Development of an Enriched Rice Cake for Women in Gestation in Antsirabe City, Madagascar

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Abstract

In Madagascar, the household food insecurity is linked to poverty and bad life condition, which affects the entire population including pregnant women and several nutrients are absent from their daily ration and lead to malnutrition. The aim of this work was to develop a food complement for pregnant women with lower income in Madagascar. This research program was carried out in collaboration with the National Nutrition Office (ONN). A questionnaire survey was made with pregnant women from Antsirabe. Their diet was rich in glucids, and poor in protein and lipids. «Koba», a food complement based on white rice, bananas, enriched with peanuts, spinach and soya was developed to have sufficient and balanced diet. According to physico-chemical analysis complement brought 10 g of protein for 100 g of products, 8.5 g of lipids, 46.7 g of glucids, 16.3 mg of calcium, 37.6 mg of magnesium and 1.9 mg of iron. The product will contribute to the improvement of nutrition status of these pregnant women by increasing supply in protein, lipids and some minerals, as well as growing energetic supply. Tests of anti-nutritional factors showed that product did not contain any anti-nutritional elements. Microbiological analysis indicated that this food complement is in a better quality. In terms of sensory factors, enriched «koba» was more appreciated than classical «koba ». As recommendations, women should consume the product during pregnancy.

1. Introduction

People are usually take care about the children's food, but the pregnant women food is neglected. Several nutrients are absent from their daily ration and lead to malnutrition. This constitutes a main public health problem and lays a serious handicap to the socio-economic development of our country. The first 1000 days in the life of a child is the period from the first day of conception to 2 years of age. The first 1000 days are a vulnerable period because this is a time of very rapid growth and development [1]. However, good nutrition during the first 1,000 days of childhood is important in preventing malnutrition. The future of the human capital will depend on this period.

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The household food insecurity is linked to poverty, which affects the entire population including pregnant women in Madagascar. Current food practices in the country are underlined by an interaction between food availability and accessibility due to the low income of the householder [2]. Poor maternal nutritional status during pregnancy is also associated with stillbirth [3], intrauterine growth restriction [4] and mortality [5] in early infancy and increased risk of no communicable diseases later in adulthood [6]. Children born with intrauterine growth restriction tend to carry their average growth deficit through childhood into adulthood and have reduced cognitive ability [7-9]. Women who had been malnourished themselves during gestation and early childhood are more likely to give birth to low birth weight (LBW, defined as birth weight of < 2500 g) infants, thus contributing to the trans-generational cycle of malnutrition and poverty [4]. The rate of malnourished Malagasy children between 0 and 5 years old is 47, 5% [10]. It is essential to take charge of the nutritional intake of the pregnant woman since the mother's good nutrition is reflected in the nutrition of her child [11, 12]. There is an evidence link between nutrition during pregnancy and fetal growth as well as well-being of the mother, development and the risk of various diseases [13, 14]. The Vakinankaratra Region has a high rate of malnutrition, which is 65.2%, the highest in the country [15].

It is necessary to give a source of essential healthy food and nutritional elements in their diet. Thus, the need of having a food rich in nutrients necessary during pregnancy, from local food resources notably accessible for the most vulnerable households, was produced to balance the nutritional needs of women during this period and to reduce the prevalence of chronic malnutrition. Hence, the goal of this study is to develop a food supplement which will cover the nutritional needs of the pregnant women living in Antsirabe.

2. Materials and Methods

2.1. Study Area

The Vakinankaratra Region is located in the Highlands of Madagascar; it constitutes the southern part of the province of Antananarivo between the volcanic massif of Ankaratra and the Mania River at the limit of the province of Fianarantsoa. This place covers an area of 16,599 km^2 and the population counted 2,074,358 inhabitants in 2018 [16].

It is subdivided into 7 districts (Ambatolampy, Antanifotsy, Antsirabe I, Antsirabe II, Betafo, Faratsiho and Mandoto), and 86 municipalities. The "Merina" ethnic group predominates in this region. Agriculture is the main activity in this place.

2.2. Study Design

This research employed a descriptive study design whereby the characteristics of respondents were described. The choice of this design was required by the nature of the issue being studied. The community was selected because it has experienced cases of malnutrition of pregnant women.

2.3. Target Population

A purposive sampling is entirely based on the judgment of the researcher in that a sample is composed of elements that contain the most characteristics, representative or typical attributes of the population [17]. The questionnaire enabled structured social interaction between the researcher and the respondents' there by providing an opportunity to obtain quantifiable and comparable information related to the study. The semi-structured questionnaires containing open and closed questions enabled the researcher to carry out an objective probe to the sampled population in Antsirabe region.

It was observed that lots of pregnant women don't care about their nutrition during the pregnancy while they need nutrients for the fetus development to the childbirth. An anemia rate of 46% in pregnant women is associated to malnutrition and micronutrient deficiencies [17]. For the current study, the target population was pregnant women of Antsirabe.

2.4. Raw Materials

An enriched rice cake composed of plant-based foods and an animal-based food was produced. This made food can provide the necessary nutritional requirements during different steps of pregnancy. It is a street food, widely consumed in the area of study, and accessible to all. Different local foods were used to make this cake, and below is listed raw material used.

2.4.1. Peanuts

After selection, the peanuts are fried, salted, skinned and then crushed before being added to the food supplement.

2.4.2. Banana

The Lacanta variety of banana does not undergo pre-treatment but it was peeled and diced. It is mostly cultivated in the south-eastern part of the island (Manakara).

2.4.3. Spinach

The spinach underwent washing, drying under the sun until hard leaves are obtained (200 g of fresh spinach gives 53 g of dry spinach), then grinding the leaves with the fingers before adding to the product.

2.4.4. White Rice Flour

Rice flour is the product of milled white rice *Oryza sativa* which is grown in Mandray Antanambao. It is the basic material for the preparation of the rice cake. The rice was manually ground using a mortar, then removed from the seed coats, and ground again until getting sufficient and thin product.

2.4.5. Soybean

Soybean is rich in omega-3 fatty acids and iron. The Davis variety of the Papilionaceae family was the raw material used in the preparation.. They were wet in water for 24 hours then boiled at 100°C for an hour. The boiled seeds were ground using a mortar. All these steps constitute the pre-treatment. It was harvested in Bemololo.

2.4.6. Milk

The only raw material from animal origin in the enriched food supplement was cow's milk. It was taken from the Tombontsoa farm. The milk was boiled at 100°C for 15 min and cooked.

2.5. Processing Equipment

For the preparation of the supplement, simple and usual utensils were used. The product packaging is a cardboard box. The shape of the rice cake is maintained and it's more presentable compared to the usual container of the rice cake in the alleys.

2.6. Physico-chemical Analysis

2.6.1. Determination of Moisture (Guilbot Method)

It consists of eliminating the water soaked in the water by dehydration at $103 \pm 2°C$ for 24 hours, while weighing the product before and after drying [18].

2.6.2. Determination of crude Ash Content

Crude ash is determined by incinerating the organic material in the sample at 550°C in a muffle furnace. They constitute the residue of the mineral compounds after this incineration [19].

2.6.3. Determination of Minerals (Ca, Fe, Mg)

To the ashes of the sample was added concentrated hydrochloric acid 12 N. The whole is heated to 150°C, cooled and then filtered in 100 mL flasks then the volume was adjusted distilled water. Serial dilutions were made in order to facilitate the reading of the results on the atomic absorption spectrophotometer. These dilutions were made with a buffer solution which is lanthanum oxide, an ionization buffer. Neutral atoms absorb the discrete wavelength radiation scattered by the hollow cathode lamp, specific to each considered element. This element is released from its chemical bonds, and then brought back to the initial state by the action of the burner's flame. The described method obeys the law of Beer-Lambert.

2.6.4. Determination of Fiber Content

The principle is based on the insolubility of fibers (lignin and cellulose) in formic acid. The insoluble formic is the fragment of crude ash remaining after treatment with formic acid and its incineration [20].

2.6.5. Determination of the Total Lipid Content

This method is based on the solubility of lipids in some organic solvents [18].

2.6.6. Determination of the Total Protein Content

Proteins are the dominant substances in nitrogenous substance. Kjeldahl's method is to deduce the amount of proteins in a sample from the nitrogen determination. There are three steps to determine the nitrogen content: -the mineralization allowing transforming the organic nitrogen into mineral nitrogen; -distillation to pass the nitrogen in a recovery solution; -and finally the titration of the sample in the presence of a colored indicator [18].

2.6.7. Determination of the Energy Value

In the organism, the carbohydrates, proteins and lipids in the absorbed nutrients undergo a metabolism. This results in energy, expressed in calories (cal) [21].

The energy value is therefore the energy supplied by the food. The coefficients of ATWATER are defined as the metabolizable energy of 1g of nutrient

a) 4 Kcal for 1 g of carbohydrates.

b) 4 Kcal for 1 g of protein

c) 9 Kcal for 1 g of lipids

2.7. Microbiological Analysis

Microbiological analysis was performed on an enriched rice cake and a classic rice cake ready for consumption. Microbiological analysis are grouped into two categories, including the enumeration of the microorganisms (FAMT, fungal flora, coliforms, *Bacillus cereus, Escherichia coli*) and the search for pathogenic germs such as *Salmonella spp*.

2.8. Research of Anti-nutritional Factors

Anti-nutritional factors are substances that disrupt the metabolic use of nutrients. They lead to harmful side effects after consumption of certain foods. Alkaloids, tannins, saponosides, flavonoids, leucoanhocyanins and iridoids were evaluated as previously described [22]. Aging tests are made according to NFV 01-003 [23].

2.9. Hedonic Product Analysis and Sensory Tests

Using the hedonic approach, the pairwise comparison test was used according to the preference between enriched rice cake and classic rice cake.

The target population (native consumers) constituted as well the team, which served as tasters of the made cake. This population was of pregnant women at different stages of pregnancy. Two products (an enriched rice cake and a classic rice cake) were presented in two different plates with their code, to be in accordance with usual use and to avoid influence on the decision of the tasters.

2.10. Data Analysis

After filling the questionnaires, the results were collected and statistically processed using the binomial law p=½.

Table 1. Comparison of the nutritional needs of reference pregnant women and those of the target group.

	Nutritional needs of pregnant women	Nutritional intake of pregnant women of the target group	Lack of value
Energy value (Kcal/d)	2.250	1849.3	- 400,7
Carbohydrates (g)	281.2	3748	+ 93,6 *
Proteins (g)	112.5	64,1	- 48,4
Fat (g)	65	12,9	- 52,1

(Legend: * excess)

This table shows that the diet of pregnant women in the area is rich in carbohydrates, low in protein and very low in lipid. It is possible to fill these proteins and lipid deficiencies with a food supplement to reach the reference values. The diet of pregnant women is not as varied as it should be. This period of their life does not really change their usual mode and amount of nutrition. It is necessary to stop these proteins and lipid deficiencies, putting within the reach of Malagasy households, a source of essential healthy and nutritional nutrients in their diet, to eradicate chronic malnutrition of the future baby, malnutrition in pregnant women, and also to break the intergeneration cycle of malnutrition often experienced in our country.

3.2. Product and Its Proposals

To improve the nutritional status of pregnant women in the study area, developing local rice cake products provides balanced amounts of the majority of the nutrients necessary for the nutritional needs of these women who are vulnerable to malnutrition. The composition of this dietary supplement is based on the combination of plant and animal foods. For the Test 1, sesame is used in an amount of 30 g. Sesame is an excellent source of protein. However it's rare and costly. Even if the sensory quality of the finished goods meets the sensory quality, its cost prevents the adoption.

On Trial 2 the amount of peanuts is 45 g. This high quantity has an undesirable impact on the sensory quality of the product. Indeed, the product becomes brittle and cannot be solid. Compared to the 2 previous tests, test 3 provides a firm and non-brittle product. Organoleptic qualities are also acceptable. Nutritional intake can partially or totally fill the gaps in the daily intake. The product is not expensive and

Regression was used in order to determine the microbiological spoilage of the enriched rice cake compared to the classic rice cake. It should be noted that this analysis was performed only for the FAMT and the fungal floral.

3. Results and Discussion

3.1. Standards of Nutritional Needs for a Pregnant Woman

The table 1 shows the comparison of the nutritional needs of reference pregnant women and those of the target group.

suitable for the target groups of the study.

The formulation of test 3 is used for the development of the product. The following figure indicates the proportion of the food supplement enriched for its realization
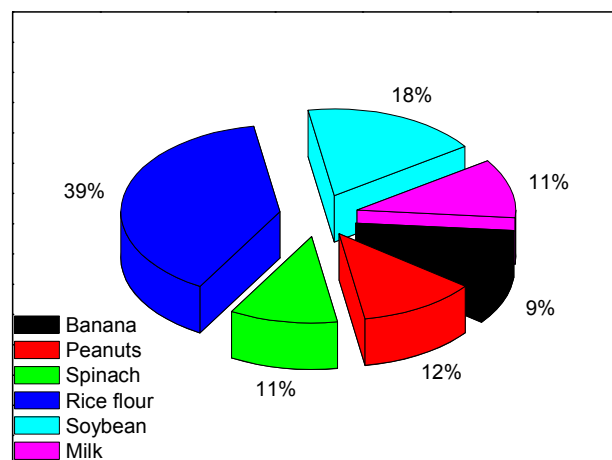

Figure 1. Formula of rice cake for pregnant women.

For a rice cake of 534 g, it is divided into 4 portions of 133 g. The choice of components is justified as follows:

a) Peanut is rich in vegetable proteins and lipids, high content of several vitamins (B1, B3, B9, E), several minerals (copper, manganese, iron, phosphorus, magnesium), several molecules very beneficial for our organism and our immune system [24];

b) Bananas can help with some common pregnancy discomforts, such as constipation and morning sickness. Its richness in potassium, magnesium and some vitamins is a major asset, indicating that the banana is an excellent fruit

with multiple virtues. In addition, a magnesium deficiency could trigger hyper-excitability of the uterus i.e. significant uterine contractions and a risk of premature delivery;

c) Vitamin B9 in spinach plays an essential role in the production of genetic material (DNA, RNA) and amino acids necessary for cell growth. Demands for folate increase during pregnancy because it is also required for growth and development of the fetus. [25]. In addition, spinach contains iron. Iron requirements in pregnant women increase particularly during the 2nd and 3rd trimester of pregnancy. This surplus iron is important to increase the oxygenation capacity of the cells of the body and to promote the growth of the fetus and the placenta;

d) In addition to being gluten-free flour, rice flour has an interesting nutritional composition. It is an excellent source of energy due to the presence of carbohydrates. It also provides fiber, minerals such as potassium and phosphorus, as well as vitamins;

e) Essential fatty acids like Omega-3 in soybeans play an important role in the development of the nervous system and the eyes of the fetus.

f) Milk is a good source of vitamin D with 3.70 µg for a 250 mL glass [26], a vitamin often missing in the daily diet. This vitamin promotes good calcium fixation [27].

3.3. Physico-chemical Analysis

Physico-chemical analysis refers to any operation to determine the nutritional values of a sample. They are considered as the basis for monitoring the results obtained during the food modification and to suggest improvements if necessary (table 2).

Table 2. Nutritional value of rice cake per 100g.

Physico-chemical parameters	Enriched rice cake (100 g)	Normal rice cake (100 g)
Moisture (%)	33.7	23.0
Total proteins (%)	10.0	3.7
Total fats (%)	8.5	0.9
Total carbohydrates (%)	46.7	65.0
Fibers (%)	17.3	7
Crude ash (%)	0.9	3.4
Calcium (mg)	16.3	7.1
Magnesium (mg)	37.6	17.7
Iron (mg)	1.9	0.5
Energy value (Kcal / KJ)	303.3/1267.8	283.1/1183.3

It can be observed from the table that, the products under study is moderately aqueous. The enriched rice cake has a high content in water (33.7%) than the classic one. This difference is due to numerous components added to the new cake made. The enriched product provides much more protein and lipids than the conventional product. This is due

to the presence of spinach, soybeans, cow's milk (usually absent in the preparation of classic rice cake), and peanuts, ingredients that define the enrichment of the cake. Thus, the food supplement carries more nutrients compared to the classic rice cake. A 133 g serving provides: 62.1 g of carbohydrates, 13.3 g of protein and 11.3g of fat. This supplement may help to fill up the lack of a daily intake of pregnant women.

The global contribution will increase from 1849.3 Kcal to 2252.6 Kcal; while the carbohydrates intake will increase from 374.8 g to 436.9 g; the protein intake will increase from 64.1 g to 77.4 g and fat intake will increase from 12.9 to 24.2g respectively. There is a gain of 403.3 Kcal by consuming the enriched rice cake. The sufficiently high fiber content in the food supplement-which is 17.3%-proves that the raw materials are rich in fibers (white rice flour, soybean powder, peanuts).

The fibers exert a regulatory effect on intestinal transit and participate in the prevention of some diseases (coronary heart disease, constipation, hypertension, stroke, diabetes diseases and obesity) by modulating the activity of the immune system. Increasing fiber intake also lowers blood pressure and serum cholesterol levels [28] and even reduced risk of mortality [29]. The classic rice cake has much more ash content than the enriched rice cake, due to the elevation of dry matter content of the classic product compared to the enriched product. The enriched product contains essential minerals notably: calcium, magnesium, and iron, of which respective values are 16.33 mg, 37.6 mg and 1.9 mg. These minerals are essential for the fetus development. Calcium is required for fetal and infant bone development and mineralization, as well as for breast milk production. Maternal bone turnover and the intestinal absorption of calcium increase during pregnancy to help meet fetal calcium requirements. The majority of calcium is transferred to the fetus in the third trimester [30, 31]. Supplementation during pregnancy has any influence on primary dentition measured as the reduction of dental caries of the child [32]. Hypertensive disorders in pregnancy, including preeclampsia, are major contributing factors to maternal and perinatal mortality [33, 34]. Moreover, calcium supplementation decreases the risk of Peterm birth (PTB) and increases birth weight [35].

During pregnancy, the body requires extra iron as the demand for hemoglobin increases with the surge in the amount of blood in the body, which can be as high as fifty per cent. During the second and third trimester, the growth of the baby and placenta will result in the body needing an increase in iron. That being said, iron demands are often met due to the absence of menstruating, reducing the loss of iron through bleeding and the body's increased ability to absorb more iron

progressively during pregnancy [36].

Iron deficiency anemia (IDA) is the most frequent form of anemia in pregnancy. Iron is essential for normal fetal development, including brain development [37]. If the mother is severely anemic, it could increase the risk of premature birth and low birth weight [38]. A double-blinded study suggest that magnesium supplementation during pregnancy has a significant influence on fetal and maternal morbidity both before and after delivery [39].

Cooking at high temperatures promotes the formation of acrylamide, a second product of the Maillard reaction a compound known as promoting cancer [40]. However, no trace of acrylamide has yet been detected in food that has been boiled [41]. This can be explained by the maximum temperature of the cooking mode, which does not exceed 100°C and by the absence of browning reaction. This explains the choice of steam cooking. It also minimizes the loss of nutritional values of the components through heat treatment.

3.4. Microbiological Analysis

Food is easily exposed to microbial damage due to the presence of water in food, which is essential for microbes. It is therefore important to monitor the microbiological quality of foods to prevent harm to customers' health through food poisoning. Table 3 presents the microbiological analyses of the enriched rice cake and the conventional cake consumed in Antsirabe area.

Table 3. Microbiological analyses of the rice cake enriched with the classic rice cake.

Microbiological standards	Enriched rice cake	Classic rice cake	Standards
Total aerobicmesophilicflora	$9,1.10^2$	$1,2.10^3$	3.10^5
Fungalflora	$1,8.10^2$	$4,6.10^3$	5.10^2
Total coliforms	-	9.10^4	10^3
Fecal coliforms	2.10^4	Abs	10^3
Bacillus cereus	$5,6.10^1$	1.10^2	10^2
Escherichia coli	-	-	10^2
Salmonella spp	-	-	Absent in 25 g

As observed in table 3, the number of total aerobic mesophilic flora (TAMF) does not exceed the microbiological reference standard. There are more of them in the classic rice cake than in the fortified rice cake, possibly because of hygiene during preparation. The high number of fungal flora in the classic rice cake proves this lack of respect for the hygiene of the handler during the manufacture of this product. The coliforms are not generally dangerous for the health, but they are nevertheless good markers for the general hygienic quality of food. The wholesomeness of the preparation instruments, the work plan and especially the personal hygiene should be more respected.

The presence of *Bacillus cereus* in large quantities in the classic rice cake shows that the existence of coliforms and this microbe is due to material contamination during the handling of the products. *Bacillus cereus* is considered to be an indicator of uncontrolled land or environmental contamination. While *Escherichia coli* and *Salmonella spp* (hygiene indicator germs) are absent.

The presence of *Escherichia coli* in a food is abnormal. It is an ideal safety indicator for foods treated with heat or not and it is known that Salmonella is pathogenic to humans.

3.5. Anti-nutritional Factors

The results of the tests for the presence of anti-nutritional factors in the food supplement are presented in the table below.

Table 4. Tests of anti-nutritional factors in rice cakes.

Anti-nutritionalFactors	Enriched Rice Cake	Classic Rice Cake
Alkaloids	-	-
Flavonoids	-	-
Leucoanthocyanins	-	-
Polyphenols	-	-
Saponins	-	-
Tannins	-	-

It is true that certain components of rice cakes contain anti-nutrients, but the experiments carried out indicate that these substances are absent in the products. This is explained by the pre-treatments made with raw materials, as in the case of soybeans (containing phytates, protease inhibitors, lectins, antitrypsic, flatulence factor), which is wetted for 24 hours, then change the water before cooking at a temperature above 100°C and after powdered and ready for preparation. For the peanuts (calcium oxalate, saponin, phytates), a heat treatment between 120 and 140°C is enough to degrade these anti-nutritional factors. The anti-nutritional factor in food inhibits proteins, minerals, vitamins and the action of enzymes. Their presence in untreated foods generally causes anorexia, slows growth and lowers the transformation coefficient of food when their concentration in the diet is high.

3.6. Aging Test

Two enriched rice cakes (refrigerated and non-refrigerated) are aged in order to be able to deduce the expiry date of the consumption of the food supplement. This aging test is done for 10 days with samples spaced 2 days apart. Thus, 5 samples were taken; their ratings are D_0, D_1, D_2, D_3 and D_4. The dilution made on the germs studied (FAMT and fungal flora) varies depending on the days of sampling. The results of the aging test following the room temperature are presented below.

Table 5. Aging test of unrefrigerated enriched rice cakes.

Microbiological dilution	D_0 10^{-2}	D_1 10^{-4}	D_2 10^{-5}	D_3 10^{-7}	D_4 10^{-8}	Reference standards
TAMF	$9,1.10^2$	$4,1.10^5$	$1,6.10^6$	$4,5.10^6$	$7,6.10^6$	3.10^5
Fungal flora	$1,8.10^2$	4.10^3	$8,6.10^4$	$1,7.10^6$	$4,8.10^6$	5.10^2

Table 6. Aging test of refrigerated enriched cakes.

Microbiological dilution	D_0 10^{-2}	D_1 10^{-4}	D_2 10^{-5}	D_3 10^{-7}	D_4 10^{-8}	Reference standards
TAMF	$5,1.10^2$	$5,8.10^3$	$2,5.10^5$	$5,3.10^5$	$9,1.10^6$	3.10^5
Fungalflora	$2,9.10^1$	$4,8.10^2$	$3,4.10^5$	$7,2.10^5$	2.10^6	5.10^2

The two products are different only in terms of their aging temperature, to deduce the effect of cold on the food supplement. Thus, the number of germs varies considerably. TAMF spoilage microorganisms and fungal flora, which may damage the product, are present and counted. Their concentrations exceed microbiological criteria at a certain time in the days of observation.

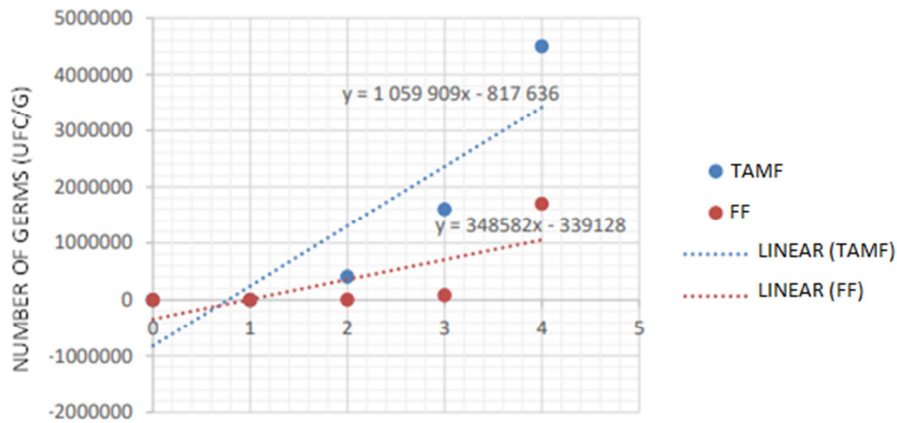The TAMF microorganisms and fungal flora are shown in the following figures.

Figure 2. TAMF germs and fungal flora and their linear line of the product Pa.

Regression lines are established to obtain equations finding the BBD of the refrigerated product. These linear lines are represented in the following figure
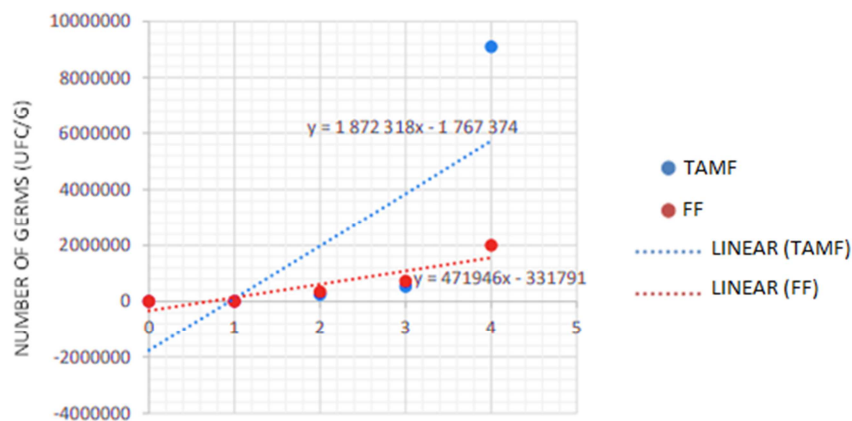

Figure 3. TAMF germs and fungal flora and their straight line of product Pr.

This proves that the cold (4°C) does not stop the spoilage of the enriched rice cake after 24 hours after baking. Beyond 24 hours after cooking, even if the product still retains its nutritional quality, the food supplement is no longer consumable.

3.7. Hedonic Product Analysis

In this way, 61 pregnant women made the sensory analysis of

the pair comparison type according to the preference of the two products: enriched rice cake and classic rice cake. The result is shown in the table 7.

Table 7. Results of the pair comparison test according to the preference.

Jury	Response	Jury	Response	Jury	Response	Jury	Response
1	1	17	1	33	1	49	1
2	1	18	1	34	1	50	0
3	0	19	1	35	1	51	0
4	1	20	1	36	1	52	1
5	0	21	1	37	1	53	1
6	1	22	1	38	1	54	1
7	1	23	0	39	1	55	1
8	1	24	1	40	1	56	1
9	1	25	1	41	1	57	1
10	1	26	0	42	1	58	1
11	0	27	1	43	1	59	1
12	1	28	1	44	1	60	1
13	1	29	1	45	0	61	1
14	1	30	1	46	1		
15	1	31	1	47	1		
16	1	32	1	48	1		

0: wrong answer; 1: right answer

There are 53 correct answers; Enriched cake is significantly more preferred than the conventional rice cake.

4. Conclusion

The current study focused on the development of a food supplement for pregnant women. The findings revealed that 53, 3% of pregnant women are unaware of the importance of a good nutrition during pregnancy Poor nutritional status of pregnant women affects the outcome of pregnancy, increases the risk of infant mortality and harms early childhood development. Thus, women need sufficient energy and nutritional intake to cope with physical changes related to gestation, such as increased blood volume, growth of maternal tissue. In this study, we manufactured an enriched rice cake, which is based on local products from Madagascar, with high nutritional potential. This product, rich in proteins-lipids-some vitamins-calcium, magnesium and iron necessary during pregnancy, is essential for the development of cognitive capacity and contributes to the normal growth of the future baby. This creation of enriched "koba varies" aims to overcome the imbalance in nutrition of pregnant women.

Acknowledgements

References

[1] Reynaldo M. (2016). Improved nutrition in the first 1000 days and adult human capital and health. Am J Hum Biol., 29 (2), 1-12. 10.1002/ajhb.22952.

[2] Randrantoarimbola L., Rafalimanantsoa J., Ratiarimananjatovo N., Randriamanantena A. A., Rakotondrazafy J. I. N., Ngbolua K. N., Robijaona B. (2018). Valorization of local products to fight against chronic malnutrition in Malagasy rural households using Food supplements bio-fortified by the leaves powder of *Moringa oleifera* Lam. J. of Adv. Med. & Life Sci., 6 (4), 1-4.

[3] Ravaoarisoa L., Rakotonirina J., Andriamiandrisoa D., Humblet P., Rakotomanga J. D. D. M. (2018). Eating habits of mothers during pregnancy and lactation, Amoron'i Mania region Madagascar: qualitative study. Pan African Medical Journal, 29 (1), 1-8.

[4] Balogun O. O., da Silva L. K., Ota E., et *al*. (2016). Vitamin supplementation for preventing miscarriage. Cochrane Database Syst. Rev. CD004073.

[5] Kuo A. H., Li C., Huber H. F., Clarke G. D., Nathanielsz P. W. (2018). Intrauterine growth restriction results in persistent vascular mismatch in adulthood. J Physiol, 596, 5777-5790.

[6] Nnam N. M. (2015). Improving maternal nutrition for better pregnancy outcomes. Proceedings of the Nutrition Society, 74 (04), 454–459.

[7] Langley-Evans S. (2015). Fetal nutrition and disease in later life. In Nutrition, health and disease, S. Langley-Evans (Ed.).

[8] Carolan-Olah M., Duarte-Gardea M., Lechuga J. (2015). A critical review: early life nutrition and prenatal programming for adult disease. J Clin Nurs, 24, 3716-3729.

[9] Victora C. G., de Onis M., Hallal P. C., et *al*. (2010). Worldwide timing of growth faltering: revisiting implications for interventions. Pediatrics, 125, e473–e480.

[10] AlbertssonW. K., Karlberg J. (2003). Natural growth in children born SGA with and without catch up growth. Horm. Res, 59, 129.

[11] Waber D. P., Bryce C. P., Girard J. M., et *al*. (2014). Impaired IQ and academic skills in adults who experienced moderate to severe infantile malnutrition: a 40 yearstudy. Nutr. Neurosci, 17, 58–64.

[12] Les Nouvelles. (2019). Malnutrition: Madagascar, 4è pays le plus touché. Retrieved from https://www.newsmada.com/2019/03/27/malnutrition-madagascar-4e-pays-le-plus-touche.

[13] Grieger J. A., Grzeskowiak L. E., Clifton V. L. (2014). Preconception Dietary Patterns in Human Pregnancies Are Associated with Preterm. The Journal of Nutrition, 8, 1075–1080.

[14] Noronha J. A., Al K. E., Seshan V., Ramasubramaniam S., Raman S. (2012). Anemia in Pregnancy, Consequences and Challenges: A Review of Literature. Journal of South Asian Federation of Obstetrics and Gynaecology, 4 (1), 64–70.

[15] Hambidge K. M., Krebs N. F. (2018). Strategies for optimizing maternal nutrition to promote infant development. Reprod Health, 15, 87.

[16] Maqbool, M., Dar, M. A., Gani, I., Mir, S. A., Khan M,, B. A. (2019). Maternal health and nutrition in pregnancy: an insight, 8, 450-459.

[17] The news. (2019). Malnutrition: Madagascar, 4th most affected country. Retrieved from https://www.newsmada.com/2019/03/27/malnutrition-madagascar-4e-pays-le-plus-touche

[18] INSTAT. (2019). Third general census of population and housing. Retrieved from https://www.instat.mg/wp-content/uploads/Rapport-Prelim-2019_ver_final.pdf

[19] FAO - Republic of Madagascar. (2005). Nutritional profile of Madagascar: Food and Nutrition Division. Retrieved from http://www.fao.org/3/a-ap840f.pdf

[20] Salghi R. (2008). Physico-chemical analysis of foodstuffs in 1st year. Retrieved from http://dhaouadiramzi.e-monsite.com/medias/files/analysephysico-chimie.pdf

[21] Gbolo B. Z., Asamboa L. S., Bongo G. N., Tshibangu D. S. T., Kasali F. M., Memvanga P. B., Ngbolua K. N., Mpiana P. T. (2017). Bioactivity and Chemical Analysis of Drepanoalpha: An Anti-Sickle Cell Anemia Poly-Herbal Formula from Congo-Kinshasa. American J. Phytomedicine & Clinical Therapeutics 5: 1.

[22] Rakotondrapiera M. V. (2017). Functional properties of starch and antioxidant capacity of the seeds of five (5) species of legumes from southern Madagascar (Master in Food Science and Nutrition, University of Antananarivo, Antananarivo). Retrieved from http://biblio.univ-antananarivo.mg/pdfs/rakotondrapieraMamitianaV_SN_MAST_17.pdf

[23] Rakotoary N. (2018). Development, formulation and characterization of a biofortified food: compound flour used for Koba ravina from TalataVolonondry and for multiple uses for households (Master in Agricultural and Food Industries, University of Antananarivo, Antananarivo). Retrieved from http://biblio.univ-antananarivo.mg/pdfs/rakotoarynorotiana_AGRO_MASTER.pdf

[24] Randriarilala M. F. (2019). Nutritional enrichment of cassava roots: use of Moringa oleifera leaves and sesame seeds (Master in Food Sciences and Nutrition, University of Antananarivo, Antananarivo). Retrieved from http://biblio.univ-antananarivo.mg/pdfs/randriarilalaMahavanontsoaF_SN_MAST_19.pdf

[25] AFNOR NF V 01-003 (2010). Lignes directrices pour la réalisation de tests de vieillissement microbiologiques - Denrées périssables ou très périssables, réfrigérées. AFNOR NF V01-003.

[26] Shalini S. A., Akshata R. S., Chauhan S. (2016); Peanuts as functional food: a review J Food Sci Technol, 53 (1), 31–41.

[27] Greenberg J. A., Bell J. S., Guan Y., Yu Y. (2011). Folic Acid Supplementation and Pregnancy: More Than Just Neural Tube Defect Prevention. Rev Obstet Gynecol, 4 (2), 52–59.

[28] NYS P. (2016). Vitamin D: the top 10 foods to avoid deficiencies. Retrieved from https://www.femmeactuelle.fr/sante/alimentation-equilibree/vitamine-d-top-10-aliments-eviter-les-carences-29513

[29] Khazai N., Judd S. E., Tangpricha V. (2008). Calcium and Vitamin D: Skeletal and Extraskeletal Health Curr Rheumatol Rep, 10 (2), 110–117.

[30] Anderson J. W., Baird P., Davis J. R. H., et al. (2009). Health benefits of dietary fiber. Nutrition Reviews, 67 (4), 188–205.

[31] Kim Y., Je Y. (2014). Dietary fiber intake and total mortality: A meta-analysis of prospective cohort studies. American Journal of Epidemiology, 180 (6), 565–573.

[32] Koletzko B., Bhatia J., Bhutta Z. A., et al. (2015). Pediatric Nutrition in Practice. World Rev Nutr Diet. Basel, Kargel, 113, 127–133.

[33] Hyde N. K., Brennan O. S. L., Bennett K., Moloney D. J., Pasco J. A. (2016) Maternal Nutrition during Pregnancy: Intake of Nutrients Important for Bone Health. Maternal and Child Health Journal, 21 (4), 845-851.

[34] Bergel E., Gibbons L., Rasines M. G., Luetich A., Belizán J. M. (2010). Maternal calcium supplementation during pregnancy and dental caries of children at 12 years of age: follow-up of a randomized controlled trial. Acta Obstetricia et Gynecologica, Early Online, 1396–1402.

[35] Kassebaum N. J., Bertozzi V. A., Coggeshall M. S., et al. (2014). Global, regional, and national levels and causes of maternal mortality during 1990-2013: A systematic analysis for the Global Burden of Disease Study 2013. Lancet (London, England), 384 (9947), 980–1004.

[36] Say L., Chou D., Gemmill A., et al. (2014). Global causes of maternal death: A WHO systematic analysis. The Lancet Global Health, 2 (6), e323–e333.

[37] Black R. E., Singhal A., Uauy R. (2014). Maternal Nutrition Interventions to Improve Maternal, Newborn, and Child Health Outcomes. (eds): International Nutrition: Achieving Millennium Goals and Beyond. Nestlé Nutr Inst Workshop Ser, 78, 71–80.

[38] Goonewardene M., Shehata M., Hamad A. (2012) Anaemia in pregnancy. Practice & Research Clinical Obstetrics & Gynaecology, 26 (1), 3-24.

[39] Milman N. (2011). Iron in Pregnancy –How Do We Secure an Appropriate Iron Status in the Mother and Child? Ann Nutr Metab, 59, 50–54.

[40] Levy A., Fraser D., Katz M., Mazor M., Sheiner E. (2005) Maternal anemia during pregnancy is an independent risk factor for low birthweight and preterm delivery. European Journal of Obstetrics & Gynecology and Reproductive Biology, 122 (2), 182–186.

[41] Tareke E., Rydberg P., Karlsson P., Eriksson S., Törnqvist M. (2002). Analysis of acrylamide, a carcinogen formed in heated foodstuffs. J. Agric. Food Chem., 50, 4998–5006.