ELSEVIER

Food Chemistry 82 (2003) 599–602

Food Chemistry

www.elsevier.com/locate/foodchem

Biochemical changes in cassava products (flour & gari) subjected to *Saccharomyces cerevisae* solid media fermentation

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Received 5 August 2002; received in revised form 10 December 2002; accepted 10 December 2002

Abstract

In an attempt to enhance the nutritional quality of cassava products (flour and gari), *Saccharomyces cerevisae* was used in the fermentation (solid media) of cassava pulp. The mash obtained was subsequently processed into flour and gari, the forms in which cassava products are popularly consumed in Nigeria. These products were analysed with regard to proximate composition, mineral composition and antinutrient content. The result revealed that there were significant increases in the protein [flour (10.9%), gari (6.3%)] and fat [flour (4.5%), gari (3.0%)] contents. Conversely, there were significant decreases in the cyanide content [flour (9.5 mg/kg), gari (9.1 mg/kg)], carbohydrate [flour (77.9%), gari (84.5%)] and mineral (Zn, Mg, Fe, Ca, Na and K) contents of the cassava products, except in the fermented gari where there was significant increase in the Mg and Fe contents. However, *Saccharomyces cerevisae* fermentation of the cassava did not bring about any significant changes in the tannin, crude fibre or ash contents of the cassava products. Heavy metals, such as Cu, Ni and Pb, were not detected in either the fermented or unfermented cassava products. Furthermore, nutrient increase was higher in cassava flour while the antinutrient decrease was higher in gari. It could be inferred that *Saccharomyces cerevisae*, a cheap and non-pathogenic saprophytic aerobe, could be used for enhancing the nutritional potential of cassava products by increasing nutrient (protein and fat) and decreasing cyanide contents.

Keywords: *S. cerevisae*; Cassava; Flour; Gari

1. Introduction

The enlarged root of the cassava plant, *Manihot esculenta Crantz*, is widely eaten in the tropics. In West Africa and parts of the Caribbean, a granular food known as gari (farinha in Caribbean) is produced by fermenting mash produced from grated roots and heating the fermented mash in a dry basin (Okafor, 1998). Before crushing, the roots are peeled to rid them of two outer coverings: a thin brown outer outer covering, and a thicker leathery parenchymatous inner covering (Okafor, 1998). Cassava is often considered an inferior food because the tuber is low in protein, essential minerals and vitamins (Aletor, 1993; Onwueme, 1978). Another drawback for the utilization of cassava as food is that certain varieties contain large amounts of cyanogenic glucosides (linamarin and lotaustralin), which can be hydrolysed to hydrocyanic acid (HCN) by the endogenous enzyme (linamarase) when the plant tissue is damaged during harvesting, processing or other mechanical processes (Conn, 1973). Cassava also contains tannic acid in the root; this substance imparts a dull colour to the processed products, which affects their market value and also acts as a growth-depressing factor by decreasing protein digestibility (Hahn, 1992).

However, in many cassava-growing areas, its use as food helps to alleviate problems of hunger and thus its importance in terms of food security in these areas cannot be over emphasized (Aletor, 1993). Thus, processes for upgrading the protein value and detoxifying cyanide of cassava, using solid substrate fermentation, have been developed at the experimental level in some countries, such as Canada (Reade & Gregory, 1975), Burundi (Vlavonou, 1988) and Nigeria (Akindahunsi, Oboh, & Oshodi, 1999) where *Rhizopus oryzae* was used for enriching cassava product with protein and detoxifying cyanide. This study is a continuation of our study on nutrient enrichment and detoxification of cassava products using cheap, non-pathogenic and saprophytic aerobic *Saccharomyces cerevisae*.

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0308-8146/03/$ - see front matter
doi:10.1016/S0308-8146(03)00016-5

2. Materials and methods

2.1. Materials

Cassava tubers were collected from the Research farm of the Federal University of Technology, Akure, Nigeria. The *Saccharomyces cerevisae* was collected from the Microbiology Department, Federal University of Technology, Akure, Nigeria. The chemicals used were of analytical grade, and glass distilled water was used.

2.2. Methods

2.2.1. Sample preparation

Cassava tubers were peeled, crushed, pressed using a hydraulic press, and the pressed pulp was later subjected to fermentation (Vlavonou, 1988). A pure strain of *Saccharomyces cerevisae* was sub-cultured and inoculated into 1 kg of the mash (cassava pulp) as the starter culture and 730 ml nutrient solution [urea (80 g), $MgSO_4$ $2H_2O$ (7 g), KH_2PO_4 (13 g) and citric acid (20 g)] and then allowed to ferment for 3 days. The product obtained was subsequently processed into flour and gari, The gari was produced by pressing the fermented pulp using a locally fabricated mechanical press and then fried in a hot metal dish to gari (Fig. 1) (Adewusi, Ojumu, & Falade, 1999).

2.2.2. Sample analysis

The proximate composition (ash, fat, crude fibre and carbohydrate) of the micro-fungi fermented cassava products was evaluated using the standard AOAC (1984) method and the protein content was determined using the micro-Kjeldhal method (N×6.25). The tannin content was determined using Makkar, Blummel, Bowry and Becken (1993) method while the cyanide content was determined using the method of De Bruijn (1971). The Na, Zn, Ca, Mg, K and Fe contents were determined on aliquots of the solutions of the ash by established flame atomic absorption spectrophotometric procedures using a Perkin-Elmer atomic absorption spectrophotometer (model 372; Perkin-Elmer, 1982).

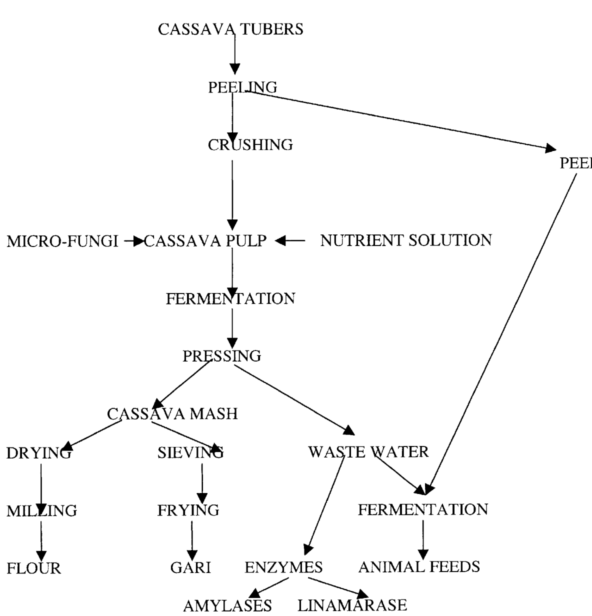

Fig. 1. Production chart for micro-fungi fermented cassava products.

2.2.3. Analysis of data

The results of the three replicates were pooled and expressed as means ± standard error (S.E). The data were analysed by students *t*-test; significance was accepted at $P \leqslant 0.05$ (Zar, 1984).

3. Results and discussion

The consumption of cassava as human food is of immense importance, which has caused it to be regarded as the mother crop for millions, particularly in the tropics. However, cassava as a staple has its problems of protein deficiency and cyanide toxicity. Since cassava products are indispensable food in many homes in Nigeria, methods for enhancing the nutrient content and reducing the antinutrients without adversely affecting the acceptability become very important (Oboh, 2002).

The results of the proximate analysis revealed that the protein contents (Table 1) of the *Saccharomyces cerevisae* fermented cassava products were higher [flour (10.9%), gari (6.3%)] than the unfermented cassava products. This high protein content could be attributed to the ability of the *Saccharomyces cerevisae* to secrete some extracellular enzymes (protein) into the cassava mash during their metabolic activities on the cassava mash during fermentation of the cassava by the fungi. The multiplication of the fungi in the cassava in the form of single cell proteins could also provide an explanation for the increase in the protein content of fermented cassava products (Akindahunsi et al., 1999; Okafor, 1998). However, the protein content of the flour is significantly higher than that of the gari. This could be attributed to the method of preparation of each of

Table 1
Proximate composition of fermented cassava products (% dry weight)

Sample	Flour		Gari	
	Unfermented	Fermented	Unfermented	Fermented
Protein	4.4c±0.1	10.9a±0.1	3.6c±0.1	6.3b±0.1
Fat	3.6ab±0.1	4.5a±0.2	2.6b±0.2	3.0ab±0.2
Crude fibre	3.8a±0.1	3.2a±0.1	4.3a±0.4	3.7a±0.2
Carbohydrate	85.7a±0.1	77.9b±0.3	87.2a±0.2	84.5a±0.3
Ash	2.1a±0.1	3.5a±0.1	1.9a±0.2	1.9a±0.1

Values are means ± S.E ($n = 3$). Means with the same letter(s) along the same row are not significantly different ($P > 0.05$).

the products. During the processing of gari, which entails pressing, sieving and frying of the fermented cassava, some of the protein may have leached off during pressing and burnt off during frying (Akindahunsi et al., 1999). It is documented that pre-processing, processing and post-processing methods of preparation of cassava products determine the quality of the products (Akindahunsi et al., 1999). The protein content of the product, as shown in Table 1, compared favourably with the protein content of *Rhizopus oryzae* fermented cassava products (Akindahunsi et al., 1999).

The reason for the unusually high fat content of the cassava products could not be explained. However, there could be possible transformation of carbohydrate to fat (Lehninger, 1987) while Akindumila and Glatz (1998) reported that certain fungi can produce microbial oil during the course of fermentation. The decrease in carbohydrate could be attributed to the possible transformation of some of the carbohydrate, which the organism possibly uses as its carbon source to some other metabolites, such as protein or fat (Lehninger, 1987). However, there was no significant change in the crude fibre or ash contents of the fermented cassava products.

Conversely, there was a significantly decreased mineral (Zn, Mg, Fe, Ca, Na and K) content of the cassava products, except in the fermented gari, where there was significant increase in the Mg content (Table 2). However, the mineral contents (Zn, Mg, Fe, Ca, Na and K) of the *Saccharomyces cerevisae* fermented cassava products (Table 2) were considerably low when compared with other food crops such as fruit (Oboh & Igbakin, 2002), mushroom (Olah & Oboh, 2001), yam tubers (Akindahunsi & Oboh, 1998) and vegetables (Akindahunsi & Oboh, 1999). Furthermore, the fermented gari had higher Fe, Mg, Ca and Na contents than the fermented cassava flour. Ni, Cu and Pb were not detected in either the fermented or unfermented cassava products.

The levels of antinutrients (cyanide and tannin) are shown in Table 3. Tannins affect nutritive value of food products by forming a complex with protein (both substrate and enzyme), thereby inhibiting digestion and absorption. They also bind Fe, making it unavailable, and recent evidence suggests that condensed tannins may cleave DNA in the presence of copper ions. Tannin also imparts a dull colour to the processed products, which affects their market value. There was no significant change in the tannin content of the fermented cassava products when compared with unfermented cassava products. The tannin contents of the *Saccharomyces cerevisae* fermented cassava products [flour (0.2%), gari (0.1%)] were very low when compared with the usual tannin content of cassava products (0.4–0.5%; Hahn, 1992). It is worth noting that the tannin content of the fermented cassava flour was higher than that of the gari, which indicates that the processes of garrification could also decrease the tannin content of cassava products. The tannin levels compared favourably with the 0.2% tannin content reported by Akindahunsi et al. (1999) for *Rhizopus oryzae* fermented cassava products. The products could also be considered to be safe with regard to tannin poisoning since the levels reported in this study are far below the critical value of 0.7–0.9% (Aletor, 1993).

There was a significant decrease in the cyanide content of the fermented cassava products when compared with the unfermented cassava products. The levels of the residual cyanide present in both the cassava flour (9.5 mg/kg) and gari (9.1 mg/kg) were very low when compared with the usual cyanide content of cassava products in Nigeria [gari, 19.0 mg/kg; fufu, 25 mg/kg] and the cyanide content of *Rhizopus oryzae* fermented cassava products [flour, 17.2 mg/kg; gari, 13.5 mg/kg]. This shows that baker's yeast is capable of utilizing cyanogenic glucosides and the breakdown products, thus explaining why it is one of the natural flora involved in cassava fermentation during gari processing (Akindahunsi et al., 1999; Oke, 1968). The cyanide levels are far below the detrimental level of 30 mg/kg (Akinrele, Cook, & Holgate, 1962). These products could therefore be considered safe with regard to cyanide poisoning. From this study, it could be concluded that baker's yeast, a cheap, non-pathogenic and saprophytic fungus, would efficiently increase the protein content of cassava products and reduce the level of cyanide, flour being richer than gari.

Table 2
Mineral composition of fermented cassava products (ppm dry weight)

Sample	Flour		Gari	
	Unfermented	Fermented	Unfermented	Fermented
Zn	13.1a±0.1	4.9b±0.2	5.8b±0.1	4.8b±0.1
Mg	43.4a±0.2	32.4bc±0.2	27.7c±0.5	34.1b±0.3
Fe	26.0a±0.4	2.2b±0.1	2.3b±0.1	2.8b±0.1
Ca	61.6a±0.7	11.0c±0.1	16.7b±0.2	13.8bc±0.1
Na	43.8b±0.3	29.6c±0.2	51.4a±0.3	30.8c±0.1
K	49.8b±0.4	38.4c±0.3	55.6a±0.4	36.9c±0.1

Values are means±S.E ($n=3$). Means with the same letter(s) along the same row are not significantly different ($P>0.05$).

Table 3
Tannin and cyanide contents of fermented cassava products

Sample	Flour		Gari	
	Unfermented	Fermented	Unfermented	Fermented
Cyanide (mg/kg)	21.3a±0.3	9.5c±0.2	14.6b±0.3	9.1c±0.2
Tannin (%)	0.2a±0.0	0.2a±0.0	0.2a±0.0	0.1a±0.0

Values are means±S.E ($n=3$). Means with the same letter(s) along the same row are not significantly different ($P>0.05$).

Acknowledgements

This work was done within the framework of the Associateship Scheme of The Abdus Salam International Centre for Theoretical Physics, Trieste, Italy. Financial support from the Swedish International Development Cooperation Agency is acknowledged, and financed in part by the Federal University of Technology, Akure, Nigeria's Senate Research Grant Number URG/MINOR/99/142.

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