Effect of Chemical Peeling on Microbiological Quality, Functional Characteristics and Yield of Some Fermented Cassava Products

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Abstract: Cassava roots peeling remains a serious global challenge due to their varying sizes and shapes. This results in over or under-peeling during mechanized and automated operations. This study was carried out to investigate the effect of chemical peeling on physiochemical, microbiological and functional characteristics of some cassava products. Yellow-fleshed cassava (IITA-TMS-IBA070593) was peeled by immersing the roots in 15% NaOH solution (lye) for 5 minutes. Softened peels were removed with brush under running water and neutralized with 3% citric acid solution at 30^{o}C. Cassava peeled with sharp stainless steel knife was used as control. Peeled roots were fermented into stiff dough mill known as *Gari* and *Fufu* after 72 and 96 hours respectively. pH, total titratable acidity (TTA) and total plate count (TPC), bacterial and fungal counts were determined on fermenting mash at 0, 24, 48, 72 and 96 hours respectively. Results showed that pH of submerged state fermenting mash for *fufu* and solid state fermenting mash for *gari* decreased as TTA increased during fermentation. pH decreased from 8.29 at 0 hour to 5.34 at 96 hours, while TTA increased from 0.20 at 0 hour to 1.60 at 96 hours. TPC increased from 0.5x 10^4CFU/g to 1.7x 10^4CFU/g, lactic acid bacteria count (LABC) increased from 1.9 x 10^4CFU/g to 20.8 x 10^4CFU/g, while fungal count increased from 1.8 x 10^4 CFU /g to 8.4 x 10^4 CFU /g. Dispersibility ranged from 40.50% to 75.50%, bulk density ranged from 0.59g/ml^3 to 0.78g/ml^3, water absorption capacity varied between 1.80g/g and 6.00g/g, while swelling power ranged from 14.39% to 15.50%. Products made from chemically peeled cassava compared favourably with knife peeled ones.

Keywords: Yellow-fleshed cassava, peeling, microbiological quality, functional characteristics

INTRODUCTION

Several unit operations involved in cassava processing have been mechanized successfully, however, cassava peeling remains a serious global challenge to design engineers involved in cassava processing (Abdulkadir, 2012). The problems encountered in peeling cassava roots arise from the differences in weight, size and shape they exhibit. Thus, it is difficult to design a cassava peeling machine that is capable of efficiently peeling all roots due to the wide differences in roots shapes and sizes (Arisa *et al*., 2016). Chemical peeling is a method often adopted in industries, factories and food processing companies. It involves chemical actions and thermal shock, which leads to softening and loosening of the skin using sodium hydroxide (NaOH) (Abdulkadir, 2012).

Fermentation plays important role in cassava processing and may be done in form of submerged or solid state process. Microorganisms such as lactic acid bacteria, yeasts and moulds are usually responsible for cassava fermentation (Westby 2002). It results in the production of different flavours, tastes, aromas and by products that aid the preservation of cassava products (Jones *et al.*, 1993).

Pro-Vitamin A cassava is a yellow-fleshed breed of cassava and is similar to ordinary varieties of cassava, but has high concentrations of β-carotene, which is a precursor to Vitamin A. It can provide up to 25% of daily recommended Vitamin A intake (Egesi, 2013). *Gari*, a fermented creamy white granular pregelatinized product is widely consumed in Nigeria and other West African countries as a staple food that contribute up to 60% total calorie intake of the population and is major a source of carbohydrate for many Nigerians. *Gari* comes in various granular sizes (International Institute for Tropical Agriculture (IITA), 1990).

Fufu is a fermented wet- paste made from cassava. It is ranked next to *Gari* as an indigenous food of southern Nigerians. It is rich in carbohydrate and has smooth texture. Nutritionally, 100g dry weight *fufu* contain 2g of protein, 0.1g of fat and 84g of carbohydrate. There are 267kcal of food energy in a 100g serving made up with water (Etudaiye *et al*. 2008).

This study aimed at evaluating some physiochemical, microbiological and functional characteristics of fermented cassava products (*Gari* and *fufu)* produced from chemically peeled yellow-fleshed cassava roots.

MATERIALS AND METHODS

Yellow-fleshed cassava roots (IITA-TMS-IBA070593) used for this work were obtained from Ikenne out station farm of International Institute of Tropical Agriculture (IITA), Ibadan and the research was conducted in the Food Technology Laboratories and Central Teaching and Research Laboratories of Bells University of Technology. Ota, Nigeria.

Peeling of Cassava

Modified peeling method described by Arisa *et al*. (2016) was adopted. Batches of washed and drained fresh cassava roots (20 kg) were respectively peeled manually using sharp stainless steel knife or by dipping the roots in 15% NaOH solution (lye) at 96^{o}C for a period of 5 minutes to loosen the peels, brushing and washing off loosened peels under running water. Peeled roots were treated with 3% citric acid solution at ambient temperature for 5 minutes to neutralize the effect of NaOH, thoroughly washed, drained and stored for subsequent use.

Gari processing

The peeled roots (7500g) were respectively processed into *gari* in the laboratory using the method described by Arisa *et al*. 2011. The peeled roots (8.55 kg) respectively for manually or chemically peeled roots were milled using a Sahara engineering cassava grating machine. The grated cassava mash was scooped into a porous bag, tightly tied and placed in a hydraulic press to dewater gradually and ferment for 72 hours. Fermented cassava mash was sieved to remove fibrous materials and to loosen the particles. *Garification* was carried out in a large shallow cast iron frying pan for 30 minutes. The *gari* was cooled and stored (room temperature) for subsequent analysis.

Fufu processing

Fufu was processed using the method described by Etudaiye *et al*. (2008). The peeled cassava roots (7500g) were cut into cubes of 3cm to 5cm long and were completely submerged in water at room temperature in a stainless steel bucket and left to ferment for 48 hours. They were drained and grated using Sahara Engineering grating machine soaked again in water for another 48 hours, sieved (150µm) and allowed to settle and sediment. Then dewatered in a muslin bag to form a firm cake which was dried in a Uniscope SM 9053 Laboratory oven (Surgifriend Medicals, England) at 60^{o}C for 24 hours then milled using Imex 10090123 disc attrition mill (Europe)).

Physiochemical analysis

The pH and total titratable acidity (TTA) of the of the fermenting gari and fufu mash were determined using the methods of AOAC, 2002).

Microbiological Analysis

Total plate counts, fungal and bacterial counts were determined at 0 hour, 24 hours, 48 hours, 72 hours and 96 hours (only for *fufu* samples) of fermentation as described by Atanda and Akano (1997). Samples (10 g) were respectively added to 90ml 0.9% saline to make stock solution. This formed the initial dilution from which subsequent ten fold dilutions were made and used for analysis. Portions (1ml) of 4th diluent (10^{-4}) was pour plated on Nutrient agar for total plate count. Man-Rogosa Sharpe (MRS) agar for lactic acid bacterial count and Yeast extract agar for yeast count. Plates were incubated for 24 hours at 37^{0}C for bacterial count and 48 hours at 25^{0}C for fungal count.

Functional properties analysis

Water absorption capacity was determined as described by AOAC (2002). Swelling power was determined using the method described by Takashi and Sheib (1988). Respective sample (1g) was weighed into a pre-weighed 15 ml plastic centrifuge tube. 10ml of distilled water was added, mixed gently heated in a water bath at 100^{0}C for 20 minutes. It was centrifuged at 3000rpm for 10 minutes. Weight of the sediment was recorded.

$$\text{Swelling power } (\%) = \frac{Weight\ of\ the\ mass\ of\ sediment}{Weight\ of\ dry\ matter\ in\ the\ gel}\ X\ 100$$

The bulk density of the sample was determined using the method described by Arisa and Aworh (2018).

The dispersibility of the sample was determined using the method described by Kulkarani *et al.* (1991).

Yield determination

Yield of cassava after both peeling and *Gari* and *Fufu* were also determined using the formula

$$\text{yield } (\%) = \frac{Weight\ of\ cassava\ after\ peeling}{Weight\ of\ fresh\ cassava\ before\ peeling} X\ 100$$

Results obtained were statistically analyzed using SAS (Statistical Analytical System) version 9.3 package. One-way analysis of variance (ANOVA) was carried out.

RESULTS AND DISCUSSION

Physiochemical characteristics of the *gari and fufu*

The effect of peeling treatments on the pH of fermenting *gari* and *Fufu* mash is presented on Figure 1. The pH of the fermenting mash of gari and fufu made from both peeling treatments decreased with increase in fermentation time (NaOH cassava peeled *fufu* (8.29 at 0 hour reduced to 5.34) at 96 hours and knife peeled (7.14 at 0 hour to 5.36) at 96 hours.

The total titratable acidity (Figure 2) of fermenting mash made into *gari* and *fufu* from knife and NaOH peeled cassava increased from 0.30 at 0 hour to 1.60 at 72 hours and 0.20 to 1.30 at 72 hours respectively for *gari* made from knife and NaOH cassava peeled *gari* this is in line with Adewumi *et al.* (2009).

The total plate count (TPC), lactic acid bacteria count (LABC) and fungal count (FC) are shown in Table 1. Fermenting mash of cassava peeled with knife had higher total plate count of $1.3x10^4$ CFU/g, higher lactic acid bacteria count of $2.2x10^4$ CFU/g and higher fungal count of $1.8x10^4$ CFU/g at 0 hour. Higher lactic acid bacteria count (LABC) of $13.8x10^4$ CFU/g and $10.3x10^4$ CFU/g for fermenting mash from cassava peeled with knife. While higher fungal count of $3.7x10^4$ CFU/g and $3.1x10^4$ CFU/g were obtained at 48hours and 72 hours respectively on fermented mash of cassava peeled with NaOH. Highest colonies were recorded for LAB count. This was similar to values reported by Olopade, *et al.* (2014). The fermenting mash of cassava peeled with knife had higher TPC of $0.5x10^4$ CFU/g, LAB count of $0.6x10^4$CFU/g and fungal count of $2.1x10^4$ CFU/g at 0 hour (Table 2), There was no growth on the mash from cassava peeled with NaOH. At 24 hours, the mash from cassava peeled with NaOH. had TPC of $1.7x10^4$ CFU/g, LAB count of $2.4x10^4$ CFU/g and fungal count of $3.9x10^4$ CFU/g. However, after 48 hours, the total plate count of the two cassava mashes progressively decreased.

Functional characteristics of the fermented *gari* and *fufu* products

Percentage dispersibility of the *gari* samples ranged between 40.50% and 45.50%, with higher value for *gari* made from cassava peeled with NaOH (Table 3). Bulk density of the *gari* samples were relatively close ($0.76g/ml^3$ and $0.78g/ml^3$). These values were higher than those reported by Achinewhu *et al*., (1998). The differences may have been due to difference in the variety of the cassava used and the peeling treatment.

The water absorption capacity (6.00g/g) obtained from the two treatments showed that chemical peeling had no effect on the water absorption capacity of the processed *gari*.

The water absorption capacity ranged between 1.80g/g and 2.20g/g, with *fufu* from cassava peeled with NaOH having higher value.

The swelling power of both *gari* samples were between 15.44% and 15.49%. Values obtained on swelling power of *fufu* samples from both peeling treatments were 14.39% and 14.70% and they compared well with the study of Achi and Akomas (2006) and were higher than 8.33 and 9.77% reported by Arisa and Aworh (2018) for manually and chemically peeled cassava flours.

Products yield

The yield of cassava from different peeling treatments is presented in Table 4. Peeling with NaOH resulted in higher peeled cassava yield of 81.85% than cassava peeled with knife (8.25%). The lower yield obtained from cassava peeled with knife could be attributed to the report of Oluwole and Adio that manual peeling in which knife is used to remove the peel is wasteful in terms of flesh loss (Oluwole and Adio, 2012). Cassava peeled with knife yielded higher percentage/quantity than that peeled with NaOH (32.16%, 37.14% respectively) (Table 5) The same trend was also followed for fufu (26.05% and 24.29 % respectively for knife peeling and NaOH peeling.

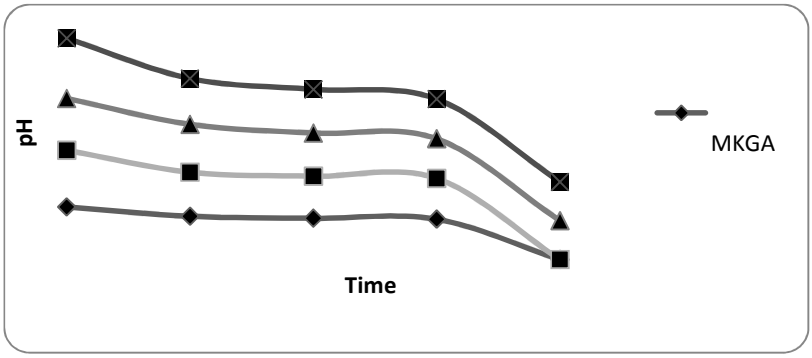

Figure 1: Effect of Peeling treatments on pH of fermenting cassava mash

Legends:

MKGA: Fermenting mash of cassava peeled with knife for *gari*
MNGA: Fermenting mash of cassava peeled with NaOH for *gari*
CKFU: Fermenting cassava mash peeled with knife for *fufu*
CNFU: Fermenting cassava peeled with NaOH for fufu

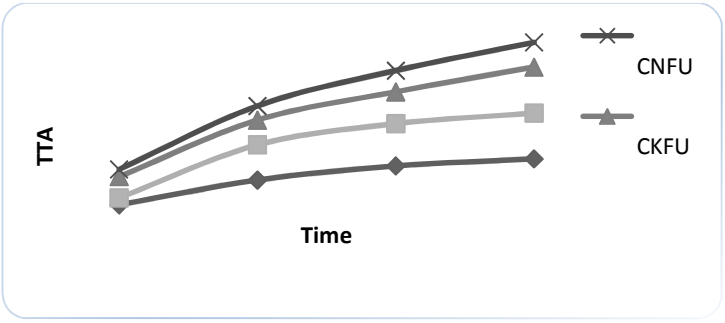

Figure 2: Effect of peeling treatments on total titratable acidity of fermenting cassava mash

Legends:

MKGA: Fermenting mash of cassava peeled with knife for *gari*
MNGA: Fermenting mash of cassava peeled with NaOH for *gari*
CKFU: Fermenting cassava mash peeled with knife for *fufu*
CNFU: Fermenting cassava peeled with NaOH for fufu

Table 1: Effect of peeling treatments on fermenting microflora of cassava mash into *Gari*

Sample	Fermentation time (hour)	TPC (10^4 CFU/g)	LABC (10^4 CFU/g)	Fungal Count (10^4 CFU/g)
MKGA	0	1.3	2.2	1.8
MNGA	0	0.5	0.6	1.7
MKGA	24	2.2	8.2	2.9
MNGA	24	1.8	8.2	3.7
MKGA	48	1.6	13.8	2.9
MNGA	48	1.4	11.8	3.7
MKGA	72	1.4	10.3	2.6
MNGA	72	1.8	8.9	3.1

Means of triplicate determinations

Legends:

TPC: Total plate count

LABC: Lactic acid bacteria count

MKGA: Fermenting mash from cassava peeled with knife

MNGA: Fermenting mash from cassava peeled with NaOH

Table 2: Effect of peeling treatments on fermenting microflora of cassava mash into *Fufu*

Sample	fermentation	TPC (10^4 cfu/g)	LAB (10^4 cfu/g)	Fungal Count (10^4 cfu/g)
CKFU	0	0.5	1.9	2.1
CNFU	0	NG	NG	NG
CKFU	24	1.4	5.1	4.8
CNFU	24	1.7	2.4	3.9
CKFU	48	1.2	11	4.4
CNFU	48	1.3	10	4.2
CKFU	72	1.4	16	8.4
CNFU	72	1.4	17.9	7.5
CKFU	96	0.7	19	1.8
CNFU	96	0.7	20.8	1.9

Means of triplicate determinations

Legends:

TPC: Total plate count

LABC: Lactic acid bacterial count

CKFU: Fermenting cassava peeled with knife

CNFU: Fermenting cassava peeled with NaOH

NG: No growth

Table 3: Effect of peeling treatments on functional properties of some fermented cassava products

Sample	Dispersibility test (%)	Bulk density (g/ml^3)	Water absorption capacity (g/g)	Swelling power (%)
KNGA	40.50±0.71	0.76±0.02	6.00±0.00	15.50±0.48
NAGA	45.50±0.71	0.78±0.04	6.00±0.28	15.44± 0.07
KNFU	75.50±0.71	0.59±0.01	1.80±0.14	14.70±0.61
NAFU	70.50±0.71	0.74±0.03	2.20±0.00	14.39± 0.56

Mean values± standard deviation

Legends:

KNGA: *Gari* made from cassava peeled with knife

NAGA: *Gari* made from cassava peeled with NaOH

KNFU: *Fufu* made from cassava peeled with knife

NAFU: *Fufu* made from cassava peeled with NaOH

Table 4: Effect of peeling treatments on yields of cassava

Sample	Weight of cassava (kg)	Weight of peeled cassava (kg)	Weight of peels (kg)	% weight of peeled cassava (kg)
KNCA	20.00	15.65	4.35	78.25
NACA	20.00	16.37	3.63	81.85

Legends:
KNCA: Cassava peeled with knife
NACA: Cassava peeled with NaOH

Table 5: Effect of peeling treatments on yields of some fermented cassava products

Sample	Weight of Cassava (kg)	Weight of product (kg)	% weight of product (kg)
KNGA	8.55	2.75	32.16
NAGA	9.29	3.45	37.14
KNFU	7.10	1.85	26.05
NAFU	7.08	1.72	24.29

Legends:
KNGA: *Gari* made from cassava peeled with knife
NAGA: *Gari* made from cassava peeled with NaOH
KNFU: *Fufu* made from cassava peeled with knife
NAFU: *Fufu* made from cassava peeled with NaOH

CONCLUSION

The physiochemical, microbiological and functional characteristics of the *gari* and *fufu* produced from the yellow-fleshed cassava roots were not affected by the peeling treatment. This showed, that chemical peeling can be used for peeling cassava roots for the production of *gari* and *fufu* in order to overcome the problem of under peeling or over peeling experienced in mechanized cassava peeling.

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