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Technology of a New Potato Based Food Product: Porridge Lumps from Orange-Fleshed Sweet Potato Enriched with Moringa Leaves Powder or Baobab Fruit Pulp

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Abstract

Cereals-based lumps are locally well appreciated foods while orange-fleshed sweet potato is an underutilised food security crop. The objective of this study was to contribute to its consumption through development of porridge lumps. Formulations of orange-fleshed sweet potato flour with moringa leaves powder (10 and 15%) and baobab fruit pulp (10 and 15%) were made. As results, a flow process was developed. Lumps pH and total dry matter values varied between 4.1 to 5.3 and 92.1 to 95.8% respectively. Mean contents of Fe, Zn, K, Na, and Mg were similar between the end-products and highest for K (11437 to 13059 µg/g). Aerobic flora loads were in the magnitude of 102 to 103 UFC/g and similar to those of yeast and molds. Very few counts were observed for thermo-tolerant coliforms. Sensory analyses showed a good appreciation. This study will contribute to improve sustainably local diets quality.

Keywords: porridge lumps; orange-fleshed sweet potato; moringa; baobab fruit; Burkina Faso.

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1. Introduction

Orange-fleshed sweet potato (OFSP) is characterised by a wide adaptability and good nutritional value making of it a particularly important crop for food security in countries vulnerable to climate change [1]. While sweet potato (*Ipomoea batatas*) is considered in developing countries as an important food crop, OFSP is reported as an underutilised food security crop in sub-Saharan western African countries [1] where diverse calls for its promotion are being made [2]. This seems a paradox in regions fighting against undernutrition while neglecting local and affordable sources of micronutrients including vitamins A, and minerals [3]. The sweet trait of OFSP roots, urbanisation and the low diversity, on the local markets, of OFSP based foods products do not help alleviating the situation [3]. Similarly to OFSP, promising local forest food products such as moringa leaves and baobab fruit pulp were proven to be very good sources of micronutrients, usable for food fortification [4].

Cereals based lumps are well appreciated food products in Burkina Faso, as well as in many others sub-Saharan western African countries. Aromatic ingredients such as ginger or baobab fruit pulp may be associated as additives and they are manufactured essentially by traditional or small scale processing units [5]. They are popular as they facilitate the culinary process of making porridge/gruels or special milk based beverage named “dèguê” in Burkina Faso and Côte d’Ivoire, or named “Burkina” in Ghana [6]. As far as we are concerned, no potato based lumps are available as published technology or available food product for porridge preparation as it exists for cereals based lumps. Since lumps based foods are well appreciated in those countries, OFSP consumption could be promoted by mean of lumps based foods production.

Thus, the main objective of this study was to contribute to OFSP consumption through the development of OFSP based lumps associated with moringa (*Moringa oleifera*) leaves powder or baobab (*Adansonia digitata*) fruit pulp for porridge preparation. More specifically, a simple technology was developed at the scale of artisanal (small scale) processing units; then some physico-chemical, microbiological and sensorial parameters were determined on the end-products.

2. Materials and methods

2.1. Processing units and raw materials

Two small scale processing units located in the city of Bobo-Dioulasso were selected, one to process OFSP roots into flour and the other to produce OFSP based lumps. OFSP (local variety: “Nooma”) was grown in a rural area, Samorogouan (11° 24′ 0″ N, 4° 55′ 60″ W), located at 83 km from Bobo-Dioulasso. Baobab fruit pulp was supplied by a local private supplier in 50 kg bag. Fresh moringa leaves were picked from plants grown in a family yard in the city of Bobo-Dioulasso.

2.2. Lumps processing

OFSP roots were cleansed, disinfected with 2.6% sodium hypochlorite (diluted at 0.2%, v/v), rinsed, then peeled and cut in thin slices. These were sundried for 24h, grinded and sieved through a mesh cloth. Moringa leaves were dried under shade, grinded and sieved through a mesh cloth while baobab fruit pulp powder was directly sieved. Preliminary tests for the manufacture of lumps were carried out, and based on colour acceptability and technological feasibility (firmness/crumbing of lumps) assessed by experienced processors from the processing unit, final formulations were made with OFSP flour enriched with moringa leaves powder (10 and 15%, w/w) or baobab fruit pulp (10 and 15 %, w/w). Three productions were carried out for each formulation (Fig. 1).

2.3. Microbiological, physico-chemical, and sensorial analyses

OFSP-based lumps and commercially available (control) pearl millet (*Pennisetum galucum*) lumps were used to assess physical and sensorial parameters. For minerals and microbiological parameters, OFSP-based products were used for determination.

Mesophilic aerobic bacteria, and yeast - molds counts were determined aerobically on plate count agar (Himedia, India) and Plate count agar (pH 5.6) supplemented with gentamicin respectively, after incubation at 30°C for 3 days. Thermo-tolerant coliforms were enumerated on violet red bile lactose agar (Liofilchem, Italy), with incubation at 44°C for 24 h.

Bulk density was determined by the ratio of lumps samples weights to their volumes in a graduated measuring cylinder [7]. Swelling index was determined by the mass ratio of lumps samples contained in bottles after addition of distilled water and one hour rest to their original weight [7]. Colour determination of the lumps was made by matching visually the colours of the samples with a Red Green Blue (RGB) colour palette [8]. A pH-meter (Hanna, USA) was used to determine pH values according to the manufacturer instructions. Moisture content was determined by thermo-gravimetric method [9] at 103 °C in an air oven (Memmert, Germany). Iron, zinc, sodium and magnesium contents were determined by atomic absorption spectrometry (Perkin-Elmer model 303) according to AOAC (2005) [10].

Porridge samples were prepared by an experimented female processor from OSFP lumps and flour enriched at 15% with moringa or baobab fruit pulp according to the local preparation process for porridge from cereals-based lumps. Porridge from millet lumps was prepared as control. Samples were subjected to sensory analyses by a panel of 20 adults porridge consumers who performed colour, aroma and taste evaluations.

2.4. Statistical Analyses

For each formulation, three productions were performed and results were expressed as means ± standard deviations. R commander version 2.8.-0 was used for statistical analyses. Analysis of variance was performed with means comparison by Tukey test ($p \leq 0.05$) for bulk density, swelling index and dry matter. For the others parameters Kruskal-Wallis and Wilcoxon tests were used to assess differences ($p \leq 0.05$) between groups. Principal Component Analysis (PCA) graph and correlation matrix between functional properties were also performed.

3. Results and discussion

The different steps for lumps manufacturing are presented in Fig. 1. OFSP based lumps with 10 and 15 % (w/w) addition of moringa/baobab fruit pulp resulted in successfully processed food products at the scale of the local small scale units**.**

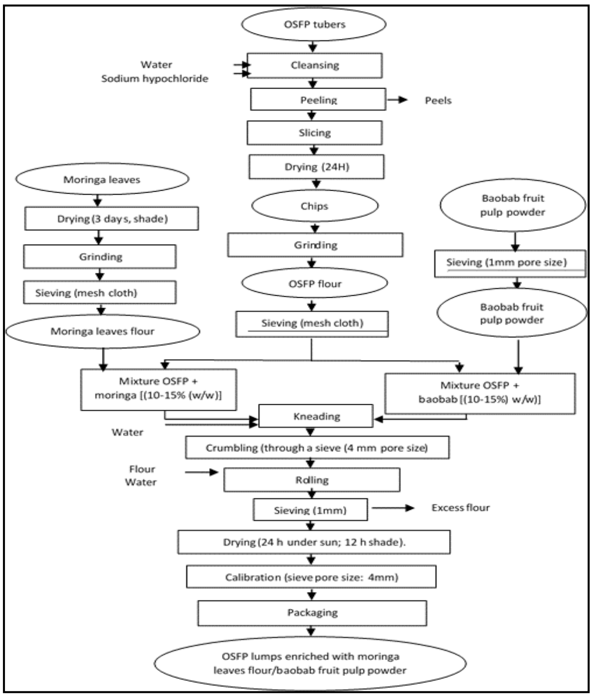

Figure 1: Flow diagram of OFSP-based lumps enriched with moringa leaves powder or baobab fruit pulp

Concerning the functional properties (Table 1), some trends were observed. Bulk densities were proportional to swelling index (Supplementary Fig. 1; supplementary Table 1) and were quite low, which should make them easily digestible by infants while providing the nutrients [11]. However, OFSP based lumps were darker, especially those enriched with baobab fruit pulp (Supplementary Fig. 2.); this could be a hindrance to infant consumption. About, dry matter and pH (Table 1), they were negatively correlated, r= -0.8, (supplementary Table 1) as confirmed by the PCA graph (supplementary Fig. 1). OFSP based lumps with baobab fruit pulp were more acidic (pH 4.1 to 4.4) than those enriched with moringa (pH 5.1 to 5.3) and millet based lumps (pH 6.4 to 6.7), while the total dry matter contents was the highest ($p<0.05$). Thus, it can be presumed that lumps samples enriched with baobab fruit pulp, as acidic and dry food products, will be preserved more easily from alteration when subjected to a long period storage at ambient temperature than some commercial cereal based lumps. This is noteworthy for postharvest losses alleviation and food safety insurance since limited hygiene and storage facilities are oftentimes the challenges to post-harvest management in these regions.

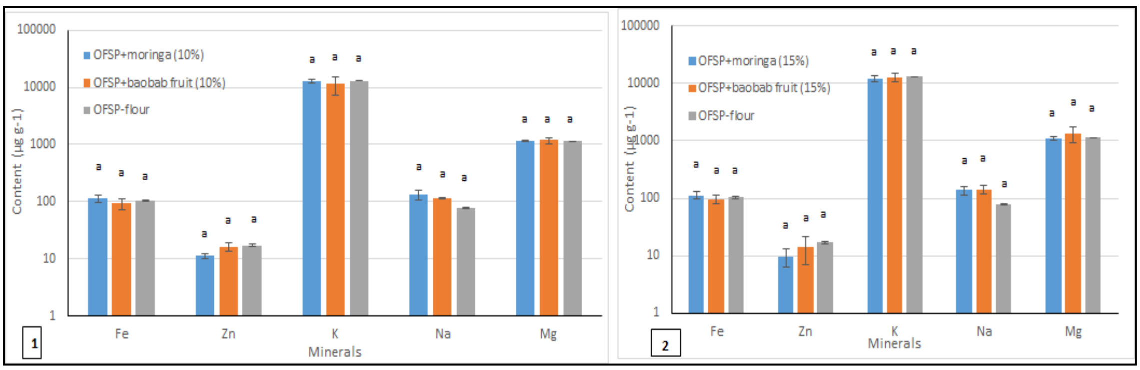

Figure 2: Mineral contents of OFSP flour and OFSP-based lumps formulated products with ([1]: 10%; [b]: 15%)

moringa leaves powder or baobab fruit pulp. Mean values ($n \geq 3$) with same letters above bars are not statistically different ($p \leq 0.05$)

For all OFSP based samples, contents in K (Fig. 2) were the highest (11437 to 13059 µg/g) while contents in Zn were the lowest (10 to 17 µg/g). Regarding mineral contents and recommended daily intakes, consumption of OFSP based lumps could contribute to alleviate micronutrient deficiencies in local nutritional recovery centers [3].

Table 1: Physical, colour and microbiological characteristics of OFSP-based and millet based lumps

Samples	Bulk density	Swelling index (g/g)	pH	Total dry matter (%)	Colour (R,G,B)	Lumps size (mm)	TAMF CFU/g	Yeasts and molds CFU/g	Thermo-tolerant coliforms CFU/g
OSFP+moringa 10%	$0.58^{a}\pm0.012$	$2.56^{a}\pm0.31$	$5.16^{a}\pm0.05$	92.41 ±0.47	^{a}70, 46, 1	2-3	$5.5\pm7.1\ 10^{2}$	$4.0\pm3.6\ 10^{2}$	$1.0\pm1.7\ 10^{1}$
OSFP+moringa 15%	$0.60^{a}\pm0.030$	$2.40^{ab}\pm0.02$	$5.23^{a}\pm0.03$	92.51 ±0.63	^{a}70, 46, 1		$4.3\pm4.9\ 10^{2}$	$2.3\pm1.5\ 10^{2}$	$<1.0\pm0.0\ 10^{1}$
OSFP+baobab 10%	$0.57^{a}\pm0.010$	$2.30^{ab}\pm0.18$	$4.28^{b}\pm0.07$	95.02 ±0.65	^{b}135, 89, 26	2-4	$5.3\pm2.5\ 10^{2}$	$5.7\pm2.1\ 10^{2}$	$<1.0\pm0.0\ 10^{1}$
OSFP+baobab 15%	$0.62^{a}\pm0.087$	$2.60^{a}\pm0.34$	$4.21^{b}\pm0.08$	95.09 ±0.65	^{b}146, 109, 39		$7.0\pm3.6\ 10^{2}$	$8.7\pm9.9\ 10^{2}$	$<1.0\pm0.0\ 10^{1}$
Millet based lumps	$0.52^{a}\pm0.006$	$1.94^{b}\pm 0.16$	$6.56^{c}\pm 0.18$	91.39 1.17	^{a} ±206, 206, 206	2-3	ND	ND	ND

^{a} Mean values ($n \geq 3$) in column with the same superscript are not statistically different ($p \leq 0.05$); TAMF: Total aerobic mesophilic flora; ND: not determined.

These data are particularly important for Burkina Faso since the OFSP variety used, "Nooma", (Supplementary Fig. 3.) is a promising new one, being progressively promoted among producers but yet to be characterized nutritionally. Loads of mesophilic aerobic flora (Table 1) were in the magnitude of 102 to 103 UFC/g for the two products. Yeast and mold loads were relatively high compared to microbiological criteria and varied between 102 and 103 CFU/g. However low loads, <1.0 10^{1} to 3.0 10^{1} CFU/g, were observed for thermo-tolerant coliforms which indicate a quasi-absence of pathogen from faecal origin. Compared to criteria for similar products (cereal flours, pastas) microbiological data could be considered satisfactory [12]. No significant differences ($p<0.05$) were observed between the two formulations or end-products for mineral content or microbiological parameter. The little proportion of baobab fruit pulp or moringa could partly explain this. In addition the products were manufacturing in the same microbiological environment and the relative low precision equipments used for processing, characteristic of small scale units, might have induced some degree of variability. However these units and households are the main processors of food products from local crops [13]. Thus, results expressed what could be expected in practice when introducing OSFP based lumps to the market and promoting their local manufacturing.

Sensory analyses (Fig. 3) showed that porridges from OFSP lumps were positively appreciated for colour, aroma and taste by 85 to 95% of panellists except aroma in the baobab enriched sample (60% of panellists).

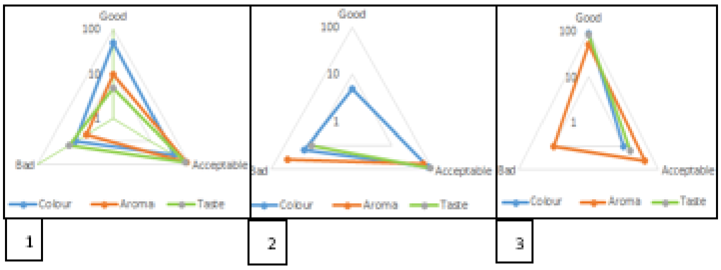

Figure 3: Sensorial appreciations (%) of colour, aroma and taste of porridge from OFSP-based ([1]: 15% moringa leaves powder; [2]: 15% baobab fruit pulp) and [3] millet-based lumps.

However these parameters were the most liked in the millet lumps based porridge. Some panellists suggested to improve the colour and to reduce the sourness where baobab fruit pulp was incorporated.

4. Conclusion

OFSP-based lumps enriched with moringa leaves powder or baobab fruit pulp for porridge preparation was an innovative idea. The process was simple and developed in small scale processing units conditions, and the end-products were globally satisfactory when considering basic microbiological, functional and sensorial characteristics. These lumps could also be used in other popular recipes such "dèguê" or "Burkina". Introducing these products into local market while taking into account some cultural drivers, may contribute to alleviate postharvest losses and to reduce micronutrient deficiencies also known as "hidden hunger".

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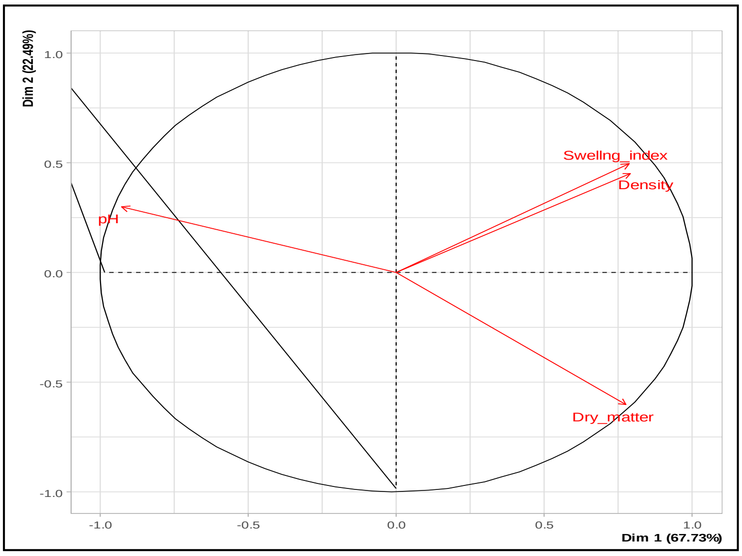
Supplementary materials

Technology of a new potato based food product: porridge lumps from orange-fleshed sweet potato enriched with moringa leaves powder or baobab fruit pulp.Geoffroy Romaric BAYILI *, Orokya Tiedéwa Nasrine TRAORE, Mamadou SANOU, Christine KERE-KANDO



Supplementary Fig. 1 Principal Component Analysis (variables plot) for bulk density, dry matter, pH and swelling index of OFSP-based and millet based lumps

Figure 4

A: OFSP+moringa   B:OFSP+baobab fruit pulp

C: Porridge from OSFP lumps

Figure 5

Supplementary Fig. 2 Pictures of OFSP-based lumps enriched with moringa leaves powder (A), enriched with baobab fruit pulp (B) and porridge from OSFP enriched lumps (C)

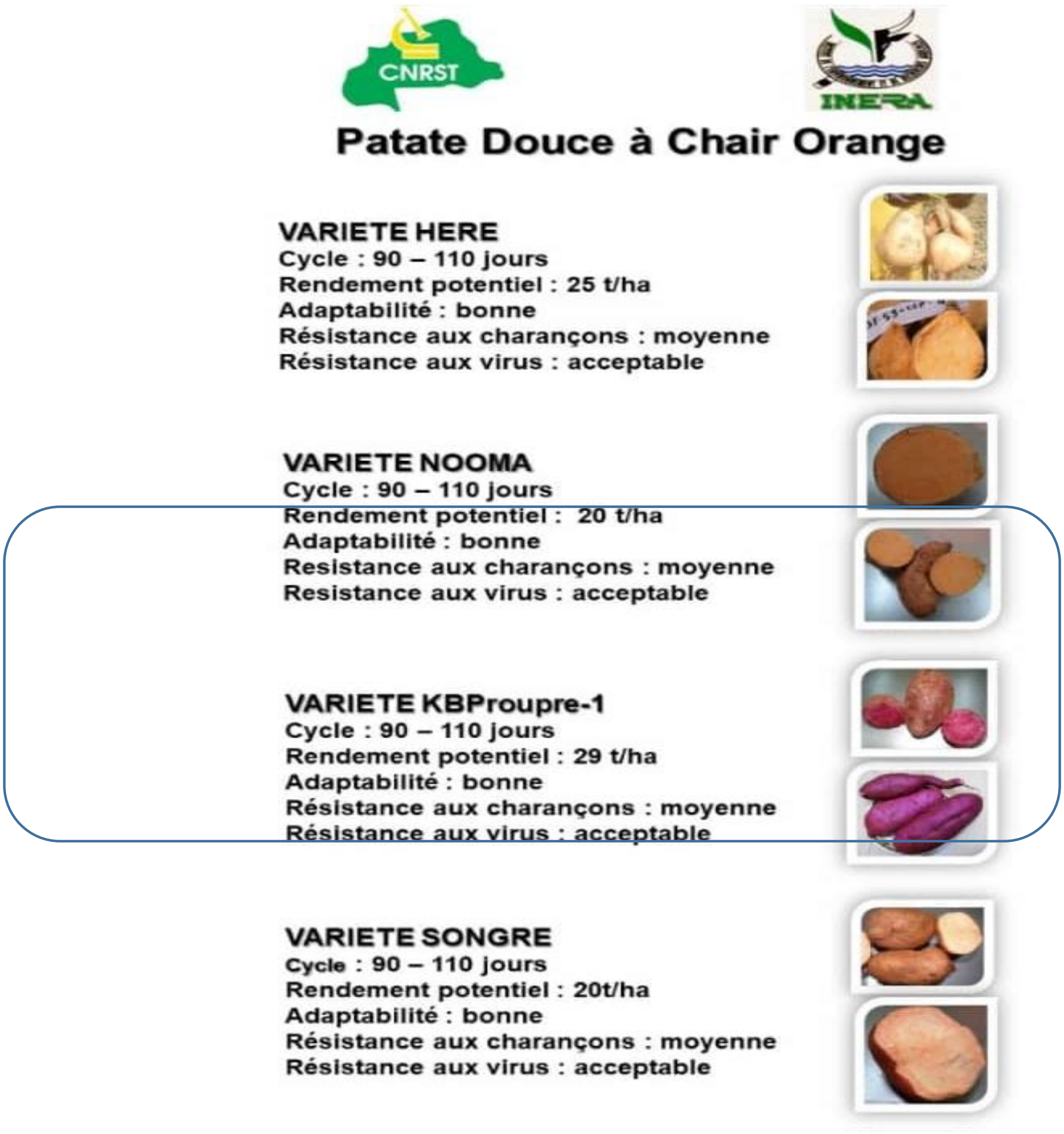


Figure 6

Supplementary Fig. 3 Information on local OSFP variety “Nooma” (in the box) developed by the national research institute in charge of environment and agriculture, INERA/CNRST (Cycle: 90 to110 days; potential yield: 20 t/ha; adaptability: good; resistance to weevils: average; resistance to virus: acceptable)

Table 2

Supplementary Table 1 Correlation matrix between bulk density, dry matter, pH and swelling index of OFSP-based and millet based lumps

	Bulk density	Dry matter	pH	Swelling index
Bulk density	1	0.2435	-0.4143	0.6655*
Dry matter	0.2435	1	-0.8114*	0.275
pH	-0.4143	-0.8114*	1	-0.513
Swelling index	0.6655*	0.275	-0.513	1

***: p<0.05**

Number of observations: 15