"Nutritional Quality of Fruit Pastes Enriched with Moringa Oleifera Leaves"

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Abstract

Madagascar is a predominantly rural country with a degree of rural poverty by more than 70% and characterized by a qualitative and quantitative food deficit. The diet is poor in protein; the proportion of protein is only 12% of energy intake. Sources of protein are available such as Moringa oleifera (ananambo) which are still marginalized by the population. Madagascar is also characterized by an abundance of fruits insufficiently utilized despite their annual provision. To enhance the Moringa oleifera and the use of fruits, processes for nutritional enrichment fruits with powder Moringa leaves have been developed to obtain fruit pastes. Six fruits have been testing in the design of those fruit pastes: banana, persimmon, papaya, guava, breadfruit and tamarind; The results of sensory analysis have allowed us to retain the banana paste and tamarind paste, enrichment Moringa has been achieved at rates of 10%, 15% and 17.5% to 30%. This has resulted in a protein enriched 10-15 times more. These fruit pastes with different levels have been hedonic tests: tamarind pulp and banana are much appreciated by consumers. Banana pastes and tamarind with 30% of Moringa are then used to help in the fight against protein-energy malnutrition. Microbiological analysis showed results in accordance with microbiological criteria a specific reference than 6 months DLC. These products can help the fight against malnutrition as they provide 30 to 40% of the protein needs of a child less than 5 years.

Keywords: Moringa oléifera, fruit pastes, enrichment, tropical fruits, malnutrition, expiry date for consumption (DLC)

I- Introduction

In Madagascar, three quarter of the population rely on agriculture for their livelihood. Rural poverty rate is 70%. It is characterized by food insecurity. (CFSVA, 2010). The average malagasy diet is based on cereals, it is poor in plant and animal proteins (FAO, PAM.2013). Thus, demographic survey in 2008-2009 showed that 50% of children fewer than 5 suffer from chronic malnutrition, 24% of which is moderate and 26% acute severe (Plan National d'Action pour la Nutrition, 2012).

Madagascar is endowed with a variety of natural resources available, edible but in majority misused, little known, and lacking nutritional education. Among them *Moringa Oleifera* (Ananambo ou Felamorongy), an unknown and wild plant growing in the Eastern, Northern and western parts of the island. It is relegated to the back by highlands population due to the lack of knowledge of its virtues and its insufficient availability. In Southern countries, it is a new nutritional and economic resource (De Saint Sauveur, Broin, 2010), with great demand for the fight against malnutrition in Africa (Ray-Yu Yang and al. 2006).

Madagascar has a great diversity and abundance of tropical fruits accoridng to WHO surveys Taolagnaro and Antananarivo in 2005. 72, 6% of Malagasy eat less than 5 fruits a day (MinSan/OMS, 2005). Fruits contains less than 0,5g of protéines / 100g of products. They are deficient in some amino-acids, (Groupe intergouvernemental sur la banane et les fruits tropicaux, 2003), non-starch with a variable content in carbohydrates, very rich in water, fiber and micronutrients.

The objective of this study is to valorize *Moringa oleifera* leaves and tropical fruits to join the National Action Plan for Nutrition ***(PNN, 2012)***. It consists in making nutritional complements: fruit pastes enriched with *Moringa oléifera* leaves powder to contribute to fight against malnutrition.

II-Materials et Methods

1. Materials

Collection of *Moringa oléifera* leaves is done on the East Coast, North Coast and West Coast, respectively in the region of Toamasina, Antseranana and Mahajanga (figure 1).

The East coast is exposed to trade winds and is hit by cyclones twice a year. Precipitations can reach three meters per year , which encourages luxurious and wet vegetation.

The Notthern part is characterized by a tropical and dry climate divided into a dry and rainy seasons. Précipitations can reach two meters per year. The region is prone to tropical and humid forest.

In the West, dry and humid season are well marked. The climate is dry, savannah wooded with baobabs and tropical and dry forest. Average annual rainfall is one to two meters per year.

Figure1: Zones of harvest of the Moringa (http://wwwmadaorchidee.free.fr)

Figure 2: Bushes of Moringa oleifera (http:www.ilovemoringa.com/MoringaOleifera.html)

1.1.1. Moringa Oleifera

Moringa oleifera from northern India is acclimated in almost all tropical regions. It is a tree with thin trunk and aerial foliage. It can reach 3 to 10 meters high. Leaves are small, coming out in the dry season and drought periods. The tree carries white and yellow flowers from January to June. It carries continually green or brown capsules, 20 to 35 cm long (figure 2 and 3). *Moringa oleifera* is resistant to drought. It develops in arid or semi-arid conditions: it can adapt to all kind of conditions. **(Foild and al, 2001)**.

Figure 3: Branches with Leaves, Flowers and Fruits of Moringa Oléifera

(**http://www.wikiherb.info/2012/08/moringa-moringa-oleifera-lamk.html**)

1.1.2. Fruits

Madagascar has a wide variety of fruits, many of which have been introduced in the country. It is the case of the guava *(Psidium Guajava)* which comes from South Africa, tamarind *(Tamarindus Indica)* from India and the Middle East **(Trillard, 1999)**, banana *(Musa Acuminata)* from Asia and India , papaya *(Carica Papaya)* from Mexico, grown in America, Asia and Africa . The island has a huge variety of fruits, some of which are available all through the year like banana, papaya and tamarind (http://www.123fruits.com/article.php3?id_article=51)

2. Methods

2.1. Preparation of Samples

2.2.1 Preparation of Moringa

Leafy branches of *Moringa* are cut from shrub, put is plastic bags and quickly transported to Antananarivo by road. They are taken to the laboratory where they are washed. Then leaves are pulled of, drained and sorted. Leaves are dried by spreading them over plastic jute sacks. They are regularly stirred: twice a day to avoid mold growing. The drying takes days in a well ventilated room at 27°c. Dried leaves are transformed in fine powder with a mixer. Leaves powder are kept in plastic and non transparent boxes, away from light. This powder will be used to enrich fruit pastes **(De Saint Sauveur, Broin, 2010)**.

2.2.2 Preparation of Fruits

Fruits are bought on the local market of Anosibe and taken to the laboratory. They are washed, drained before use: case of papaya, banana, persimmon and bread fruit. Tamarind is taken out from its shell and kernels are taken away.

2.2.3 Making of Fruit Pastes

Fruits used to make fruits pastes are those that were available at the time of the study, i.e. from March: papaya, banana, persimmon, breadfruit and tamarind. Fruits are pealed, seeded, pitted, pulp only kept.

Classical fruits pastes are made with fruit pulp cooked with granulated sugar in equal proportions until reduction of the paste. The paste is ready when it pulls away from the recipient. This process is modified in the experimentation: quantity of granulated sugar for cooking are varied: 100%, 75% and 50% of the weight of the pulps. Pulps are first cooked for 10 minutes to soften at 50°c. Then sugar is added and the blend is cooked at 80°c until reduction (about 30 minutes).

2.2.4 Incorporation of Moringa

Moringa leaves powder is incorporated in fruit pastes progressively taking into account

- Temperature of fruit pastes which should be lower than 50°C
- Organoleptic properties of resulting products
- Daily protein requirement of a child under 5 year-old: 20 to 25 g /day (Latham, 2001).

Incorporation rate of *Moringa* are set at 10%, 15%, 17, 5% then at 30% of pulp.

2.2.5Diagram of Making Fruit Paste

The diagram of fruit paste making is shown in figure 4.

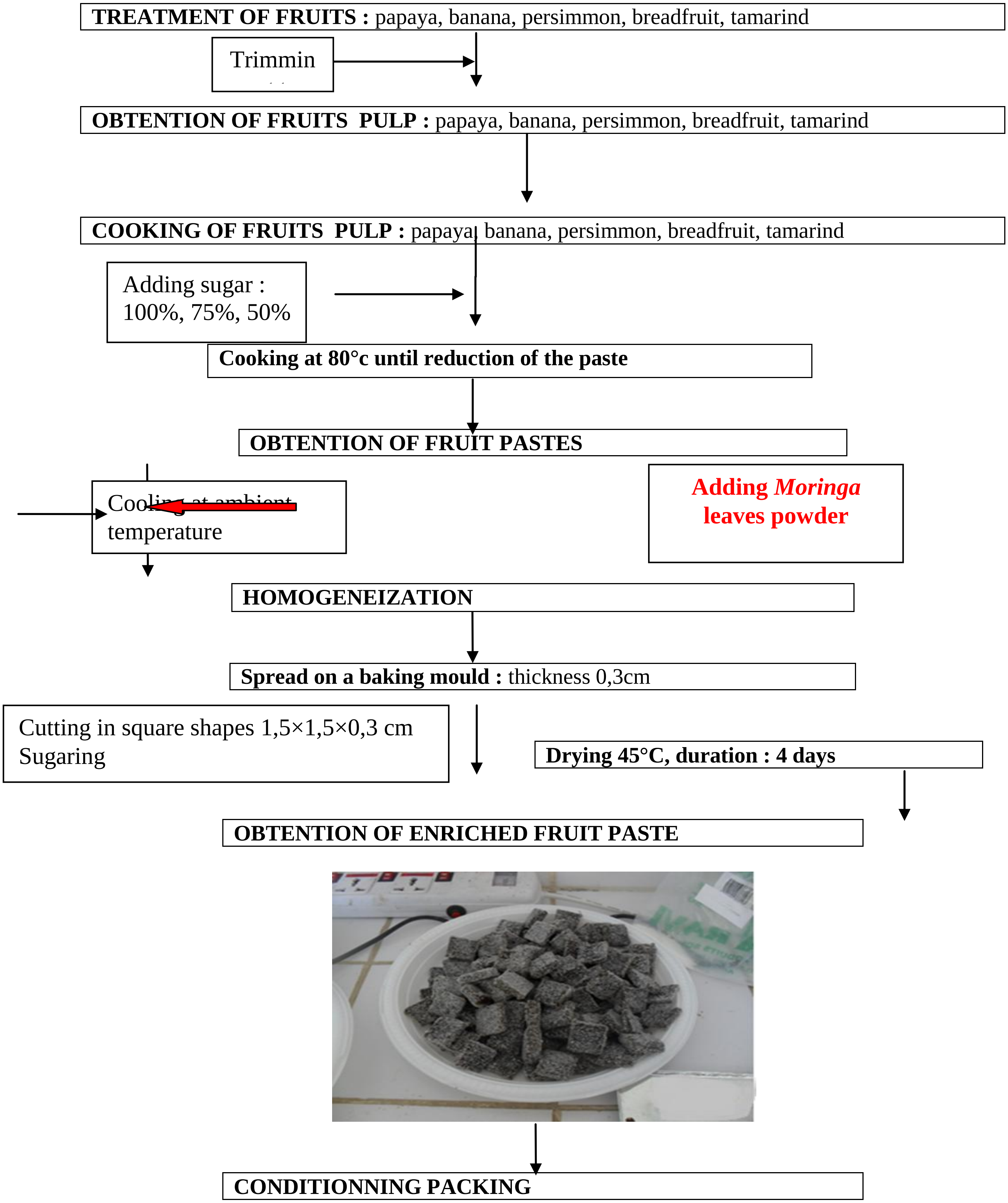


Figure 4: Steps in Makking Fruit Enriched with Moringa

2.2. Sensory Analysis of Enriched and Non-Enriched Fruit Pastes

2.2.1 Sensory Analysis of Non Enriched Fruit Pastes

Sensory analysis is conducted by a panel of 10 judges. They are asked to give their appreciation on organoleptic properties of fruits pastes (papaya, banana, persimmon, breadfruit, tamarind) without *Moringa* added. After a training session, they proceed to the evalution of the products on a rating scale from 0 to 9 on the following variables: texture, colour, taste, bitterness, consistence, astringency. In order to highlight the correlation between the describers and the products, datas are analyzed by principal component analysis (PCA) on XLSTAT.

The objective is to be able to choose which fruits paste suits better to enriching process.

2.2.2 Sensory Analysis of Enriched Fruit Paste

Sensory analysis of tamarind and banana enriched with different concentration of *Moringa* is done by men and women without age distinction, who have and have not yet tasted fruit pastes.

TRIANGULAR TEST (product-oriented) (Watts et al. 1991)

Perceptible difference between fruit pastes sample with and without *Moringa* is made with triangular test. Three coded samples are presented to judges: two are identical and one is different: judges must identify which one is different.

HEDONIC TEST (consumer-oriented)

To determine consumer's preference for fruit pastes with different concentrations of *Moringa,* a ranking test is done by 115 consumers selected randomly. Consumers tasted two series of enriched fruit pastes samples one by one and ranked their preference. (Score 1= most preferred sample, score 3 =not liked at all, score 2= intermediate). A difference analysis is made bu comparing total rankings for all possible pairs using Friedman test (F) On XLSAT 15.1.01.

RANKING TEST (product-oriented)

In order to obtain an indication of the taste that would be most acceptable for fruit pastes, a ranking test is done by a panel of initiated tasters: they are asked to rank samples by tastes, without equality ; from less acceptable taste to most acceptable taste. (Cote 1= most acceptable taste and cote 4 = less acceptable taste with intermediate level).

2.3. Physico-Chemical Analysis of Moringa, Enriched Fruit Pastes and Non Enriched Fruits Pastes (AFNOR, 1989)

- Samples pH is measured with a pH meter (TACUSSEL type) on a sample solution at 20% in distilled water.
- Water content is determined by drying samples in a ventilated oven down to a constant weight to an accuracy of ±0,001
- Lipid content is obtained by SOXHLET method: fat content is extracted with light petroleum by reflux system for seven hours.
- Protein quantity is determined by KJELDAHL method by mineralization of the sample with sulfur acid. Nitrogen quantity is determined by acidimetry.
- Ash quantity is determined by calcination of the sample in a muffle furnace for 16 hours at 600°C. Amount of mineral elements (sodium, potassium and magnesium) are measured from ash with an atomic absorption spectrophotometer.
- Glucid content is obtained by difference : % Glucid = 100 (%H_20+%Protein+%Lipid+% crude ash)
- Energy value of the food is obtained by multiplying each macro nutrient content by Atwater index. Index values are :
  - 1g of protein provides 4 Kcal
  - 1g carbohydrates provides 4 Kcal
  - 1g lipid provides 9 Kcal

Energ value of the sample to be analyzed is obtained by the following formula
Energy value = (Glucid×4) + (Protein×4) + (Lipid×9).

2.4. Microbiological Analysis of Enriched Fruit Pastes

Microbial identification is done using standard microbiological methods. (GUIRAUD et Al, .2010.)

25g of product and 225 g of Tryptone Water Salt are resuspended in a sterile bag. Homogeneization is made with a mixer « stomacher ». Initial supension is obtained ***(NFV 08 002)***. Serial dilutions: 10^{-1}, 10^{-2}, 10^{-3} to count the viable microorganisms at 30°C ***(NFV 08 010)***.

- Total viable count is identified and counted on a Plate Count Agar (PCA) after a 72hour-incubation at 30°c.
- Counting of *Escherichia coli* is done onto a EMB plate after a 24-hour incubation at 44 °c.
- Counting of *Staphylococcus aureus* is done in a selective yellow solid medium, which inoculation is made on surface and with 24-hour incubation at 37°c.
- Counting of *Bacillus cereus* is done in a MOSSEL medium. Incubation is at 30°C for 24h.
- Total and faecal coliforms are counted on agar-plate culture of crystal violet and neutral red with bile and lactose. **(VRBL).** Culture is done by seeding in sandwich de 1ml of the and for faecal colifors: 44°c for 24h.
- Detection of *Salmonella* is done onto a HEKTOEN ENTERIC AGAR plate after 24-hour at 37°c.

Best-before date of fruit paste is determined from products aging experience by proceeding to regular samplings. Measurement of this population is done by counting on petri dishes.

III- Results and Discussion

III 1. Sensory Analysis of Non Enriched Fruit Pastes

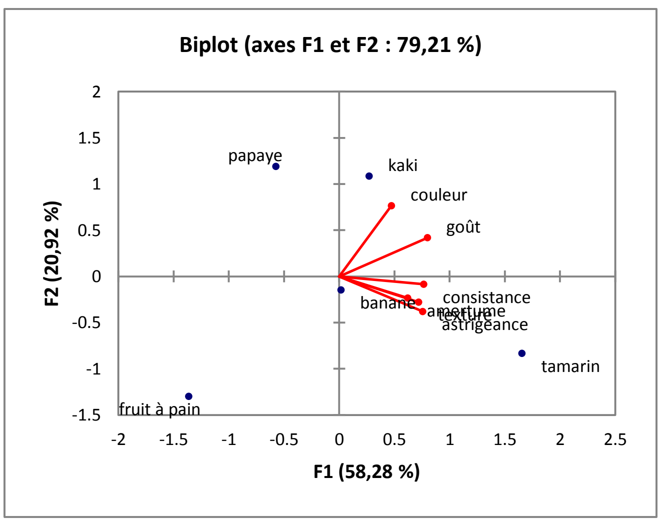


Fig. 5: Sensory Profile of Tastes Fruits

In this study, some fruits have been tested: papaya, tamarind, and persimmon. Those fruits are cooked successively in sugar in the following proportions: 50/100, 75/100 and 100/100. Indeed, sugar plays an important role in the making of fruit pastes. It reinforces organoleptic properties of products produits, lowers water activity and maintains the cohesion of gels made of molecules of fruit pectin by trapping water molecule around it.

Various fruit pastes obtained undergo organolecptic tests to determine different descriptors that will help choose fruit pastes to be enriched. Figure 9 presents 79, 21% of all information about the products and their descriptors.

Banana and tamarind on the basis of the following descriptors: consistency, texture, astringency, bitterness are considered for the making of fruit pastes enriched with *Moringa*.

Nutritional analysis is made for those banana and tamarind. (tableau 1).

III 2. Nutritional Analysis of Fruits and Moringa

Table1: Nutritional Composition of Tamarind and Banana

Analysis	**Tamarind**	**Banana**
Humidity H%(g for100g of raw material)	27,52	46,22
Dry matter content MS% (g for 100g raw material)	72,48	53,78
pH at room temperature	2,7	5,0
Total protein (g/100gMS)	0,87	0,70
Lipids (g/100gMS)	0,23	0,43
Glucids (g/100gMS)	61,86	49,71
Ash (g/100gMS)	9,52	2,94
Fiber (g/100gMS)	1,18	0,40
Sodium (mg/100gMS)	32	3
Potassium (mg/100gMS)	-	74
Magnesium (mg/100gMS)	19	58
Calories (cal)	252,99	205,51

Results show relatively high water content for tamarind and banana: 27,52% et 46,22% . Dry matter content is alos high: 72, 48% for tamarind and 53, 78% for banana. They are poor in proteins (0, 87% and 0, 70%), in lipid (content inferior to 1%), but rich in glucid (61, 86% and 49, 71%). These are very energetic food: 100g of tamarind bring 252,99cal and 100g of banana 205, 51 Cal.

Low protein content justifies enriching process of these fruits. The results of nutritional analysis of Moringa collected in different regions are in table 2.

Table 2: Composition of Moringa Oléiféra

Analysis	Fresh leaves Antseranana	Fresh leaves Toamasina	Fresh leaves Mahajanga	Leaves powder Mahajanga
Humidity H%(g for 100g of raw material)	56,26	60,26	49,10	5,63
Dry matter content MS% (g for 100g of raw material)	43,74	39,74	50,90	94,37
pH at room temperature	5,5	5,8	5,5	5,5
Total protein %	15,22	12,42	12,07	23,60
Total protein (g/100g dry matter)	34,79	31,25	23,71	25,00
Lipid %	4,99	6,37	6,01	5,61
carbohydrates%	11,87	11,17	22,61	55,43
Ash %	11,66	9,78	10,21	8 ,33
Energetic value (cal)	153,27	151,69	192,81	366,61
Sodium (mg/100gMS)	-	10,1	-	19
Potassium (mg/100gMS)	22	-	-	1,8
Magnesium(mg/100gM)	10	87	-	71

Humidity content of fresh leaves is very high: 56, 26% for Antseranana, 60, 26% for Toamasina and 49, 10% for Mahajanga.

Vegetal material is dried, ground and analyzed. Nutritonal analysis showed: the importance of dry matter (94, 37%) and a higher amount of nutritional elements inputs: protein content of 25g for 100g of dry matter 55, 43% of carbohydrates content and energetic input of 366,61cal.

Thus, dry leaves of *Moringa* will be used in the enriching process: addition of 10%, 15%, 17, 5% and 30% of *Moringa*. Tamarind and banana pastes enriched were subject to sensory analysis.

III 3. Sensory Analysis of Enriched Fruit Pastes

Triangular test: 11out of 18 individuals identified tamarind fruit pastes that were enriched. 13 out of 18 individuals identified enriched fruit pastes for banana. According to critical numbers tables for triangular tests: n and n'> 9 (9 is the critical number of correct answers at 5%). This means that judges found a perceptible difference between tamarind and banana pastes with and without *Moringa*.

Hedonic test :

- ✓ Case of tamarind pastes: Friedman test gives a p-value (p = 0, 0001) which is inferior to significance level α=0, 05. There is a significant difference between tamarind and banana pastes with different concentrations of *Moringa* : paired comparison test in table 3 at significance level α shows that tamarind pastes at 10% are different from those at 15% and 17,5%, and there is no difference between tamarind paste at 15% and 17,5%. Thus, tamarind pastes at 17, 5% are as much appreciated as those at 15% by consumers.

Table 3 : Multiples Comparisons by Pairs with Nemenyi Procedure / Bilateral Test

Sample	Sample size	Sum of ranks	Average of ranks	Groups	
pt 17, 5%17	115	270,000	2,348	B	
pt 15% 643	115	221,000	1,922	B	
pt 10% 326	115	199,000	1,730		A

- ✓Case of banana pastes: Friedman test gives a p-value (p=0,112) higher than the significance level α=0, 05. Thus, there is no significant difference between banana pastes with different concentration of *Moringa*. This result is confirmed by multiple paired comparison test (table 4) Consumers appreciate banana paste with *Moringa* at 10% and 15% as well as at 17,5%.

Table 4 : Multiple Paired Comparisons with Nemenyi Procedure / Bilateral Test

Sample	Sample size	Sum of ranks	Average of ranks	Groups
pb 15% 261	115	218,000	1,896	A
pb 17,5%195	115	224,000	1,948	A
pb 10% 689	115	248,000	2,157	A

Protein content is measured for tamarind and banana pastes (table 5).

	Tamarind pastes 17,5%	Banana pastes 17,5%
Average weight (g)	1,47	1,12
Humidity H%	10,10	15,20
Dry matter content MS%	89,90	84,80
Total protein (g/100g of dry matter)	1,35	1,44

Table 5: Protein Content of Tamarind and Exotic Pastes with 17, 5% of Moringa

Results show: low protein content in fruit pastes at 17, 5% at *Moringa*: 1, 35% and 1, 44%. Conditioning is set for 10 per packet, equivalent to a proteinic contribution of 0, 19 g/ packet. This contribution is very inferior to WHO recommendation (25 to 30g daily intake for children under 5 years). Quantity of *Moringa* in tamarind and banana pastes is increased to a maximum incorporation: 30%.

Ranking test: Differences between pair ranking sum are in table 7 and ranking test of fruit pastes are in table 6.
Critical value for p< 0,05 for 14 tasters and samples is 9 (table of difference of sum of absolute ranks for the comparisons of all treatments at a significant threshold of 5%) : Differences between samples of tamarind pastes (10% - 17,5%) and (10% - 30%) and (15%- 30%) and (17,5% -30%) are significant as well as for banana paste : (10%-30%) and (15%-30%) and (17,5%- 30%).

Tamarind paste	10%	15%	17,5%	30%
Sum of rankings	44	36	34	23
Banana paste	10%	15%	17,5%	30%
Sum of ranking	44	42	35	19

Table 6: Sum of ranks for tamarind and banana paste

Table 7: Results of the Ranking Test

Products considered	Number of good answers : X	Comparisons
pt10% - pt 15%	44-36= 8	X<9
pt10% - pt 17, 5%	44-34= 10	X>9
pt10% - pt 30%	44-23= 21	X>9
pt15% - pt 17, 5%	36-34= 2	X<9
pt15% - pt 30%	36-23= 13	X>9
pt17, 5% - pt 30%	34-23= 11	X>9
Products considered	Number of good answers : X	Comparison
pb10% - pb15%	44-42= 2	X<9
pb10% - pb 17,5%	44-35= 9	X=9
pb10% - pb 30%	44-19= 25	X>9
pe15% - pe 17,5%	42-35= 7	X<9
pb15% - pb30%	42-19= 23	X>9
pb17,5% - pb 30%	35-19= 16	X>9

pt: tamarind paste ; pb: banana paste

Tamarind and banana pastes at 30% of *Moringa* are not so different from those at 10%, 15% and 17,5%. According to ranking test tamarind and banana pastes at 17,5% of *Moringa* were accepted in hedonic analysis and since the objective is to increase to its maximum the protein content. Thus, it can be considered that tamarind and banana fruit pastes with 30% of *Moringa* content can be taken as a dietary complement. 7

Nutritional analysis is done on new fruit pastes (tamarind and banana) and results are shown in table 8

	Enriched tamarind fruit pastes	Enriched banana fruit pastes
Average weight	1,47g	1,12g
pH	3,4	3,4
Humidity H% (g for100g of raw material)	9,4	3,4
Dry matter content MS% (g for 100g of raw material)	90,6	96,6
Total protein (g/100g dry matter)	8,60	10,24
Lipid (g/100g dry matter)	1,21	1,34
Glucid (g/100g dry matter)	78,17	76,87
Ash (g/100g dry matter)	2,62	4,15
Energy value (Kcal)	354,34	371,80

Table 8: Chemical Composition of the Fruits Pastes Enriched

Results obtained show that tamarind pastes enriched contain 8,60 g of protein for 100g of dry matter and banana pastes contains 10,24 g of protein for 100g of dry matter. Thus, tests gave a protein enrichment of fruits 10 to 15 times higher. Tamarind and banana pastes bring up 30 to 40% of daily protein needs of a child under 5.

As for energy value, each bit of tamarind and banana paste bring an average of 5, 20 cal and 4, 16 Kcal. As it is a new food product, it is useful to conduct a microbiological analysis and determine its expiry date. Results are shown in table 9, graphs 1 and 2.

Germs in banana pastes	D_0	D_{10}	D_{80}	D_{160}	D_{180}	Criteria	Methods
FAMT à 30 °C	$1.8\ 10^2$	$5.6.10^2$	$7.4.10^2$	$9.1.10^2$	$9.5.10^2$	1.10^3	*NF ISO 4833*
E.coli	<1	Abs	Abs	Abs	Abs	1.10	NF V 08 053
Staphylococcus aureus	Abs	Abs	Abs	Abs	Abs	1.10	NF V 08 057-1
Bacillus cereus	*1.5. 10*	*1.5. 10*	*1.5. 10*	*1.5. 10*	*1.5. 10*	10^2	XP V 08-058
Total Coliforms	5.10	5.4.10	6.3.10	6.4.10	6.4.10	1.10^2	*NF V 08-050*
Faecal coliformes	<1	*Abs*	*Abs*	*Abs*	*Abs*	1.10	*NF V 08-060*
Salmonella sp.	Abs/25g	Abs/25g	Abs/25g	Abs/25g	Abs/25g	Abs/25g	NF V 08 052
INTERPRETATION	**CONFORM**						**Equation of expiry date : y=2,33x +537,2 expiry date : 5 months et 5days**

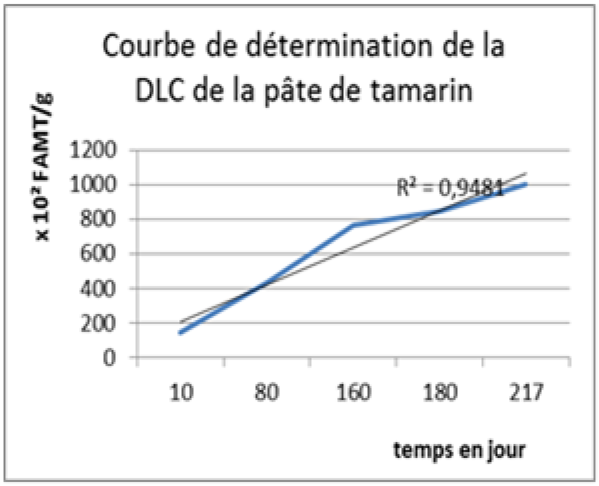
Germs in tamarind pastes	D_0	D_{10}	D_{80}	D_{160}	D_{180}	Critères	Methods
FAMT à 30 °C	$0{,}99.10^2$	$1{,}405.10^2$	$4{,}31.10^2$	$7{,}63.10^2$	$8{,}46.10^2$	1.10^3	*NF ISO 4833*
E.coli	Abs	Abs	Abs	Abs	Abs	1.10	NF V 08 053
Staphylococcus aureus	Abs	Abs	Abs	Abs	Abs	1.10	NF V 08 057-1
Bacillus cereus	*1. 10*	*1.1. 10*	*1.1. 10*	*1.4. 10*	*1.4. 10*	10^2	XP V 08-058
Total coliforms	6.1.10	7.2.10	7.3.10	7.5.10	7.5.10	1.10^2	*NF V 08-050*
Faecal coliforms	*Abs*	*Abs*	*Abs*	*Abs*	*Abs*	1.10	*NF V 08-060*
Salmonella sp.	Abs/25g	Abs/25g	Abs/25g	Abs/25g	Abs/25g	Abs/25g	NF V 08 052
INTERPRETATION	**CONFORM**						**Equation of expiry date : y= 4,15x + $0{,}99.10^2$ Expiry date : 7 months et 3 days**

Table 9: Microbiological Results and Expiry Date

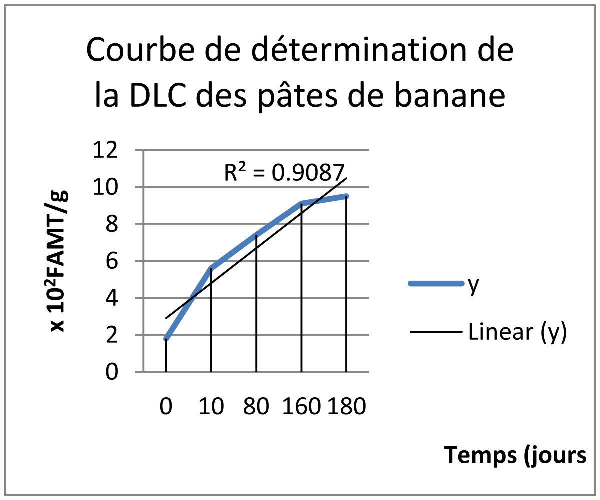
Tamarind and banana enriched with *Moringa* all contain a FAMT (1, 8.102 - 9, 9.10) but with concentration inferior to microbiological criteria of reference (1.10^3). This is probably due to the air-drying of *Moringa* because it did not undergo any thermic treatment. Total coliforms are found in the two products (5.10- 6.1.10) but in line with standards (1.10^2); faecal coliforms *Staphylococcus aureus* and salmonella at the root of toxi- infections are not found in the two products. Bacteries at the roots of food poisoning such as *Escherichia coli* are absent from tamarind and banana pastes. However, *Bacillus cereus* is found in both products at rate inferior to the standard (10^2): 1.5. 10 - 1. 10. From these results, it can be said that tamarind and banana pastes have acceptable microbiological quality.

This results partly from the antibacterial role of sugar. It bonds with water molecules and makes them unavailable for the growth of microorganisms which need it for their development. On the other hand, this also thanks to acid pH of fruit paste (3, 4) pathogens that cannot develop well at a pH inferior to 4. Indeed, ideal pH for the growth of bacteries varies from 6, 5 to 7, 5. Stove-drying also enables conservation by water reduction in fruit pastes. Low water content (10, 10% - 15, 20%) also contributes to non-prolifération of microorganisms.

For tamarind and banana pastes, expiry date is given by linear regression line from graphs 1 and 2. For tamarind paste: y= 4,15x + 0, 99.102**,** which gives an expiry date of 7 months and 3 days. For banana paste: y=2, 33 x + 537,2 and expiry date is 6 months and 5 days.



Graph 1: Curve of growth of the FAMT in the Tamarind Tastes



Graphs 2: Curve of growth of the FAMT in the Exotic Pastes

IV. Conclusion

Our results allowed us to reach our set target: banana and tamarind, poor in protein are enriched with vegetable leaves: *Moringa* which is little used in diet but rich in protein.Valorization consisted in making fruit pastes: tamarind pastes and banana pastes with *Moringa*. Enriching of fruits is 10 to 15 times higher. Incorporation of *Moringa* is 30%. This are products processed from fruits and sugar. Sugar, in addition to bringing in organolecptic properties, reduces water activity in the products, inhibits bacterial development and helps maintain cohesion of gels in fruit pastes. Acidity rate, low water content and the drying of fruit pastes at 45°c (partial dehydration) contributes also to the inhibition of bacterial development. Products with good microbiological quality and an expiry date over 6 months are obtained. These produtcs will be soon tested in school canteens.

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ASJA University for its technical collaboration

VI. Bibliography

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