Research Article

Formulated Therapeutic Food Fortified of Vegetable for Nutritional Recuperation of Undernourished Infants in Benin

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Abstract

The aim of work is to evaluate the nutritional characteristics of developed therapeutic foods based on Groundnut-maize and Pistache-maize. Indeed, nutritional characteristics of formulated therapeutic foods were determined and compared at that of plumpynut a usual therapeutic food. Protein content of two therapeutic foods T1 Groundnut-maize cookie, T2 Pistache-maize cookie and plumpynut are respectively 16.18%, 16.12% and 16.35%. Energy value are respectively 556.05, 584.33 and 555.70 Kcal. Iron content was respectively 12.05, 11.58 and 16.25 mg. T2 cookie presents a higher energy value and could be used in recuperation of infants, who suffer of several wasting with bilateral oedema. T1 cookie presents a higher (38.30 mg/100g) calcium content and could be used in optimal growth of undernourished infants. The nutritional characteristics of therapeutic foods were same and their mineral content was around of that of plumpynut a usual therapeutic food. In regarding, their nutritional potential, a formulated therapeutic cookies

could be used for cover the shortage in repartition of plumpynut and recuperation of undernourished infants.

Keywords: Therapeutic foods; Plumpynut; Malnutrition; Infant; Nutritional recuperation

1. Introduction

Malnutrition was a public health problem, which touch the human in developing countries specially the infant and young children with the high physiologic and economic consequences [1]. In Benin, prevalence of stunting, wasting, underweight and anaemia were respectively 32%, 5%, 17% against 2% in overweight and 72% of children under-fives years [2]. Several strategies were encouraged by many organisations for reduce and combat this problem. Indeed, the complementary feeding which consisted at identification of many fortified foods on nutritional status for completed others functional food in view to improve the nutritional quality of all, was interesting approach, and accessible at least cost for combat the malnutrition in developing countries [3]. Malnutrition is as a virus which affect the nutritional status of children and reduce their cognitive, physiologic development and their immunity status [4]. This situation is worrying since stunting is associated with mediocre school results and, in the long term, to a lower productivity and lower incomes [1]. The vaccine against this problem is a fortified food [1]. Nutritional status is recognized as an indicator of development and well-being [1]. For children to grow adequately, several conditions must be met [3]. Their food consumption and their health status which act in synergy are the immediate determinants of their nutritional status [5].

Therapeutic food was used for an infant' nutrition recuperation in developing countries [6, 7]. In Benin, PlumpyNut was the usual therapeutic food used for infant nutritional recuperation. Indeed, these therapeutic foods were distributed irregularly in different high prevalence region of malnutrition [6]. This situation affects especially the infant in nutritional recuperation. Generally therapeutic foods used not satisfy at habitude food of people and increase the rejection' prevalence of treatment [6]. In order to manage this shortage of therapeutic food, the use of local raw material available for the development of therapeutic food was an investigate way [5].

The Beninese biodiversity contains some fruit, legume and vegetable products which were rich in some nutrient [8]. These raw materials could be used for developed a therapeutic food, which improve the nutritional and health status of malnourish infant [9]. Plants belonging to Lamiaceae family like Sweet Fennel (*Ocimum gratissimum* Linn.) have retained the attention of researchers, not only because of their high diversity and their distribution around the world but also for their variable use as popular medicines to treat diseases. Several studies have revealed the antimicrobial and fungicidal activities of *O. gratissimum* [10]. Every day consumption of vegetable leaves permits a satisfying and equilibrate feeding. Some traditional vegetables leave as *Ocimum gratissimum* have a medicine function and were used for treat some diseases such as malaria, intestinal parasite and infection [8]. Despite the economic, nutritional, medicinal and antibiotics activity of some local vegetable leaf were less used because of insufficiency scientific knowledges on theirs nutritional and medicine potential [8]. Every parts of *Moringa oleifera* are used for different purposes, mostly providing a highly nutritious food for both humans and animals and medicinal purposes to prevent different diseases [11]. It contains vitamins (A, B, C and E), minerals (Ca, Fe, Zn, P, Cu and others), essential amino acids, essential fatty acids (both omega-3 and omega-6 fatty acids) and phytochemicals [9].

Moringa leaf powder is an excellent nutritional supplement and can be added to any dish to increase macro- and micro-nutrients content of the foods. For healthy individuals, a few spoonsful of Moringa leaf powder can be added to any meal to make it more nutritious. In case of pregnant women and lactating mothers, consuming fresh or dried Moringa leaf powder or pods can improve a mother's health and reduce iron deficiency anaemia [12]. One hundred (100) gram of dried leaf powder of Moringa contains 25 g of protein, 8 g of fat, 12 g of mineral, 40 g of carbohydrate, 15 g of fiber, 27 mg of iron, 2,6 mg of zinc, 14300 UI of vitamin A, 850 mg of vitamin C [13]. According to [14], the baobab is an important source of human nutrition today in Africa. Chemical analysis of baobab parts showed the presence of proteins, amino acids, iron, vitamin C, A and E in leaves, seeds and fruit pulp [15]. Baobab pulp and leaves have a high antioxidant activity when compared to other fruits and can consequently be considered as so-called functional foods, which may have a positive impact on health in addition to their role as a food [14]. Baobab pulp presents a high nutritional value and bioavailability of the minerals and vitamins especially high vitamin C content in baobab foods [16]. Cookies are a form of confectionary products usually dried to low moisture content [17]. The objective of this study is to use the traditional development process and local available raw material in order to develop a therapeutic cookies food for the nutritional recuperation of malnourish infants.

2. Materials and Methods

The raw material is consisted of cereals as maize (*Zea mays*), Fresh *Moringa oleifera* and *Ocimum gratissimum* leave, baobab pulp (*Adansonia digitata*), seed of groundnut (*Vigna subterranea* (L.) and *Citrullus lanatus* (Cucurbitacées) called ''pistache''. Raw material was obtained from local market at Abomey-calavi also located in southern Benin. The fresh *Moringa oleifera and Ocimum gratissimum leave* were collected in Agricultural park of Abomey-calavi.

2.1 Material preparation

Moringa oleifera and Ocimum gratissimum leave powder were prepared by sorting and cleaning the leave from any extraneous materials by using tap water and ventilated in a shade area for two days at room temperature. It was dried in an oven at 100°C for 3 hours and powdered by using piston. The powdered leaf was sieved to remove unwanted matter by using 710 µm sieves size in a repeated manner to get fine powder. Seeds of maize, groundnut and ''pistache'' were cleaned and dried as described by [5]. The therapeutic cake food has been prepared by mixing, in varied proportions, the roasted maize, groundnut and pistache flours, *Moringa oleifera* and *Ocimum gratissimum* leave powder, malted maize and baobab pulp. The mixture was placed in bio white paper package.

2.2 Therapeutic cookie food preparation

Therapeutic cookie food was prepared by the procedure of [17]. Commercially baking powder (1g), sodium chloride (0.9 g), sugar (5 g), ''muscarde'' nut (*Myristica Fragans*) (2 g) were used and added in the formulation. The *Moringa oleifera* and *Ocimum gratissimum* leave powder, baobab pulp, roasted and malted maize, oil and roasted pistache or groundnut flours were mixed and stirred. The dough was kneaded two times for each 15 minutes and sheeted to a thickness of 3 cm and cut using a mould die of diameter 6 cm. Cookies were baked in a pre-heated oven at 180°C for 15 minutes, cooled and evaluated for proximate analysis.

2.3 Therapeutic cookie food formulation

Two therapeutic foods have been formulated with a different raw material as roasted maize and groundnut flours, *Moringa oleifera* and *Ocimum gratissimum* leave powder, malted maize and baobab pulp (T1) and roasted

maize and pistache flours, *Moringa oleifera* leaf powder, *Ocimum gratissimum*, malted maize and baobab pulp (T2). These developed cookies formulations were compared at plumpynut (usual therapeutic food). Blends were prepared using mixtures of raw material in the different ratios (Table 1). The different cookies were formulated to two times contain of the World Health Organization/United Nations Infant Fund requirement nutrient intake per day for each nutrient, minerals or vitamins as follows 400 kcal energy, 15 g protein, 8 g fat, 2.9 g ash, 18.6 mg iron, 300, 400 and 500 mg calcium respectively of children aged to 6 months, 7-11 months and 12-23 months, 30 mg vitamin C and 400 µg ER vitamin A [18].

Formulation of therapeutic foods	Material	Ratio of material (%)
T1 (Cookie of Groundnut-maize)	Groundnut	50
	Maize	20
	Oil	10
	Moringa leaf powder	5
	Ocimum gratissimum	5
	Baobab pulp	5
	Malted maize flour	5
T2 (Cookie of Pistache-maize)	Pistache	50
	Maize	20
	Oil	10
	Moringa leaf powder	5
	Ocimum gratissimum	5
	Baobab pulp	5
	Malted maize flour	5

Table 1: Therapeutic foods formulation.

2.4 Physico-chemical analysis

These analysis of cookies were determined using recommended methods [19]. The cookie was analysed for dry matter, pH and titratable acidity.

2.5 Nutritional analysis

Proximate composition of protein, fat and ash contents of the samples were determined following [19] and the process described by [5]. Total available carbohydrate was calculated as 100% minus the sum of protein, fat and ash contents obtained as described above. Energy Value (EV) was calculated according to equation of Atwater and Benedict (1902). EV = (9 x Fat (%) + 4 x Proteins (%) + 4 x Carbohydrates (%)) according to the method of [20].

2.6 Minerals Analysis

Iron, Zinc and Calcium content of cookies were determined by using Atomic absorption spectrophotometer (AAS: Varian SpectrAA 200) by using the procedure reported by [5].

2.7 Statistical analysis

The data were evaluated by analysis of variance (ANOVA) procedures in Statistica 7.1 were used to perform descriptive analysis and compare the means of

triplicate measurements of parameters. Let's notify that the means were considered to be significantly different when p <0.05. The least significant difference test was used to separate the means when the difference was significant.

3. Results

3.1 Physicochemical characteristics of therapeutic cookies

The physicochemical characteristics of formulated therapeutic cookies were showed in Table 2. The dry matter, pH and titratable acidity in T1 groundnut-maize, T2 pistache-maize and Plumpynut (usual therapeutic food) ranged respectively as 97.62-98%, 5.94-6.58 and 0.15-0.33 eq as lactic acid. The pH value has increased of formulated therapeutic food to Plumpynut. Contrary the titratable acidity has decreased concomitantly. Plumpynut have presented the higher dry matter (98%) and therapeutic T1 groundnut-maize had a lower (97.62%) dry matter. The formulated therapeutic food has presented a lower pH value compared that (6.58) of plumpynut. The value of pH was 5.94 and 5.96 respectively for T2 pistache-maize and T1 groundnut-maize. There is no significant difference ($p<0.05$) between pH value of T1 and T2. Contrary, the titratable acidity of formulated therapeutic food has presented a higher value compared that (0.15 eq lactic acid) of plumpynut concomitantly.

3.2 Nutritional characteristics of therapeutic cookies

The protein content in Plumpynut, T1 and T2 cookies were respectively 16.35%, 16.18% et 16.12% (Table 2). There is no significant difference between these values ($p \geq 0.05$). The high level of fat (43.25%) has been measured in T2 (pistache-maize) cookie. Plumpynut and T1 cookie contains respectively 38.50% and 37.35% of fat. The fat content of samples was statistically different ($p<0.05$). Ash content in Plumpynut, T1 and T2 cookies were respectively 7.2%, 5.6% et 5.4%. There is significant difference between these values ($p \geq 0.05$). The high ash content (7.2%) has been measured in Plumpynut. The energy value in Plumpynut, T1 and T2 cookies were respectively 555.70 Kcal, 556.05 Kcal et 584.33 Kcal. Energy value of samples were statistically different ($P<0.05$). T2 cookie of pistache-maize presents the high energy value.

3.3 Mineral content of therapeutic cookies

Mineral content of therapeutic foods was presented in Table 3. The mineral content has been variable. There is significant difference between mineral content values of Plumpynut, T1 and T2 cookies ($p \geq 0.05$). The iron content in Plumpynut, T1 and T2 cookies were respectively 16.25 mg, 12.05 mg and 11.58%. Plumpynut presents the high iron (16.25 mg), zinc (32.12 mg) and magnesium (68.57 mg) content. This is T1 groundnut -maize cookie which presents the high calcium content (38.30 mg). The lowest mineral (iron, zinc, calcium and magnesium) content was measured in T2 pistache-maize cookie. Therapeutic foods present a good mineral content.

Characteristics of therapeutic food							
Tablet	**Dry matter (%)**	**pH**	**Titratable acidity (eq as lactic acid)**	**Protein (%)**	**Fat (%)**	**Ash (%)**	**Energy value (Kcal)**
T1	97.85 ± 0.05^{b}	5.96 ± 0.05^{a}	0.33 ± 0.05^{b}	16.18 ± 0.05^{a}	37.35 ± 0.05^{a}	5.4 ± 0.10^{a}	556.05 ± 1.50^{b}
T2	97.62 ± 0.03^{a}	5.94 ± 0.01^{a}	0.36 ± 0.10^{b}	16.12 ± 0.10^{a}	43.25 ± 0.12^{c}	5.6 ± 0.12^{b}	584.33 ± 1.20^{c}
Plumpynut	98 ± 0.02^{c}	6.58 ± 0.02^{b}	0.15 ± 0.01^{a}	16.35 ± 0.12^{a}	38.50 ± 0.03^{b}	7.2 ± 0.12^{c}	555.70 ± 1.51^{a}

Means of the same letter within a column are not significantly different (P>0.05). *T1= Groundnut flour (50%), roasted maize (20%), Oil (10%), Moringa oleifera (5%), Ocimum gratissimum (5%), malted maize (5%), baobab pulp (5%). T2= Pistache flour (50%), roasted maize (20%), Oil (10%), Moringa oleifera leaf powder (5%) and Ocimum gratissimum (5%) malted maize (5%), baobab pulp (5%).*

Table 2: Biochemical characteristics of therapeutic foods.

Therapeutic foods	**Fe**	**Zn**	**Ca**	**Mg**
T1	12.05 ± 0.05^{b}	26.23 ± 0.01^{b}	38.30 ± 0.52^{c}	62.50 ± 0.06^{b}
T2	11.58 ± 0.02^{a}	24.50 ± 0.05^{a}	12.75 ± 0.02^{a}	61.26 ± 0.07^{a}
Plumpynut	16.25 ± 0.03^{c}	32.12 ± 0.07^{c}	35.22 ± 0.12^{b}	68.57 ± 0.23^{c}

Means of the same letter within a column are not significantly different (P>0.05). *T1= Groundnut flour (50%), roasted maize (20%), Oil (10%), Moringa oleifera (5%), Ocimum gratissimum (5%), malted maize (5%), baobab pulp (5%). T2= Pistache flour (50%), roasted maize (20%), Oil (10%), Moringa oleifera leaf powder (5%) and Ocimum gratissimum (5%) malted maize (5%), baobab pulp (5%).*

Table 3: Mineral Content of the therapeutic foods (mg/100g).

4. Discussion

Biochemical analysis has showed that the formulated therapeutic cookies contains high nutritional and energy value. These analyses have permit to compare the nutritional characteristics of two formulated therapeutic cookies foods and Plumpynut (usual therapeutic food). Protein and energy value varied of 16.12 to 16.35% and 555.70 to 584.33 Kcal. The level of protein in Plumpynut, T1 and T2 cookies were respectively 16.35%, 16.18% et 16.12%. There is no significant difference between protein content ($p \geq 0.05$). The protein content of formulated therapeutic T1 groundnut-maize cookie and T2 pistache-maize cookie were similar at that of plumpynut. Indeed, these two formulated therapeutic food could be used as conventional food for the recuperation of malnourish infant. [6] have found below protein (15.29% of plumpynut and pistache-rice, 15.26% of fish-rice) content in two developed therapeutic infant flours based on rice, dried fish powder and pistache flour and plumpynut for the recuperation of malnourish infants in ivory-coast. Energy value of therapeutic foods and plumpynut are higher than 500 Kcal. The energy value obtained could be explain in partly by addition of oil in two therapeutic cookies food. The addition of oil increases the fat content and concomitantly the energy value of therapeutic foods also increase. Energy value of samples were statistically different ($P<0.05$). T2 cookie of pistache-maize presents the high energy value. The roasted seeds of ‘’pistache’’ were very rich in fat. The fat presents a high energy value compared to carbohydrate and protein [5]. These characteristics of “pistache’’ has permit to increase the energy value of T2 pistache-maize therapeutic cookie. The high fat content and energy value of “pistache’’ flour and oil addition in therapeutic cookies were interesting nutritional characteristics could be improved the deficiency in essential fatty acids, energy needs and others nutrients which could contribute highly in clinical problems of malnutrition. In this study, fat content was in significant difference. The high fat content (43.25%) has been measured in T2 (pistache-maize) cookie. Plumpynut and T1 cookie contains respectively 38.50% and 37.35% of fat. The fat content of samples was statistically different ($P<0.05$). Therapeutic T2 pistache-maize contains a high fat content and energy value compared of usual therapeutic food plumpynut. This is an important potential could be used in nutritional recuperation of infant who suffer of several wasting with bilateral oedema. [21] have showed also that the higher fat content of pistache. Indeed, in function of the clinical and pathologic status of malnourish infant, they have a high energy and essential fatty acids need compared at the infant in well-being [18]. This therapeutic T2 food could be used for cover the energy need of malnourish infant in their optimal nutritional rehabilitation. The energy value and fat content of therapeutic cookies were higher than those obtained by [6], who showed as energy value in formulated therapeutic food such as fish-rice flour and pistache-rice flour respectively 570.19 kcal and 572.53 kcal. Contrary the energy value obtained in therapeutic food in this study were two times lower than those obtained in infant nutritional recuperation diet in study on acceptability and effectiveness of local complementary foods in Niger [6]. These porridges based on mil, groundnut, peanut and sorghum contains 1050.6 to 1664.6 kcal in 100 g. So, the energy value of therapeutic cookie in this study was higher than (400 to 436 kcal) of the Misola flour (mil, soybean, peanut and milk) elaborated for the infant nutritional recuperation centers of Burkina Faso [22].

The therapeutic foods have been formulated based on many raw materials such as maize flour (roasted and malted), groundnut flour, pistache flour and vegetable as *Moringa* leaf powder and *Ocimum gratissimum* leaf powder and baobab pulp. The protein raw materials

(groundnut and pistache) were rich in mineral compared at the cereal flour (maize). The addition of vegetable leaf powder in this two formulated therapeutic foods has permit to increase the mineral content and antioxidants compounds. This antimicrobial and antibiotic potential of therapeutic food could help and participate in reparation of cells et in the rehabilitation of malnourish infants. The work of [8] have showed that the vegetable as *Ocimum gratissimum* present an antimicrobial, nutritional and medicine activities. Indeed, therapeutic foods presents a high mineral content. Their micronutrient content was higher correlated at their protein and energy value. In this study, there is significant difference between mineral content values of Plumpynut, T1 and T2 cookies ($p \geq 0.05$). Plumpynut presents the high iron (16.25 mg), zinc (32.12 mg) and magnesium (68.57 mg) content. This is T1 groundnut - maize cookie which presents the high calcium content (38.30 mg). The lowest mineral (iron, zinc, calcium and magnesium) content was measured in T2 pistache-maize cookie. the addition of *Moringa* and *Ocimum gratissimum* leaves powder permit to increase the mineral content of formulated therapeutic cookies. This is a high calcium content (38.30 mg) of T1 groundnut - maize cookie could be used in growth of malnourish infants for reduce their stunting. Their high potential in micronutrients of therapeutic foods could be used for rehabilitation of the clinical status and the micronutrient deficiency of malnourish infants. The roasting of groundnut and "pistache" and addition malted of maize have permit to improve the nutritional value of therapeutic cookies. The protein, fat content and energy value of therapeutic groundnut-maize cookie and pistache-cookie were around of those of plumpynut a usual therapeutic food. But, the T2 pistache-maize therapeutic food presents a higher fat content. Cookies are a form of confectionary products usually dried to low moisture content [17]. Frequently the infant flour is the form of presentation of therapeutic food [6]. Cookies are easy to consume by infants and this is an another therapeutic food presentation for infant consumption [23]. Therapeutic foods present also an interesting micronutrient content, precisely T1 groundnut-maize therapeutic food presents a higher calcium content. In regarding, their nutritional potential, a formulated therapeutic cookies could be used in the recuperation of malnourish infants. This is a novel way, we can have developed for cover the shortage in the repartition of plumpynut for the rehabilitation of malnourish infant.

5. Conclusion

This work has permit to compare the nutritional characteristics of formulated therapeutic food T1 groundnut-maize and T2 pistache-maize at usual therapeutic plumpynut. Results have showed that formulated therapeutic food have presented a similar protein content and higher fat and energy value compared those of plumpynut. Therapeutic T2 pistache-maize cookie presents a higher energy value and could be used in recuperation of infants, who suffer of several wasting with bilateral oedema. Therapeutic T1 groundnut-maize cookie presents a higher calcium content and could be used in growth of malnourish infants for reduce their stunting. This is two formulated foods could be response at nutritional standard regarding the requirement nutrient intake for the nutritional rehabilitation of malnourish infants. Indeed, the development of this food could be contribute to supply the continuous shortage of therapeutic food in developing country. But, the bio effectiveness of therapeutic food in nutritional recuperation of malnourish infant and others research were important for appreciate the nutritional characteristics of local formulated therapeutic foods.

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Conflicts of Interest

Authors declare that they have no conflicts of interest.

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