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Effects of Cassava Leaves Detoxification Processes on the Physicochemical and Sensory Qualities of *Saka Saka*

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Abstract: Cassava is a worldwide major source of food and energy, particularly in the countries of South America, Africa, and Asia. In Central Africa, *saka saka* is a major cassava leaf based dish. Because of their high toxicity due to cyanogen they contain, cassava leaves are diversely treated to prevent consumer intoxication. This work consisted in evaluating the main and interaction effects of three detoxification processes, washing, drying and bicarbonate treatment, on the quality of *saka saka*. For this purpose, the detoxification of the cassava leaves was performed following a complete factorial design of experiment. The treated material was used to prepare the *saka saka* dish which some physicochemical and sensual quality characteristics have been evaluated. The results have been treated by Analysis of Variance at 5% significance level. The results showed that the bicarbonate treatment is the most efficient method to reduce the cyanogen content in the cassava leaves. All the three factors and their combinations have significant effects on the leaf pH, lipids, ash and cyanide content and *saka saka* odor, color and taste. The combination of washing and drying is the most interesting as it is efficient, produces the most enjoyed dish and doesn't use chemical that can induce adverse effects to consumer.

Keywords: Cassava, Leaves, Detoxification, Experiment, Sensual

1. Introduction

Cassava is mainly known for its roots. However, the leaves are consumed as a vegetable in some countries as a source of protein and valuable nutrients [1-4]. In Congo, cassava leaves dishes are called *saka-saka*, or *pondu* in national languages. It is a specialty known in all the country's departments and is the national dish.

Because of their higher cyanogenic potential, cassava leaves are consumed much less than the roots [5]. Cyanogens are responsible for more or less serious intoxications that can lead to the death of consumers in case of defective detoxification [6].

The detoxification processes of cassava leaves are varied. In most cases, these leaves are ground and boiled, which significantly reduces their cyanide content [7]. However, the choice of less toxic varieties, metabolic control and fermentation, extraction by soaking, treatment with sodium bicarbonate or enzymes, hot drying and cooking are also being used [8-15]. The constant concern in investigating these methods is to effectively remove cyanides while preserving the values of nutritional and organoleptic characteristics.

The objective of this work is to evaluate the effect of the combination of detoxification methods on some quality characteristics of cassava leaves.

2. Materials and Methods

2.1. Materials

The bitter cassava leaves used were purchased at the Total market in Brazzaville. They were washed and ground in the laboratory in an aluminum mortar fitted with a pestle. The grindings were divided into 8 samples according to the experimental design below.

2.2. Detoxification Tests

2.2.1. Design of the Experiment

The detoxification of cassava leaves was carried out according to a full factorial design with three factors, each at two levels, in four replicates. The three factors were the treatment processes of washing (A), bicarbonate (B) and drying (C) all at lower -1 (no treatment) and upper 1 (treatment) levels. The design of this 8-trial design, whose matrix is shown in Table 1, was carried out using Minitab 17.3.1.

2.2.2. Leaves Treatment

The fresh cassava leaves have been detoxified by: washing, drying and treating with sodium bicarbonate [12, 14, 15]. Washing was performed by two successive washes of 300 g samples of shredded material with two 300 ml fractions of distilled water. The water/crushed mixtures were wrung out after each wash through muslin. Bicarbonate detoxification was performed by mixing 300 g of sample with 1500 ml of 0.4% sodium bicarbonate. Incubation was carried out for 3 min at room temperature, followed by 6 h in a water bath at 55°C. Drying was carried out by drying 300 g samples of leaf crush at 50°C for 3 h. Samples treated by the treatment appearing first in the combination were reprocessed by the next treatment (s). The trials were randomized.

2.2.3. Cooking

The 8 samples of 240 g for sensory evaluation, 7 treated and one control, each mixed with 8 g of salt and 20 g of corn oil in 200 ml of water were cooked at 100°C for 1 h 30 min.

2.2.4. Evaluation of Physicochemical Characteristics of Raw Samples

(i) PH Measurement

The pH values were read by pricking the electrode of the pH-meter directly into the sample.

(ii) Determination of Ash Content

The ash contents were determined by incineration [16]. A 2 g mass of each sample, oven-dried at 50°C for 24 h and contained in a crucible of previously determined mass, was calcined in a muffle furnace at 550°C for 8 h. The ash content was expressed by the following formula (1):

$$Ash(\%) = \frac{m_2 - m_0}{m_1 - m_0} \times 100 \quad (1)$$

where m_0 is the empty weight of the crucible, in grams, m_1 is the weight of the crucible plus the sample and, m_2 is the weight of the crucible plus the ash.

(iii) Determination of Total Lipids

The estimation of total lipids was performed in the Soxhlet following the procedure. Dried samples of 10 g, previously dried, were used as extraction matrices. The extract solvent was evaporated under reduced pressure and the residue weighed. The total lipid content was expressed as a percentage per 100 g of dry matter.

(iv) Determination of Cyanides

The cyanides were determined by the titrimetric method [17]. For this purpose, a treated or untreated (control) sample of 20 g of shredded material was transferred to a flask and mixed with 200 ml of distilled water. The mixture was distilled to 150 ml of distillate. A volume of 20 ml of 0.02 M NaOH was added to the distillate and the mixture made up to 250 ml with distilled water. Three samples, two at 100 ml and one at 50 ml were prepared. To each of the 100 ml samples were added 8 ml of 6 M ammonia and 2 ml of 5% KI; to the 50 ml sample 4 ml and 1 ml of the same products. The samples were titrated with 0.2 M silver nitrate $AgNO_3$ using the 50 ml sample as a test. The percentage of cyanides was estimated by the following formula (2 and 3).

In ppm:

$$QHCN = V_{Titrage} \times 1.08 \quad (2)$$

In mg / Kg:

$$QHCN = \frac{\text{QHCN(ppm)} \times 1000}{20} \quad (3)$$

With the QHCN quantity of hydrocyanic acid

2.2.5. Assessment of Sensory Characteristics

The *saka saka* samples were evaluated for color, odor and taste by a panel of inexperienced assessors recruited from the ENSP students. The assessors were each given the eight samples, paper towels, a glass of mineral water, eight spoons, biscuits and an evaluation sheet shown in the annex. They were asked to taste and rate the samples on a hedonic scale ranging from 1 (don't like extremely) to 9 (like extremely).

2.2.6. Data Analysis

Some data were transformed into natural logarithms (ln), in order to obtain the highest correlation values. They were analyzed by graphs and analysis of variance using Minitab software at the 5% significance level. The effects were considered significant for values of P<0.05.

3. Results

3.1. Effects on Physicochemical Characteristics of Treated Cassava Leaves

3.1.1. PH

The pH data of the different samples are shown in Table 1 along with the effect estimates and p-values for each individual term and interaction. The p-values indicate that two main effects, bicarbonate (p=0.0230) and washing (p=0.0190) and a bicarbonate*drying interaction (p=0.0050) are significant. The largest effect equal to 3.1158 is obtained with bicarbonate, which increases the pH; while the other factors tend to decrease it. The effect of the three factors combination is not significant.

It can be seen that only bicarbonate has a significant positive effect on the ash content. The percentage of ash increases when bicarbonate increases from level -1 to level 1. The effects of the other two variables and the interactions are not significant.

Table 1. *PH data of cassava leaves.*

Trial	(1)	a	b	c	ab	ac	bc	abc
1	6.45	5.61	9.74	6.29	9.44	6.04	9.05	9.52
2	6.51	6.22	10.18	6.49	9.1	6.39	8.74	9.35
3	6.44	5.84	9.65	6.3	9.47		8.83	8.82
4	6.18	6.15		6.34	9.18			9.58
5		5.65						9.12
Effect		-0.2271	3.1158	-0.2204	0.1742	0.2429	-0.2842	0.1392
P-Value		0.0190	0.0000	0.0230	0.0660	0.0130	0.0050	0.1360

Table 2. *Percentage of total lipids per dry mass of cassava leaves.*

Trial	(1)	a	b	c	ab	ac	bc	abc
1	10.4	10.6	11.7	11	7.6	8.6	9	7.6
2	10	8.9	8.6	10.8	10.7	10.8	9.1	6.3
3	8.1	8.8	10.4		8.8	8	11.1	5.6
4	12.3	7.4			7.5	8.4		
Effect		-1.594	-0.548	-0.065	0.019	-0.165	-0.427	0.173
P-value		0.015	0.368	0.915	0.975	0.785	0.481	0.774

Table 3. *Ash percentages in cassava leaves samples.*

Trial	(1)	a	b	c	ab	ac	bc	abc
1	7.4	4.6	7	2.03	8.2	4	7	4.8
2	2.38	3.89	8.59	6.57	8.38	6.25	8.14	6.75
3	5.54	0			5.81	3.33	6.36	4.51
4	4.62	0			6.73			
Effect		-1.241	2.915	-0.209	0.077	0.448	-1.069	-1.097
P Value		0.120	0.001	0.786	0.920	0.562	0.176	0.166

Table 4. *Cyanide content in samples.*

Term	(1)	a	b	c	ab	ac	bc	abc
1	64.6	27	21.6	27	10.8	13.5	16.2	13.5
2	116.1	40.5	48.6	21.6	21.6	18.9	21.6	8.64
3	94.5	27	21.6	37.8	32.4	42.3	10.8	10.8
Effect	-	-19.59	-23.64	-24.39	15.03	12.48	11.13	-13.14
P Value	-	0.002	0.001	0	0.014	0.036	0.058	0.028

3.1.2. Lipids

The values of the total lipid contents and the results of the effect analysis are shown in Table 2. It can be seen that only the washing factor has a significant negative effect. The lipid level decreases when the washing is changed from level -1 to level 1, with a negative effect of -1.594 p=(0.015). The effects of the other factors and interactions are not significant (p>0.05).

3.1.3. Ash

The ash contents of the different cassava leaf samples their corresponding effect analysis are shown in Table 3. It varies from 0 to 8. It is found that only bicarbonate has a significant positive effect on the ash content (p=0.001). The percentage of ash increases when the bicarbonate goes from level -1 to level 1. The effects of the other two variables and interactions are not significant.

3.1.4. Cyanides

The values of the cyanide percentages and the results of the effects analysis are shown in Table 4 show that all the main effects and interactions are significant (p<0.05). The three main effects of washing, bicarbonate and drying negatively influence the level of cyanides. The greatest effect was seen for the bicarbonate treatment, followed by drying and washing. The effect of the washing * drying interaction is greater than that of the other interactions.

3.2. Effects of Cassava Leaves Detoxification Processes on Color, Odor and Taste of Saka Saka

The color, odor and taste rate data for *saka saka* samples prepared from cassava leaves detoxified by different processes individually and in combination are shown in Tables 4, 5 and 6. The columns are not of equal length because outliers were removed after the analyses of the raw data.

3.2.1. Effects on Color

The results of the analysis of variance, presented in Table 5, show that all three factors and the two- and three-factor interactions have significant effects on the characteristic color. All P values are equal to 0.000<0.05. Positive effects are obtained with the drying factor and the three two-factor interactions. The main effects of the other factors and the three-factor interaction (Wash*Bicarbonate*Drying) are negative.

3.2.2. Effects on Odor

For the odor characteristic, only two factors (bicarbonate and drying) and one two-factor interaction (Bicarbonate*Drying) have negative significant effects. For the other factors and interactions, the corresponding p values are above the 5% significance level for the other factors and interactions. Their effects are therefore not significant (Table 6).

3.2.3. Effects on Taste

The examination of the results presented in Table 7 of the analysis of variance shows that all main effects and interactions are significant; all P values are less than 0.05. The effects are negative for washing and the interactions bicarbonate*drying and washing*drying*bicarbonate and positive for the rest of the factors and interactions.

Table 5. *Rate data for color.*

Trial	(1)	a	b	c	ab	ac	bc	abc
1	6	8	6	5	4	7	4	6
2	6	8	7	6	2	8	5	6
3	6	6	7	7	3	8	5	5
4	6	6	8	5	2	8	5	6
5	7	7	6	6	4	8	4	6
6	7	7	7	5	2	8	6	
7	6	6	7	6	2	8	5	
8	5		6					
9			7					
Effect		-0.1385	-0.4055	0.1738	0.4285	0.1702	0.2897	-0.4055
p-value		0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 6. *Rate data for odor.*

Trial	(1)	a	b	c	ab	ac	bc	abc
1	6	4	6	4	6	7	4	6
2	6	5	6	5	6	6	4	4
3	5	6	5	4	6	5	6	4
4	7	6	7	6	6	6	5	5
5	7	6	7	6	6	7	4	5
6	5	5	5	6	5	7	5	5
7	6	6	6	6		6	6	6
8	7	6	6	5		5	5	5
9		5		6				
Effect		-0.0017	-0.1027	-0.0757	0.004	0.0502	-0.112	-0.0246
P- value		0.96	0.004	0.031	0.907	0.147	0.002	0.474

Table 7. *Rate data for taste.*

Trial	(1)	a	b	C	ab	ac	bc	abc
1	6	3	6	4	6	7	5	4
2	6	8	2	2	4	6	5	7
3	5	7	4	5	5	8	6	5
4	7	3	7	6	2	4	6	5
5	6	9	5	6	4	8	5	5
6	6	2	3	5	7	6	6	
7	4	3	2	8	7	7	7	
8	7		3					
9			6					
Effect		-0.1712	0.1225	0.0889	0.1045	0.1568	-0.2678	-0.2544
P-value		0.000	0.004	0.031	0.012	0.000	0.000	0.000

4. Conclusion

From the results obtained, it appears that the treatment of cassava leaves by washing, drying, bicarbonate or combinations of these processes, influence the values of the quality characteristics of *saka saka*. The average cyanide level is reduced from 91.7 in the control to between 42 and 10 mg/kg in the treated samples. All three factors and their interactions have significant negative effects on cyanide levels. Bicarbonate has a greater effect than drying and washing. Other authors have obtained similar results [12, 14, 15]. The only differences observed are in the amounts of cyanides which were determined by different methods. Otherwise, bicarbonate remains the most important detoxification factor, followed by drying.

The pH values are also affected by the treatments. While the control has a value of 5.66, the pH is more acidic (less than 5) in the samples treated by drying and more basic (more than 8) in those treated with bicarbonate. The percentage of lipids decreases when the washing goes from the lower to the higher level, while the percentage of ash increases when the bicarbonate factor goes from the lower to the higher level.

The results obtained show that all the tested detoxification factors and their interactions have significant effects on three sensual quality characteristics (color, odor and taste) of the cassava leaf product which is *saka saka*. The most important interactions are two-factor interactions among which the washing*drying interaction gives positive effects on all characteristics.

At the present stage of this work, we believe that wash-drying, which gives the product most appreciated by consumers, can be retained as a detoxification procedure. Although carbonate has a greater effect on cyanide reduction, it gives *saka saka* that is less appreciated by panelists. The other two factors also have significant negative effects on the cyanide characteristic. Even if the cyanide reduction is less with these two methods, the remaining cyanides could be significantly reduced during cooking. In addition, these two methods can better guarantee the safety of consumers than bicarbonate, which is a chemical product.

Detoxification by two-level factors made it possible to identify the factors with significant effects. However, experimentation with several level factors should make it possible to optimize the quality of *saka saka*.

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