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Potentiality of leafy vegetables foliar extract to improve maize flour nutritional value and overcome malnutrition

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Abstract
Malnutrition is a public health problem which affects particularly young children. To improve nutritional status of these children, infant flours should be enriched. Maize flour has been supplemented with taro and sweet potato foliar extracts in diverse proportions (5, 10 and 20%). Dry matter, ash, pH, protein, phenolic compound, energetic value and minerals have been determined. The results showed that maize flour nutrients have increased with foliar extracts incorporation. Protein content (10.06%) increased from 12.68% (T_5) to 20.74% (T_{20}) with taro leaves extract. They increased also from 12.74 % (P_5) to 17.24 % (P_{20}) with potato leaves extract. Energetic value, total phenolic, magnesium and zinc also increased. But, iron and calcium rate decreased. Calcium content decreased from 1920.4 mg/100g (T_5) to 381.33 mg/100g (T_{20}) with taro leaves extract and from 1869.33 mg/100g (P_5) to 1075.60 mg/100g (P_{20}) with potato leaves extract. The foliar extract improves nutrients values and the best incorporation rate is 20%.

Keywords: maize flour, foliar extracts, enrichment, nutrients, malnutrition

1. Introduction

In the world and particularly in developing countries, children under 5 years old are more affected by malnutrition which is a public health problem (WHO, 2011) [1]. Indeed, in 2011, at least one child other three suffered of stunting in Africa (UNICEF, 2014) [2]. In Côte d'Ivoire, in 2014, the prevalence of chronic malnutrition of children under 5 years old was 40.6 % including 15.7 % for the severe form (UNICEF, 2014) [3].

Malnutrition affects children generally during weaning period (Dewey and Brown, 2003) [4]. In fact, after 6 months of exclusive breast feeding, mothers must give other foods, in addition to their milk, to their children in order to cover their nutritional intake in proteins and energy (WHO and UNICEF, 2003; Qiong *et al.*, 2013; Madoka and Colin, 2014) [5, 6, 7]. Such food could give essential nutrients for children growth. However, in developing countries, mothers are not always aware of children food diversification. They generally give porridge make only of cereals or tubers which are deficient in some amino acids, vitamin A, iron and folic acid, necessary to cover children needs between 6 and 24 months (Blandino *et al.*, 2003; Camara *et al.*, 2009) [8, 9]. To overcome this nutritional deficiency and improve health of young children, food should be diversified or enriched (Briend, 2009; Agmusy *et al.*, 2014) [10, 11]. This attitude would also reduce death rate of this children (Agmusy *et al.*, 2014) [11].

Several studies have been conducted concerning the improvement of infant flour based on cereals. Indeed, Gnahé *et al.* (2009) [12] have elaborated a mixed flour with taro, maize and pigeon pea to cover children needs in protein, minerals and energy. Kouassi *et al.* (2015) [13] have improved maize and sorghum flour with germination and fermentation process and the adjunction of soya. However, leafy vegetables could also improve cereals flour nutritional value. Indeed, leafy vegetables are good sources of proteins, vitamins and minerals which could help to remedied nutritional deficiencies like malnutrition (Zanin *et al.*, 1998) [14]. The best process to optimized leafy vegetables contain is to make foliar extraction in the aim to eliminate the fibers and to preserve the nutrients (Bertin, 2006) [15]. Moreover, Magon *et al.* (2014) [16], in their studies, have showed that the adjunction of leaf concentrate as protein/calorie supplement was effective in preventing declining maternal haemoglobin concentrations and increasing infant's birth weight.

The aim of this study is to formulate infant maize flour with taro and sweet potatoes foliar extract in order to improve children nutritional status. Foliar extracts will be incorporate in diverse proportions. The nutritional composition of the enriched maize flour will be determined and the best incorporation rate will be identified.

2. Material and Methods

2.1 Material

Maize (*Zea mays*) grains were collected in Abobo market, one of the 10 towns' hall of Abidjan. Taro (*Colocassia esculenta*) and sweet potatoes (*Ipomea batatas*) leaves were collected in a field located at Awoué, a village in the sub-prefecture of Alepe at 45 km in the North-east of Abidjan (Côte d'Ivoire).

2.2 Methods

2.2.1 Flour and Foliar extract production

To obtain flour, maize grains were sorted, washed, dried, roasted, grinded and sifted.

Foliar extract were obtain according to Bertin (2006) [15] methods: 1 kg of leaves were washed, cut up and then crushed with 2 L of tap water. The juice was heated until boiling during 30 minutes to precipitate proteins. The coagulum was collected by centrifugation (Sigma) at 4000 tr/min and dried in an oven (Memmert) at 45°C during 24 hours. The final product was crushed in fine powder which constitutes the foliar extract.

2.2.2. Formulations

Taro and sweet potato foliar extract were added in diverse proportions (5%, 10% and 20%) to the maize flour. Six formulations were obtained:

- Enriched Maize flour with 5% of sweet potato foliar extract (P_5)
- Enriched Maize flour with 10% of sweet potato foliar extract (P_{10})
- Enriched Maize flour with 20% of sweet potato foliar extract (P_{20})
- Enriched Maize flour with 5% of taro foliar extract (T_5)
- Enriched Maize flour with 10% of taro foliar extract (T_{10})
- Enriched Maize flour with 20% of taro foliar extract (T_{20}).

2.2.3 Analysis

Moisture, matter dry, ash, pH, proteins and lipids were determined by AOAC method (AOAC, 1990) [17]. Total carbohydrates were determined by difference according to the equation 1 in order to allow in energy value calculation:

% carbohydrates = 100 - (% Moisture + % Lipids + % Proteins + % Ashes) (1)

Energy value was calculated according to Atwater and Rosa (1902) [18] as specified in equation 2:

Energy value (Kcal) = (9 x % Lipids) + (4 x % Proteins) + (4 x % Carbohydrates) (2)

Total sugar were determined by Dubois *et al.* (1956) [19] method. Total phenolic were determined by Folin-Ciocalteu method (Mc Donald *et al.*, 2001) [20] at 765 nm and expressed as gallic acid equivalents (GAE) in milligrams per gram of extract using a standard curve generated with gallic acid. Total flavonoids, were determined at 415 nm and expressed at quercetin equivalents (QE) in microgram per gram of extract using the standard curve of quercetin (Chang *et al.*, 2002) [21].

Minerals were determined according to Kularatre (2013) [22]. Calcium, magnesium, potassium and zinc were determined using Shimadzu AA-680 Atomic Absorption spectrophotometer (Japan) at their specified wavelengths (422.7 nm, 285.2 nm, 766.5 nm and 214.6 nm). Iron concentration was estimated using an UV visible spectrophotometer (Jasco V–530, Japan) at 510 nm.

2.2.4. Statistical analysis

The statistical analysis of data was carried out with XLSTAT software, version 2.0 (Addinsoft, 2014) [23]. All analyses were done in triplicate. A one-way analysis of variance (Anova) was performed and means were separated using a Turkey HDS multiple range test ($P = 0.05$).

3. Results and Discussion

3.1 Dry mater, moisture, ash and energy value of Maize, foliar extracts and enriched flour

Dry mater, moisture, ash and energy value of Maize, foliar extracts and enriched flour are shown in table 1. Dry matter, moisture, ash and energy value of the enriched flours differ significantly to that of maize flour. Moisture rate in flours enriched with sweet potato foliar extract varied from 8.33% to 9.33% while in those enriched with taro foliar extract it varied from 8.33% to 9.44%. These moisture rates were under 15%, the recommended rate for dehydrated products and flours (Asiedu, 1991) [24]. At this moisture rates, the enriched flours obtained will be in favor to limit microbial load increase (Ayree *et al.*, 2006) [25].

Ash content was elevated in the different foliar extracts (7.46% for sweet potato foliar extract and 9.40% for taro foliar extract) and increased with foliar extracts incorporation. Indeed, it increases from 0.60% in maize flour to 2.00% in maize flour enriched at 20% with sweet potato foliar extract and from 0.60% in maize flour to 2.20% in maize flour enriched at 20% with taro foliar extract. Energy value also increased with foliar extracts incorporation. Indeed, maize flour energy value (382.25 kcal) becomes 440.38 kcal and 454.08 kcal with respectively 20% of sweet potato and taro foliar extracts incorporation. This augmentation of energy value could be linked to the increase of macronutrients. With foliar extracts incorporation, energy value of maize flour was upper 400 kcal/100g, the recommended value for infant flours (FAO/OMS, 2006) [26].

Table 1: Dry matter, moisture and ash content of maize, foliar extracts and enriched flours.

	Dry matter (%)	Moisture (%)	Ash (%)	Energy value (Kcal/100g)
Maize	90.63 ± 0.03^b	9.33 ± 0.19^c	0.60 ± 0.01^a	382.25 ± 4.11^b
PFE	89.22 ± 0.10^a	10.77 ± 0.05^c	7.46 ± 0.11^d	452.65 ± 3.14^d
P_5	90.67 ± 0.01^b	9.33 ± 0.01^c	1.00 ± 0.01^b	420.01 ± 1.52^b
P_{10}	91.45 ± 0.19^d	8.55 ± 0.15^b	1.60 ± 0.05^c	439.44 ± 1.45^c
P_{20}	91.67 ± 0.01^d	8.33 ± 0.01^b	2.00 ± 0.01^c	440.38 ± 1.45^c
TFE	91.79 ± 0.18^d	7.63 ± 0.12^a	9.40 ± 0.10^d	455.96 ± 4.78^d
T_5	90.56 ± 0.10^b	9.44 ± 0.09^c	1.20 ± 0.01^b	377.02 ± 5.42^a
T_{10}	91.77 ± 0.03^d	8.23 ± 0.02^{ab}	0.73 ± 0.11^a	440.44 ± 1.70^c
T_{20}	91.11 ± 0.19^c	8.88 ± 0.16^b	2.20 ± 0.10^c	454.08 ± 3.26^d

In column, means with the same superscript do not differ significantly ($P \leq 0.05$).

PFE: sweet potato foliar extract; P_5, P_{10} and P_{20}: maize flour enriched with respectively 5%, 10% and 20% of sweet potato foliar extract;

TFE: Taro foliar extract; T_5, T_{10} and T_{20}: maize flour enriched with respectively 5%, 10% and 20% of taro foliar extract

3.2 pH, total phenolic and flavonoid content of Maize, foliar extracts and enriched flours

The results of pH, total phenolic and flavonoid content of Maize, foliar extracts and enriched flours are presented in table 2. According these results the pH of foliar extracts was acid, 5.66 for sweet potatoes leaves and 5.64 for taro leaves. The pH of flours were also acid varying from 6.06 (P_{20}) to 6.48 (T_{20}). Such acid pH values were useful for food, because the majority of enzymatic reactions occurred in acidic media (Soro *et al.*, 2013) [27]. Total phenolic contents were respectively 85.93, 1686.66 and 2636.66 mg GAE /g of extract in maize flour, taro foliar extract and sweet potatoes foliar extract (Table 2). It increased in enriched flours and the best values were obtained with 10% of incorporation (147.33 mg GAE /g for T_{10} and 496.66 mg GAE /g for P_{10}). However, there were any statistical differences for flours enriched with taro foliar extracts. Flavonoid content was 56.07 mg QE / g in maize flour. It was increased and reached high level in enriched flour with 10% of sweet potatoes leaves extract (313.33 mg QE / g of extract). On other hand, in enriched flour with taro foliar extracts flavonoids contents were not improved (56.07 mg QE/g to 18.27 mg QE / g of extract). In general, the incorporation of sweet potatoes and taro foliar extracts increased total phenolic and flavonoids contents of maize flour. That could be great for flours antioxidant capacities, thus contributing to elimination of free radicals (Popovici, 2009) [28]. Sweet potatoes and taro foliar extract total phenolic content were respectively higher than that indicated by Zoro *et al.* (2014) [29] (163.2 meq GAE /g of extract) and Acho *et al.* (2014) [30] (289.87 meq GAE /g of extract). Their flavonoid contents were also higher than that indicated by the same authors (96 mg QE / g of extract in sweet potatoes leaves and 12.87 mg QE / g of extract in taro leaves). The difference could be due to soil, cultural environment and leaves age (Herzog *et al.*, 1993) [31].

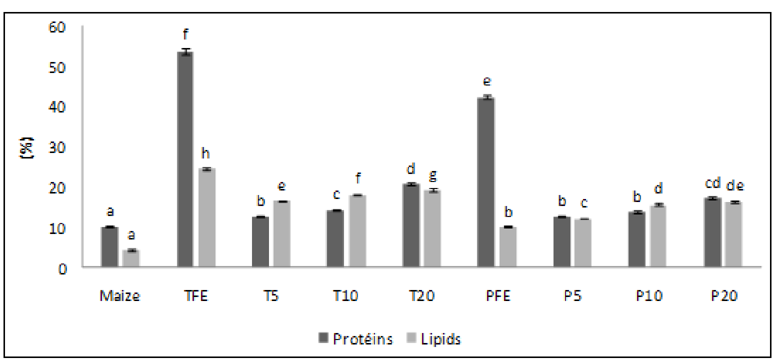
Table 2: pH, total phenolic and flavonoid content of maize, foliar extract and enriched flours.

	pH	Total phenolic (mg GAE/g)	Flavonoid (mg QE/g)
Maize	6.09 ± 0.01^{b}	85.93 ± 6.01^{a}	56.07 ± 1.00^{a}
PFE	5.66 ± 0.01^{a}	2636.66 ± 57.51^{e}	$176.1 \pm 17.3^{b\,c}$
P_5	6.26 ± 0.01^{c}	206.16 ± 29.31^{a}	34.5 ± 0.70^{a}
P_{10}	6.09 ± 0.01^{b}	496.66 ± 20.21^{c}	313.33 ± 36.79^{d}
P_{20}	6.06 ± 0.01^{b}	358.33 ± 83.11^{b}	214.5 ± 30.77^{c}
TFE	5.64 ± 0.01^{a}	1686.66 ± 74.88^{d}	145.5 ± 16.25^{b}
T_5	6.31 ± 0.01^{c}	136 ± 13.85^{a}	28.8 ± 4.09^{a}
T_{10}	6.41 ± 0.01^{d}	147.33 ± 20.34^{a}	18.27 ± 2.44^{a}
T_{20}	6.48 ± 0.01^{d}	114 ± 11.78^{a}	29.78 ± 2.77^{a}

In column, means with the same superscript do not differ significantly ($P \leq 0.05$).
PFE: sweet potato foliar extract, P_5, P_{10} and P_{20}: maize flour enriched with respectively 5%, 10% and 20% of sweet potato foliar extract, TFE: Taro foliar extract, T_5, T_{10} and T_{20}: maize flour enriched with respectively 5%, 10% and 20% of taro foliar extract

3.3 Protein, lipid and total sugar contents of maize, foliar extracts and enriched flours

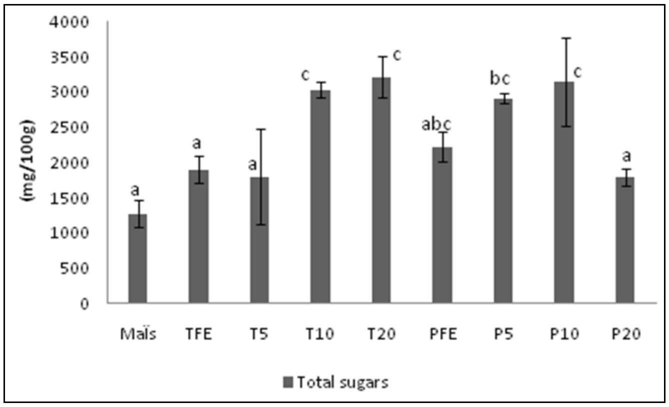
The results of protein and lipid contents of maize flour, foliar extracts and enriched flours are given in figure 1. Protein and lipid rates in maize flour (10.05% and 4.4% respectively) increased with foliar extracts incorporation and the values differed significantly. The highest values were obtained with 20% of foliar extracts incorporation. Indeed, at this incorporation rate, protein level became 17.24% and 20.74% with sweet potatoes and taro extract respectively. Lipids rate increased until 16.33% with sweet potatoes foliar extract and 19.40% with taro foliar extract. Taro foliar extract protein rate (53.81%) was closed to that of alfalfa foliar extract (55%) (Gawel, 2012) [32]. The increase of protein and lipid contents due to foliar extracts incorporation corroborate with those of Kouassi *et al.* (2015) [13] who had showed that the incorporation of a rich nutrients food (soya in their case) improved protein and lipid in cereal flours. Moreover, as meats and fishes are expensive in developing countries, incorporation of plant proteins in infant flours should be great. Indeed, leafy vegetables are cheap and available (Agbo, 2000) [33].



PFE: sweet potato foliar extract; P5, P10 and P20: maize flour enriched with respectively 5%, 10% and 20% of sweet potato foliar extracts; TFE: Taro foliar extract; T5, T10 and T20: maize flour enriched with respectively 5%, 10% and 20% of taro foliar extracts

Fig 1: Protein and lipid contents of maize flour, foliar extracts and enriched flours.

Maize total sugar rate is 1273.84 mg / 100 g DM (dry matter) (Figure 2). With taro foliar extract, it increased from 1805.77 to 3219.59 mg / 100g DM. Total sugar content also increased with sweet potatoes foliar extract. The highest value was obtained with 10% of incorporation and was about 3149.6 mg / 100g DM. The augmentation of total sugar should be great if the enriched flours are used for children by enhancing energy value (Mouquet-River, 2006) [34].



PFE: sweet potato foliar extract; P5, P10 and P20: maize flour enriched with respectively 5%, 10% and 20% of sweet potato foliar extracts; TFE: Taro foliar extract; T5, T10 and T20: maize flour enriched with respectively 5%, 10% and 20% of taro foliar extracts

Fig 2: Total sugar contents of maize flour, foliar extracts and enriched flours.

3.4 Mineral contents of maize, foliar extracts and enriched flours

Mineral contents of maize, foliar extracts and enriched flours are presented in table 3. In general, foliar extracts were rich in mineral and their incorporation increased mineral rate in maize flour. Sweet potato and taro foliar extracts contained high rate in calcium (2652 and 1436.4 mg/100 g DM respectively). They increased maize flour calcium rate (292.13 mg/100 g DM) until 1879.33 mg/100 g DM with 5% of sweet potatoes foliar extract and until 1920.40 mg/100 g DM with also 5% of taro foliar extract. But these rates decreased with the augmentation of foliar extract proportion in flour (Table 3). Calcium is useful for children growth, bones and teeth fortification, muscles, heart and digestive system Paiko *et al.* (2012) [35]. Calcium rate were higher than that of alfalfa leaves (338 mg/100 g DM) (Vyas *et al.*, 2009) [36].

Magnesium rates of maize flours (24.76 mg/100 g DM) increased with foliar extract incorporation, respectively, from 36.32 (P_5) to 72.68 mg/100 g DM (P_{20}) for sweet potatoes foliar extract and from 21.23 (T_5) to 39.04 mg/100 g DM (T_{20}) for taro foliar extract. Those of potassium decreased. Indeed, the initial value in maize flours (341.8 mg/100 g DM) decreased until 104 mg/100 g DM (P_5) and 107.74 mg/100 g DM (T_5). But, these rates increase with the augmentation of foliar extracts (212.66 mg/100 g DM (P_{20}) and 231.66 mg/100 g DM (T_{20})). Magnesium is necessary for the human biochemical reactions, muscle and nerve, heart and sugar regulation in blood (Saris *et al.*, 2000) [37]. Magnesium and potassium content of sweet potatoes foliar extract was higher than that of alfalfa leaves which are respectively 150 and 740 mg/100 g DM (Grela and Pietrzak, 2014) [38]. But, their contents in taro foliar extract were low.

Iron content of foliar extract was about 73.8 and 43.16 mg/100 g DM respectively for sweet potatoes and taro. Maize flour iron rate (10.14 mg/100 g DM) increased until 26.18 mg/100 g DM (P_{20}) and 37.72 mg/100 g DM (T_5). Maize flour contained 0.46 mg/100 g DM of zinc. Sweet potatoes foliar extract had 1.8 mg/100 g DM and taro foliar extract 5.96 mg/100 g DM. Their incorporation also increased zinc rate of maize flour until 1.28 mg/100 g DM (P_{20}) and 1.21 mg/100 g DM (T_{20}). The increased of iron and zinc in enriched flours was due to their high proportion in foliar extract. Iron is essential for metabolic reactions, hemoglobin and many enzymes (Lokombé-Léké and Mullié, 2004) [39]. Iron can also be implicated in anemia prevention. Indeed, Vyas *et al.* (2009) [36] had showed that ingestion of amount of alfalfa foliar extracts containing 5 mg of iron and 13 µg of folic acid is effective and more profitable for the control of anemia than the ingestion of supplements containing 60 mg of iron and 500µg of folic acid. Iron content in sweet potatoes foliar extract is higher than that indicated by Pico *et al.* (2011) [40] in the same material vegetal (55.7 mg/100 g DM). However, zinc content is lower (9.24 mg/100 g DM) than that indicated by the same authors.

Table 3: Mineral contents of maize, foliar extracts and enriched flours

	Calcium (mg/100g)	Magnesium (mg/100g)	Potassium (mg/100g)	Iron (mg/100g)	Zinc (mg/100g)
Maize	292.13 ± 5.51^{b}	24.76 ± 1.61^{a}	341.80 ± 5.27^{d}	10.14 ± 0.61^{b}	0.46 ± 0.30^{b}
PFE	1436.4 ± 7.82^{f}	167.05 ± 6.76^{a}	1144.80 ± 5.45^{e}	73.80 ± 1.15^{f}	1.80 ± 0.26^{f}
P5	1879.33 ± 1.32^{f}	36.32 ± 1.47^{bc}	104.00 ± 3.57^{a}	0.00 ± 0.00^{a}	0.67 ± 0.05^{c}
P10	1485.20 ± 9.40^{e}	37.04 ± 1.01^{c}	142.40 ± 2.81^{b}	10.68 ± 0.68^{b}	0.50 ± 0.07^{b}
P20	1075.60 ± 8.90^{d}	72.68 ± 0.17^{d}	212.66 ± 5.77^{c}	26.18 ± 1.35^{d}	1.28 ± 0.02^{g}
TFE	2652.00 ± 16.23^{g}	114.88 ± 4.91^{e}	212.14 ± 7.45^{c}	43.16 ± 1.42^{e}	5.96 ± 0.11^{a}
T5	1920.40 ± 7.20^{f}	21.23 ± 1.22^{a}	107.74 ± 2.80^{a}	37.72 ± 0.72^{e}	0.00 ± 0.00^{a}
T10	134.16 ± 8.86^{a}	34.49 ± 0.60^{b}	120.93 ± 1.96^{b}	15.69 ± 0.95^{c}	0.82 ± 0.14^{d}
T20	381.33 ± 2.92^{c}	39.04 ± 0.69^{c}	231.66 ± 4.36^{c}	20.70 ± 0.79^{d}	1.21 ± 0.03^{e}

In column, means with the same superscript do not differ significantly ($P \leq 0.05$).

PFE: sweet potato foliar extract; P5, P10 and P20: maize flour enriched with respectively 5%, 10% and 20% of sweet potato foliar extracts; TFE: Taro foliar extract; T5, T10 and T20: maize flour enriched with respectively 5%, 10% and 20% of taro foliar extracts

T5, T10 and T20: maize flour enriched with respectively 5%, 10% and 20% of taro foliar extract

4. Conclusion

The aim of this work is improve nutritional quality of maize flour, often used like complementary food for children, with taro and sweet potatoes foliar extracts. These foliar extracts were rich in protein and minerals and increased maize flour. Enriched flours had interesting rate in protein, lipid, and sugar and their energy value was closed to that of the recommendation for infant flours.

Taro foliar extract increased protein, ash, lipid and energy value while sweet potatoes foliar extract increased total phenolic, flavonoid and mineral contents. The best formulation rate was 20%. As leafy vegetables are available and cheap on market, flour enrichment with them should be promoted in order to undertake malnutrition problem.

5. References

1. WHO. Regional strategy one nutrition 2010-2019 Plane and off action regional Strategy on the nutrition, 2011, 36.
2. UNICEF. Key statistics on survival, the protection and the development of the child, 2014, 8.
3. UNICEF. Situation of the Child in Ivory Coast analyzes, 2014, 127.
4. Dewey KG, Brown KH. Undated on technical issues concerning complementary feeding of young children in developing countries and applications for intervention programs. Food Nutr. Bull. 2003; 24(1):5-28.
5. WHO/UNICEF. Alimentation complémentaire des jeunes enfants dans les pays en développement. OMS: Genève, 2003, 130-131.
6. Qiong W, Michelle HV, Josip C, Rudan D, Sati Y, Ye L *et al.* Improving the intake off nutritious food in children aged 6-23 months in Wuyi County, Clouded - multi-method Approach.Croation Medical Newspaper, 2013, 5:157-170.
7. Madoka I, Colin W. Introducing Solid Foods to Infants in the Asia Pacific Region. Nutrients, 2014; 6:276-288.
8. Blandino A, Al-Aseeri ME, Pandiella SS, Cantero D, Webb C. Cereal-based Fermented foods and beverages. Food Research International, 2003; 36:527-543.
9. Camara F, Husks K, Assemand E, Tano K, Dago G. Quantification off the energy, Iron Intake and the Promoter and Inhibiters Absorption in Rural and Urban Coast of Ivoire. Europe. Newspaper of Sciences. Resources; 2009; 35(1):130-141.
10. Briend A. L'aliment de complément: recommandations actuelles. Med Trop, 2009; 69:298-302.
11. Agmusy S, Gezahegn T, Alemayehu B. Complementary feeding pratice of mothers and associated factors in Hiwot Fana Specialized Hospital, Eastern Ethiopia, 2014, 11.
12. Gnahé DA, Kunimboa AA, Gbogouri GA, Brou K, Gnakri D. Rheological and nutritional characteristic of weaning mush preparated from mixed flours of taro Colocassia esculenta L. Schott, pigeon pea Cajanus cajan and malted maize Zea mays. Pakistan journal of Nutrition. 2009; 8(7):1032-1035.
13. Kouassi K, Adouko A, Gnahe D, Gbogouri G, Kouakou B, Gnakri D. Comparison of the nutritional and rheological characteristics of the infantile pulps prepared by the techniques of germination and fermentation. Int. J. Biol. Chem. Sci. 2015; 9(2):944-953.
14. Zanin V, Boucet, Choisy, Dijon J, Hennequin E, Kariger E *et al.* Un nouveau concept nutritionnel pour l'homme. L'extrait foliaire de luzerne. Association pour la promotion des extraits foliaires en nutrition, 1998, 42.
15. Bertin E. Les extraits foliaires de Luzerne. Un nouveau concept pour lutter contre la malnutrition dans le monde. Agriculture. Le rotarien, 2006, 23-27.
16. Magon A, Collin SM, Joshi P, Davys G, Attlee A, Mathur B *et al.* Leaf concentrate fortification of antenatal protein-calorie snacks improves pregnancy outcomes. J. Health Popul. Nutr. 2014; 32(3):430-440.
17. AOAC. Official methods of analysis. AOAC ED., Washington DC, 1990, 684.
18. Atwater WO *Et al.* Benedict F.G. Experiments on the metabolism of matter and energy in the human body, 1898-1900. United States. Office of experiment stations. Bulletin N° 109. Government Printing Office, Washington, DC, 1902.
19. Dubois M, Gilles K, Hamilton JK, Rebers PA, Smith F. Colorimetric method for determinations of sugars and related substances. Anal. Chem, 1956; 280:350-6.
20. Mc Donald S, Prenzler P, Autolovich M, Robards K. Phenolic content and antioxidant activity of olive extracts. Food Chemistry, 2001; 73:73-84.
21. Chang C, Yang Mr., Wen H, Chern J. Estimate off total flavonoid content in propolis by two complementary colorimetric methods. Newspaper off Food and Drug Analysis, 2002; 10:178-182.
22. Kularate K, Fretas C. Epiphytic lichens as biomonitors of airborne heavy metal pollution. Environmental and experimental botany, 2013; 88:24-32.
23. Addinsoft. XLSTAT, Analyse de données et statistique avec MS Excel. Addinsoft, New York, USA, 2014.
24. Asiedu J. The transformation of the agricultural produce into tropical zone, technological approach, Karthala edition and CTA, Paris, France and HAS J Wageningen, Netherlands, 1991, 335.
25. Aryee F, Oduro I, Elect W, Afuakwa J. The physicochemical properties off flour samples from the roots off 31 varieties off cassava. Newspaper off Food Control, 2006; 17:916-922.
26. FAO/OMS. Programme mixte FAO/OMS sur les normes alimentaires. Rapport des vingt –septième sessions du comité du codex sur la nutrition et les aliments diététiques ou de régime. ALINOM, 2006, 105.
27. Soro S, Konan G, Elleingand E, N'guessan D, Koffi E. Formulation of infantile food containing flours of yam enriched with soya. African Newspaper off Food, Agriculture, Nutrition and Development. 2013; 13(5):8313-8339.
28. Popovici C, Saykova I, Tylkowski B. Evaluation of the antioxydant activity of the phenolic compounds by the reactivity with free radical DPPH. Review of industrial engineering, 2009; 4:25-39.
29. Zoro AF, Zoué LT, Bédikou ME, Kra SA, Niamké SL. Effect of cooking on nutritive and antioxidant characteristics of leafy vegetables consumed in Western Côte d'Ivoire. Archives of Applied Science Research. 2014; 6(4):114-123.
30. Acho CF, Zoué LT, Akpa EE, Yapo VG, Niamké SL. Leafy vegetables consumed in Southern Côte d'Ivoire: a source of high value nutrients. Journal of Animal & Plant Sciences, 2014; 20(3):3159-3170.
31. Herzog F, Farah Z, Amado R. Nutritive value of four wild

leafy vegetables in Côte d'Ivoire. Int. J. Vit. Nutr. Res., 1993; 63:234-238.
32. Gawel E. Chemical composition of lucerne leaf efl and his applications as a phytobiotic in human nutrition. Acta scientiarum Polonorum Technologie Aliment. 2012; 11(3):303-310.
33. Agbo NG. Supplementation of a traditional Ivorian food attiéké with soybean. Ivory Coast, 1996, in Proceeding. The Third International Soybean. Processsing and Use Conference. The Japaneese Society for Food Sciences and Technology. The organizing commitee for ISPU-III.15-20, 2000, 15-50.
34. Mouquet-Rivier C. L'alimentation de complément de jeunes enfants au Burkina Faso., 2006, 1-59.
35. Paiko Y, Dauda B, Salau R, Jacob J. Preliminary dated one off the nutritional potentials the larvae of edible dung beetle consumed in Paikoro Local Government Area off Niger state, Nigeria. Continental Newspaper off Food Science and Technology. 2012; 6(2):38-42.
36. Vyas S, Collin S, Bertin E, Davys G, Mathur B. Leaf concentrate ace adolescent year alternate to iron and folic acid supplements for anemic girls: randomized controlled trial in India, 2009, 16.
37. Saris NR, Mervaala E, Karppanen H, Khawaja J, Lewenstam A. Magnesium: year update one physiological, clinical, and analytical aspects. Clinica Chimica Acta, 2000; 294:1-26.
38. Grela ER, Pietrzak K. Production Technology, Chemical Composition and Use of Alfalfa Protein-Xanthophyll Concentrate as Dietary Supplement. J Food Process Technol, 2014; 5:373.
39. Lokombé-Léké A, Mullié C. Nutrition du nourrisson et diversification alimentaire. Cahiers de Nutrition et Diététique, 2004; 39:349-359.
40. Pico SMPF, Gutiérrez D, Aragon IG, Escobar AS, Ortiz D, Sanchez T *et al.* Evaluation of the nutritional and anti-nutritional composition and in vitro bioavailability of foliar extract. Rev. Chil. Nutr. 2011; 38(2):168-176.