce gelatinization of starch and eventually retrogradation when the tuber is cooled.Retrogradation principles as discussed earlier for *garri* would also apply here. Furthermore, boiling also results in the leaching of free sugars, thus yielding relative increases of overall RS concentration in such foods (Englyst*et al*., 1982; Englyst and Cummings, 1987).

Table 3: Resistant starch content of cassava after different operations of processing into *abacha*

Operations during *abacha* processing	Mean RS (g/kg) in *abacha* during processing by traditional method (boiled 10 min)
Cassava tuber	69.7 ± 0.9^{a}
Boiling	82.6 ± 3.0^{b}
Shredding	80.7 ± 2.7^{b}
Soaking/Fermentation 24 h	70.6 ± 2.6^{c}
48 h	57.1 ± 1.4^{d}
Washing	45.8 ± 2.2^{e}

Means with different suffixes are significantly different at $p < 0.05$

Shredding, a size reduction step, which follows boiling is less severe in this process than is used in *garri* processing and is followed immediately by soaking and fermentation. This step did not result in a significant loss of RS during the processing of *abacha*.

Soaking/fermentation and washing were the operations principally responsible for losses in RS. Fermentation exerted its effects as has been stated earlier for*fufu* and *garri*, while washing may have led to losses of RS and indeed starch generally from the tuber.

CONCLUSION

Soaking/Fermentation are the operations responsible for the highest rates of losses in RS during processing. Size reduction facilitates losses due to these operations. Other operations that result in RS losses are dewatering and washing. The unit operations,boiling and frying result in increases in concentrations of RS.A reduction in use and duration of operations leading to losses of RS and increase in use and duration of operations that improve RS content during traditional processing will enable the retention of more RS in cassava based foods.

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