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Levels of Cyanide in Cassava Fermented with Lemon Grass (*Cymbopogon citratus*) and the Organoleptic Assessment of its Food Products.

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Abstract: The effects of *Cymbopogon citratus* (lemon grass) on the detoxification of cassava tubers and the sensory evaluation of their cassava fufu products were investigated. One kilogram of freshly harvested cassava tuber was fermented with varying amounts (1.0, 2.0, 3.0, 4.0 and 5.0 g) of lemon grass for one to five days. Fermentation resulted in a decrease in the cyanide content and this was significant ($P<0.001$) by the 5th day in all the treatments. However, the cyanide content of cassava tubers fermented with 2.0 g and 3.0 g lemon grass showed the lowest content of residual cyanide (0.81 and 1.08 mg HCN/100 g wet weight respectively). Furthermore, the 'fufu' (a dough) produced from the fermented cassava products using 1.0 g and 2.0 g lemon grass were most acceptable as judged by a 10-point sensory evaluation. Thus, 2 g of lemon grass per kilogram of cassava is recommended for use in the fermentation of cassava for the production of fufu in order to achieve optimal detoxification and acceptability.

Key words: Lemon grass · Cassava · Cyanide · Detoxification · Fufu · Fermentation

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) originated from Brazil and was introduced to Africa by Portuguese traders in the 16th century [1]. Cassava is mainly utilized as human food and in Africa, the most commonly consumed forms of cassava food products are garri and fufu [2]. Cassava roots provide about 30% of Africans staple food and its starch content is known to be highest producer of carbohydrate among the staple food crops [3].

However, cassava contains cyanogenic glycosides (linamarin and lotaustralin) in its root, which when hydrolyzed release hydrocyanic (prussic) acid, a toxic chemical [4,5]. Fermentation, the most common method of processing the cassava crop in Africa [6], has been reported as one of the best ways of eliminating cyanogens from cassava. However, one limitation of fermented products is the production of pungent odour; and in addition, the protein and micronutrient contents of cassava products are low [7]. Thus, there is need to improve cassava fermentation in order to eliminate odour and enhance the nutritional quality of the products.

This study investigates the effects of varying amounts of lemon grass (*Cymbopogon citratus*), on cyanide loss from cassava tubers during fermentation and the sensory quality of the obtained fufu meals. Lemon grass was used in this study because it is commonly used as a traditional herbal condiment to enhance food flavours.

MATERIALS AND METHODS

Preparation of the Spice: Five hundred grams of lemon grass (*Cymbopogon citratus*) leaves was weighed. This was spread on a tray and dried in an oven at 65°C for 48 h. The dried leaves were then milled into powder using a blender (SMB 2898 SUPER MASTER, JAPAN).

Fermentation of Cassava Samples: Six plastic buckets were used as fermenters. Freshly harvested cassava tubers were peeled and 1.0 kg portion was weighed and washed in clean water. Each kilogram portion was placed in a plastic bucket containing a litre of clean water and 1.0 g, 2.0 g, 3.0 g, 4.0 g and 5.0 g of powdered lemon grass were separately added to five of the plastic buckets each containing 1.0 kg of cassava tuber. The sixth bucket with 1.0 kg cassava tuber served as the control. The cassava tubers were fermented for 5 days at room temperature. On each day of fermentation period, 20.0 g of each sample including control was mashed using mortar and pestle and the cyanide content was determined using steam distillation apparatus.

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Determination of Cyanide Content: The cyanide content of each sample was determined using the alkaline titration method [8]. Twenty gram of the mashed cassava sample was placed in a litre round bottom flask and mixed with 200 cm^3 distilled water. The mixture in the flask was allowed to stand for 3 h, after which it was steam distilled until 150 cm^3 of distillate was obtained.

Twenty centimeter cube of 0.02 M sodium hydroxide solution was added to the distillate and the volume was made up to 250 cm^3 in a volumetric flask. From the diluted distillate, two aliquots, each 100 cm^3 were obtained. To each of the aliquots, 8 cm^3 of 6 M ammonia solution and 2 cm^3 of 5% potassium iodide solution were added. The mixture obtained was titrated with 0.02 M silver nitrate ($AgNO_3$) solution. The end point of the titration was reached when the solution changed from a clear solution to a faint turbid solution. A blank sample was prepared using 150 cm^3 of distilled water in place of the cassava distillate. The amount of cyanide in the sample was determined from the relation: 1cm^3 0.02M $AgNO_3$ = 1.08 mg HCN.

The chemicals used were AnalaR Grade, supplied by BDH, Poole, England.

Preparation of Fufu from the Fermented Cassava Tubers: At the end of the 5 –day fermentation period, the softened cassava tubers were crushed manually in clean water to produce a homogenous mixture which was sieved, allowed to settle and decanted to obtain a paste. The paste was packed into a cloth bag, tied, squeezed and pressed under heavy weight to produce a semi-compact meal. The semi – compact meal was rolled into balls and cooked in boiling water for 30 to 40 minutes. The cooked mass was pounded in a mortar with pestle to produce the fufu meal.

Sensory Evaluation of the Fufu Meal: The sensory evaluation of the fufu meal was performed by ten invited judges using appropriate questionnaires. The judges assessed and rated the fufu meal for the following attributes: colour, appearance, texture, aroma, firmness, taste, flavour, mouldability, cohesiveness and acceptability, using a 5-point scale from a score of 10 for very desirable to a score of 2 for very undesirable. Very desirable = 10, Desirable =8, Fairly Desirable = 6, Undesirable = 4 and Very Undesirable =2. The various samples were coded in order not to bias the assessment of the judges. The study was conducted in the Biochemistry Laboratory, Delta State University, Abraka, Nigeria, in the month of October, 2004.

Statistics: Student's *t*-test Analysis was used to analyze the data obtained and significant difference was established at both 5%, 1% and 0.1% levels of probability.

RESULTS

Results are shown on Table 1-2. Table 1, shows the changes in cyanide content of cassava samples soaked with varying amounts of lemon grass (*Cymbopogon citratus*) for the 5-day fermentation period.

Data (Table 1) indicate a decrease in cyanide content of all the samples at the end of the 5-day period. Residual cyanide level was lowest in cassava sample soaked with 2.0 g lemon grass and that soaked with 3.0 g. The residual cyanide levels for samples fermented with 1.0 g, 4.0 g and 5.0 g were the same at the end of the 5-day fermentation period. The residual cyanide level for the control sample was the highest at the end of the 5-day fermentation period. This suggests that the rate of cyanide loss was lowest in the control sample.

The removal of cyanide from cassava tubers during fermentation is due to the rupture of the plant tissue which releases linamarin and this can be hydrolyzed by linamarase present in the cell wall of cassava.

Table 2, presents the scores of the sensory attributes of the fufu samples as rated by the selected panel of judges and the statistical report.

The fufu meal prepared from each sample varied in their sensory qualities as indicated by the sensory evaluation (Table 2). Fufu meal prepared from cassava fermented with 2.0 g lemon grass was the most preferred as judged by the rating of the total score of the sensory attributes.

Student's *t*-test analysis of the total percentage score of the sensory attributes shows no significant difference between fufu made from cassava fermented without lemon grass and fufu made from cassava fermented with 1.0 g and 2.0 g lemon grass at the 5%, 1% and 0.1% probability levels. There were significant differences at 5%, 1% and 0.1% levels of probability between fufu made from cassava fermented without lemon grass and fufu made from cassava fermented with 4.0 g and 5.0 g lemon grass. However, there was a significant difference only at 5% level of probability between fufu made from cassava fermented without lemon grass and fufu made from cassava fermented with 3.0 g lemon grass.

Evidence from this study (Table 1) showed that the detoxification of fermented cassava was further enhanced to a reasonable degree when cassava tubers

Table 1: Changes in cyanide content of cassava samples soaked with lemon grass (Cymbopogon citratus) during a 5-day fermentation period

	Amount of *Cymbopogon citratus* (g) / kg of soaked cassava tubers					
	0.0	1.0	2.0	3.0	4.0	5.0
Fermentation period (Days)	Changes in cyanide contents+ (mgHCN/100 g cassava wet weight)					
1.	7.02	7.02	7.02	7.02	7.02	7.02
2.	4.32	4.59	4.86	2.43	2.70	2.16
3.	3.51	3.51	2.70	1.62	2.43	1.89
4.	2.70	2.70	2.43	1.62	1.89	1.89
5.	1.62*	1.35*	0.81*	1.08*	1.35*	1.35*

** P<0.001 when compared with day 1 value (7.02).* *+Each value is a mean of two close titration values*

Table 2: The scores for the attributes of the fufu meals and the statistical reports of the total percentage scores

	Amount of *Cymbopogon citratus* (g) / kg fermented cassava tubers					
	A(0.0)	B(1.0)	C(2.0)	D(3.0)	E(4.0)	F(5.0)
Attributes	Mean Score of Attributes					
Colour	7.6±0.7	9.0±0.3	8.2±0.6	7.4±0.3	7.0±0.3	7.0±0.3
Appearance	7.4±0.6	8.8±0.3	8.4±0.5	7.6±0.4	7.2±0.5	6.6±0.4
Texture	7.8±0.6	7.4±0.7	8.4±0.7	7.6±0.6	7.6±0.6	7.8±0.7
Aroma	7.8±0.5	7.0±0.5	8.4±0.5	7.4±0.6	7.6±0.4	6.2±0.5
Firmness	8.0±0.6	9.0±0.3	8.8±0.5	7.6±0.5	7.2±0.5	6.6±0.6
Taste	9.0±0.3	7.2±0.7	8.2±0.6	7.8±0.6	7.0±0.6	6.8±0.5
Flavour	7.8±0.5	7.0±0.5	8.4±0.5	7.4±0.6	7.6±0.4	6.2±0.5
Mouldability	7.2±0.4	8.2±0.8	8.6±0.6	8.0±0.3	7.4±0.4	7.2±0.5
Cohesiveness	8.4±0.6	7.8±0.6	7.0±0.6	7.6±0.4	8.4±0.5	7.6±0.4
Acceptability	8.2±0.6	8.2±0.6	8.2±0.7	7.6±0.4	7.0±0.6	7.8±0.6
Total score (%)	79.2±3.2	79.6±3.3	82.6±4.4	76.0±3.2	74.0±2.6	69.8±3.3
Rating	3rd	2nd	1st	4th	5th	6th

	Student's t – test analysis of total percentage score					
Samples Compared	T – calculated	T critical =2.10 at P=0.05	T critical =2.88 at P=0.01	T critical =3.92 at P=0.001	n	df
A vs B	0.25	NS	NS	NS	10	18
A vs F	6.40	S*	S**	S***	10	18
A vs E	3.97	S*	S**	S***	10	18
A vs C	1.95	NS	NS	NS	10	18
A vs D	2.24	S*	NS	NS	10	18
C vs B	1.62	NS	NS	NS	10	18
C vs F	7.31	S*	S**	S***	10	18
C vs E	5.31	S*	S**	S***	10	18
C vs D	3.84	S*	S**	NS	10	18
B vs F	6.09	S*	S**	S***	10	18
B vs E	3.84	S*	S**	NS	10	18
B vs D	2.29	S*	NS	NS	10	18
F vs D	4.28	S*	S**	S***	10	18
F vs E	3.13	S*	S**	NS	10	18
E vs D	1.55	NS	NS	NS	10	18

NS=Not significant, S* = Significant (P<0.05), S**= Significant (p<0.01), S*** = Significant (P<0.001), n = No. of judges.

were fermented with lemon grass (*Cymbopogon citratus*). But, fufu prepared from cassava tubers fermented with lower amounts (1.0 g and 2.0 g) of lemon grass were most acceptable than the fufu meals made from cassava fermented without lemon grass and those fermented with higher concentrations (3.0 g, 4.0 g and 5.0 g) of lemon grass.

DISCUSSION

In many African countries, the age-old traditional methods are still being used in traditional fermentation processes and so, fermented products are still characterized by pungent odour and poor nutritional quality. There is currently an increasing state of nutritional insecurity in Africa and one important nutritional insecurity issue in Africa is micronutrient deficiencies in the diet of the people [9]. Therefore, there is need to improve some of the traditional processes in order to enhance the flavour and nutritional quality of fermented cassava products.

Some household processing interventions for enhancing the nutritional quality of cassava products include fermentation of cassava with protein-enriching bacteria and moulds [10,11], co-fermentation of cassava with cowpea and soyabean [12], co-processing of cassava

with some micronutrient-rich soruces like vegetables [13]. Red palm oil - an important source of Provitamin A, carotenoids [14] has been incorporated into the production of fermented cassava (gari) in some parts of Nigeria for ages and in Ghana, Fermented cassava products are normally pounded with plantain and some other vegetables. These household processing methods could improve the (micro) nutrient intakes of the people in many African locations, but none has improved the flavour of fermented cassava products.

Lemon grass (*Cymbopogon citratus*) is a herbal spice and it is preferred for its characteristic vibrant flavour. The grass has been reported [15] to revitalize the body and promote good health. It aids digestion and inhibit chemical–induced carcinogenesis by modulating xenobiotic-metabolizing enzymes in the liver and intestine.

Evidence (Table 1 and 2) indicate that the use of lemon grass in the processing of cassava into fufu will not only enhance detoxification of cassava tubers but would also improve the aroma and organoleptic acceptability of the resulting fufu meal at amounts between 1.0 – 2.0 g/kg cassava tuber.

Our observations add to the accumulating fermentation methods for improving the flavour and nutrient contents of fermented cassava products. However, the ability of the lemon grass co-fermented cassava products to stimulate cellular growth and metabolism and promote good health needs to be documented because this preliminary report is embellished with improved nutritional strategy.

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