African food tradition revisited by research

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TABLE OF CONTENTS

1. Introduction

The baobab (*Adansonia digitata L.*) is important to the livelihood and can be found in most of Sub-Sahara Africa's semi-arid and sub-humid regions as well as in western Madagascar providing food, medicine, etc. (Gebauer et al. 2002 ; Cisse et al. 2009, Caluwé et al., 2010). Baobab fruit pulp is called "Bouy" or Monkey bread is widely used by Senegalese people and it is consumed in different forms (Diop et al. 2005 ; Cisse et al., 2009). Baobab fruit pulp is a natural dried fruit pulp.

The baobab fruit is commonly used as famine food by native African populations. It can help preparing decoctions, sauces and natural refreshing drink, due to its nutritional properties (Chadare, et al. 2008). The pulp is therapeutically employed in many cases for human purposes include as febrifuge, analgesic, anti-diarrhea / anti-dysentery and for treatment of smallpox and measles (Vertuani, et al., 2002; Chadare, et al. 2008).

The baobab is used for many purposes and represents an important source of income for the Senegalese people, but it is valorized in traditional ways. The fruit can be harvested all year round. Since years ago, the growth of small and middle enterprises makes the baobab fruit as an important food for industries.

Traditional food products (drink, syrup) from *Adansonia digitata* fruit are generally manufactured at home (in small scale) or small factories, enterprise (in semi industrial scale) with a lack of technical tools to control the quality. It is in this context the quality of traditional products from *Adansonia digitata* were evaluated.

2. Sampling

Different samples of baobab products were collected across Senegal (**Figure 1**) according the SOPs for sampling strategy for group 3 (D1.2.1.3). To avoid changing of the sample from collection to analysis, three areas have been selected. This is the region of Dakar where two companies were choosen, the region of Thies at 70 km of Dakar and the region of Kaolack at the center of Senegal at 192 Km at Dakar.

Figure 1. Sampling area of baobab fruit

According the SOPs for sampling strategy for group 3 (D1.2.1.3), the **table 1** shows the location of all samples and the number of samples for each area. All the samples are from the specie of *Adansonia digitata*.

Table 1. Location and number of samples of baobab products

	Dakar	Thies	Kaolack
Nectar of baobab	6	3	3
Syrup of baobab	6	3	3

3. Analyses of samples

Samples collected (nectar and syrup) were analysed for physical, chemical and textural analysis, microbiological analysis and biochemical and nutritional analysis using respectively SOP's defined on the deliverable D1.2.3.3, D1.2.3.6 and D1.2.3.13.

4. Results and discussion

Table 2 and **3** give the results of the sensory and physical characteristics of baobab products. The four products in each type of product show significant differences. For baobab drink, the results showed that all samples were significantly different at $p<0.05$. The drink from Kaolack gave the highest density (1.26) compared to Dakar 2 the lowest 1.05. The difference can be due to the water content in the different samples. Mostly in Dakar, juice producers add more water to increase income and to reduce the particles sedimentation.

The colour parameters were all significantly different between samples (**Table 2** and **3**). For the lightness, drinks from Dakar showed high value compared to Kaolack and Thiés. Unlike a*and b* values from Kaolack and Thiés are greater than the one of Dakar region. According to Ndiaye et al. (2009), the browning depend on the L*, a* and b*. The difference can be explained by the processing used. The browning reaction can be the main factor that occurred during the processing. The lack of standard processing line can be a challenge to provide to Senegalese enterprises for good drinks with approximately same conditions.

Table 4 and **5** give the results of the inventory of the technological flora and pathogenic germs of Baobab products for different regions. The four products are characterized by an excellent microbiological quality. Only yeasts and moulds are present in very limited numbers in some cases. No pathogen was found regardless of the origin and the type of products.

Table 6 and **7** show the chemical, biochemical and nutritional characteristics for all the products. The four products in each type of product show significant differences. For nectar, the product of Dakar 1 presents the most interesting characteristics with titratable acidity, vitamin C and polyphenols content of 54 .17 meq.100 g^{-1}, 0.07 g.100 g^{-1} and 1.01 g.100 g^{-1} respectively. While for the syrup, the product from Kaolack seems to have the best quality regarding the content of vitamin C, titratable acidity and total polyphenol.

According to **Table 6**, baobab drinks from Dakar 2 are less acidic (high pH value) compared to Kaolack, Thiés and Dakar 1 (pH values not significantly different at $p<0.05$). These results are confirmed by the titrable acidity of Dakar 1 which presents the highest value (low pH) compared to the other baobab drink regions' samples.

Samples drinks from Thiés has significantly ($p<0.05$) more total soluble solid (340 g/100 g MS) compared to Kaolack, Dakar 1 and Dakar 2 respectively 277, 219 and 144 g/100g DM of total soluble solid. From **Table 6**, samples from Thiés and Dakar 2 present high content in total sugars and low reducing sugars. The results can be explained by the variability of baobab fruit pulp from one region to another and by the process (formulation, heating) used to produce the drink

Drinks from Dakar 1 have been shown the highest significant vitamin C content compared to other selected regions. Kaolack and Dakar 2 did show significant difference compared to Thiés, who held the lowest vitamin C content. The variability of fruit source or handling product before, during and after processing can be divers' explanation of this difference between samples from different regions. The total polyphenol of samples from Dakar 1 have also been reported to have the most important content. As we see in Table 6 and 7, all the samples are significantly different in polyphenol contents ($p<0.05$). We can assume that the polyphenol content is related to the origin zone

Compared to the levels initially present in the fruit of the baobab tree, we see that in the case of vitamin C only 1/5 is found in the nectars. In the case of total polyphenols, the nectar contains 1/3 of the initial content of the fruit.

5. Conclusion

The sensory and physical, chemical, biochemical and nutritional characteristics of the products are significantly different. Regarding microbiological analysis, the products have an excellent quality.

Optimizing local processing of baobab fruit for quality of byproducts can be considered as a factor of great interest because it is possible to achieve microbial safety, more bioactive compounds' retention, etc. by applying satisfied conditions at much adequate treatment parameters than what is commonly used, which would allow a better retention of nutritional compounds and physicochemical characteristics. In any case, we can conclude that improving the local processing by increasing the quality attributes of baobab by products has good prospects for use in baobab fruit enterprises and semi-industries as an alternative to the high techniques that the owners did not wanted to invest.

Table 2. Results for sensory, physical and textural analysis of Baobab drink

Parameter and unit of measurement	SOP number	Respon-sible partner and lab	Baobab drink							
			Dakar 1		Dakar 2		Kaolack		Thies	
			Number of Samples	(Mean +/- SD)	Number of Samples	(Mean +/- SD)	Number of Samples	(Mean +/- SD)	Number of Samples	(Mean +/- SD)
Density	Phys-ExtPlantes-01-fr	UCAD @ UCAD	3	$1,09^{c} \pm 0.002$	3	$1,05^{d} \pm 0.001$	3	$1,26^{a} \pm 0.001$	3	$1,15^{b} \pm 0.002$
Colour parameters (Lab)	Phys-ExtPlantes-03-fr	UCAD @ UCAD								
		L	3	$41,61^{a} \pm 0.01$	3	$40,19^{b} \pm 0.03$	3	$32.32^{d} \pm 0.03$	3	$36,36^{c} \pm 0.03$
		a*	3	$1,27^{d} \pm 0.03$	3	$1,87^{c} \pm 0.01$	3	$3.02^{a} \pm 0.03$	3	$2,69^{b} \pm 0.02$
		b*	3	$11,21^{c} \pm 0.03$	3	$9,84^{d} \pm 0.06$	3	$14.15^{a} \pm 0.05$	3	$12,72^{b} \pm 0.04$

Table 3. Results for sensory, physical and textural analysis of Baobab syrup

Parameter and unit of measurement	SOP number	Respon-sible partner and lab	Baobab syrup							
			Dakar 1		Dakar 2		Kaolack		Thies	
			Number of Samples	(Mean +/- SD)	Number of Samples	(Mean +/- SD)	Number of Samples	(Mean +/- SD)	Number of Samples	(Mean +/- SD)
Density	Phys-ExtPlantes-01-fr	UCAD @ UCAD	3	1,30[c] ± 0.001	3	1,33[b] ± 0.001	3	1,62[a] ± 0.001	3	1,26[d] ± 0.001
Colour parameters (Lab)	Phys-ExtPlantes-03-fr	UCAD @ UCAD								
		L	3	40,59[a] ± 0.01	3	35,51[b]± 0.06	3	28,58[d] ± 0.03	3	30,58[c] ± 0.03
		a*	3	2,36[d] ± 0.02	3	3,13[c] ± 0.01	3	5.47[b] ± 0.03	3	10,02[a] ± 0.03
		b*	3	13,62[a] ± 0.08	3	13,53[a] ± 0.01	3	12.34[b] ± 0.04	3	11,27[c]± 0.04

Table 4. Results for inventory of the technological flora and pathogenic germs of Baobab drink

Parameter and unit of measurement	SOP number	Respon-sible partner and lab	Baobab drink							
			Dakar 1		Dakar 2		Kaolack		Thies	
			Number of Samples	(Mean +/- SD)	Number of Samples	(Mean +/- SD)	Number of Samples	(Mean +/- SD)	Number of Samples	(Mean +/- SD)
Enumeration of microorganisms (CFU/g)	Micro-01, ISO 4833	UAC @ UAC	3	4	3	17.10^2	3	218	3	142
Enterobacteriaceae	Micro-02, ISO 21528-2	UAC @ UAC	3	0	3	0	3	0	3	0
Escherichia coli	Micro-03, ISO 16649-2	UAC @ UAC	3	0	3	0	3	0	3	0
Bacillus cereus	Micro-04, ISO 7932	UAC @ UAC	3	0	3	0	3	0	3	0
Staphylococcus aureus and CPS	Micro-05, ISO 6888-1	UAC @ UAC	3	0	3	0	3	0	3	0
Listeria monocytogenes	Micro-06, ISO 112901/A12004	UAC @ UAC	3	0	3	0	3	0	3	0
Salmonella	Micro-07, ISO 65792002	UAC @ UAC	3	0	3	0	3	0	3	0
Clostridium perfringens	Micro-08, ISO 7937	UAC @ UAC	3	0	3	0	3	0	3	0
Yeasts and moulds	Micro-09, ISO 7954	UAC @ UAC	3	0	3	336	3	182	3	100
Lactic acid bacteria (LAB)	Micro-10, M-METH-MO-13	UAC @ UAC	3	0	3	0	3	0	3	0

Table 5. Results for inventory of the technological flora and pathogenic germs of Baobab syrup

Parameter and unit of measurement	SOP number	Respon-sible partner and lab	Baobab syrup							
			Dakar 1		Dakar 2		Kaolack		Thies	
			Number of Samples	(Mean +/- SD)	Number of Samples	(Mean +/- SD)	Number of Samples	(Mean +/- SD)	Number of Samples	(Mean +/- SD)
Enumeration of microorganisms (CFU/g)	Micro-01, ISO 4833	UAC @ UAC	3	0	3	0	3	0	3	6600
Enterobacteriaceae	Micro-02, ISO 21528-2	UAC @ UAC	3	0	3	0	3	0	3	0
Escherichia coli	Micro-03, ISO 16649-2	UAC @ UAC	3	0	3	0	3	0	3	0
Bacillus cereus	Micro-04, ISO 7932	UAC @ UAC	3	0	3	0	3	0	3	0
Staphylococcus aureus and CPS	Micro-05, ISO 6888-1	UAC @ UAC	3	0	3	0	3	0	3	0
Listeria monocytogenes	Micro-06, ISO 112901/A12004	UAC @ UAC	3	0	3	0	3	0	3	0
Salmonella	Micro-07, ISO 65792002	UAC @ UAC	3	0	3	0	3	0	3	0
Clostridium perfringens	Micro-08, ISO 7937	UAC @ UAC	3	0	3	0	3	0	3	0
Yeasts and moulds	Micro-09, ISO 7954	UAC @ UAC	3	0	3	0	3	0	3	681
Lactic acid bacteria (LAB)	Micro-10, M-METH-MO-13	UAC @ UAC	3	118	3	436	3	709	3	30

Table 6. Results for chemical, biochemical and nutritional analysis of Baobab drink

Parameter and unit of measurement	SOP number	Respon-sible partner and lab	Baobab drink							
			Dakar 1		Dakar 2		Kaolack		Thies	
			Number of Samples	(Mean +/- SD)	Number of Samples	(Mean +/- SD)	Number of Samples	(Mean +/- SD)	Number of Samples	(Mean +/- SD)
pH	Chem-ExtPlantes-01-fr	UCAD @ UCAD	3	3,22[b] ± 0.01	3	3,45 [a]± 0.09	3	3,28 [b] ± 0.02	3	3,24 [b] ± 0.12
Total soluble solid (g/100g)	Chem-ExtPlantes 03-fr	UCAD @ UCAD	3	144,00[d] ± 1.24	3	219,00[c] ± 4.02	3	277,00[b] ± 2.01	3	340,00[a]± 3.02
Titrable Acidity (meq/100g MS)	Chem-ExtPlantes-02-fr	UCAD @ UCAD	3	54,17 [a]± 0.002	3	31,96[b] ± 2.74	3	29,96[b] ± 1.02	3	23,53[c] ± 0.45
Total sugar (g/100g MS)	Chem-ExtPlantes-11-fr	UCAD @ UCAD	3	86,69[c] ± 3.38	3	101,05[a] ± 1.21	3	75,67[d] ± 1.47	3	96,92[b]± 1.78
Reducing sugar (g/100g MS)	Chem-ExtPlantes-12-fr	UCAD @ UCAD	3	34,23[a] ± 0.94	3	1,61[d] ± 0.14	3	12,56[b] ± 0.24	3	4,38[c] ± 0.01
Vitamin C (g/100 g MS)	Nutri-ExtPlantes-01/02-fr	UCAD @ UCAD	3	0,07[a] ± 0.001	3	0,05[b] ± 0.001	3	0,05[b] ± 0.001	3	0,02[c] ± 0.001
Total polyphénols g/100g MS)	Bioch-ExtPlantes-05-fr	UCAD @ UCAD	3	1,01[a] ± 0.01	3	0,78[b] ± 0.002	3	0,19[d] ± 0.002	3	0,27[c] ± 0.001

Table 7. Results for chemical analysis of Baobab syrup

Parameter and unit of measurement	SOP number	Respon-sible partner and lab	Baobab syrup							
			Dakar 1		Dakar 2		Kaolack		Thies	
			Number of Samples	(Mean +/- SD)	Number of Samples	(Mean +/- SD)	Number of Samples	(Mean +/- SD)	Number of Samples	(Mean +/- SD)
pH	Chem-ExtPlantes-01-fr	UCAD @ UCAD	3	3,23[a] ± 0.01	3	3,15[a]± 0.14	3	3,14[a] ± 0.005	3	3,31[a] ± 0.005
Total soluble solids (g/100g)	Chem-ExtPlantes 03-fr	UCAD @ UCAD	3	610[c] ± 1.20	3	670[b] ± 1.25	173	715,00[a] ± 1.20	3	609[c] ± 1.23
Titrable Acidity (meq/100g MS)	Chem-ExtPlantes-02-fr	UCAD @ UCAD	3	18,03[d] ± 0.16	3	19,40[c] ± 0.30	3	72,19[a] ± 0.33	3	28,08[b] ± 0.05
Total sugar (g/100g MS)	Chem-ExtPlantes-11-fr	UCAD @ UCAD	3	139,84[c] ± 2.22	3	162,08[b] ± 9.30	3	1044,76[a] ± 0.86	3	131,18[c] ± 4.25
Reducing sugar (g/100g MS)	Chem-ExtPlantes-12-fr	UCAD @ UCAD	3	63,04[b] ± 2.66	3	10,27[c] ± 0.04	3	320,28[a] ± 12.23	3	7,11 [c]± 0.02
Vitamin C (g/100 g MS)	Nutri-ExtPlantes-01/02-fr	UCAD @ UCAD	3	0,02[b] ± 0.001	3	0,01 [c]± 0.001	3	0,18[a] ± 0.001	3	0,01[c] ± 0.001
Total polyphénols g/100g MS)	Bioch-ExtPlantes-05-fr	UCAD @ UCAD	3	0,18[c] ± 0.001	3	0,17[d] ± 0.002	3	2,68[a] ± 0.01	3	0,21[b] ± 0.001

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