Journal of Nutrition & Food Sciences
ISSN: 2155-9600
Michel et al., J Nutr Food Sci 2012, 2:5
DOI: 10.4172/2155-9600.1000146

Research Article Open Access

Improvement of the Nutritional Quality and the Energy Density of the Fermented Gruels Maize Used Like Complemented Food of Infant

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Abstract

The goal of this present work is to improve nutritional quality of the maize gruels fermented by the addition with maize of groundnut seeds and, to increase the energy density of the gruels by incorporation of calcium malt and carbonate.

The method consists of studying the effect of the addition of groundnut seeds, dried beforehand and peeled, at the time of the crushing of maize seeds soaked in the respective proportions of 25% and 75%. The given parameters are the content of proteins, lipids, ashes, fibres and glucids. The method also consists of studying the effect of the incorporation of calcium malt and carbonate on the gruels according to their content of dry matter. The given parameters are the consistency of the gruels (expressed in mm/30s) carried out thanks to the viscosimeter of Bostwick and the energy density determined by calculation and expressed in kcal/100 ml of gruel.

The results obtained show an increase in the content of proteins of 6.62 g/100 g of MS for the traditional fermented maize dough with 12.44 g/100 g of MS for the dough improved resulting from the modified process and the content of lipids of 4.21 g/100 g from ms for the traditional dough with 15.73 g/100 g of MS for the improved dough resulting from the modified process. The results also show that the gruels obtained in absence of malt are viscous with a null rate of flow. On the other hand, the incorporation of malt at the rate of 2.4% in the presence of calcium carbonate made it possible to prepare gruels having a desirable consistency (120 mm/30s for a content of dry matter of approximately 21 g of MS/100 g of gruels).

The modifications of the traditional process of production of the dough of maize fermented by carrying out the production of the dough containing maize and of groundnut and by carrying out the precooking and by preparing gruels in the presence of malt and carbonate involved a significant growth of the contents of proteins and lipids and made it possible to prepare gruels in conformity with the standards recommended. The maize-groundnut gruels present a better nutritional value and cause a ponderal catch for the rats. These results appear adapted within the framework of the fight against infantile malnutrition in the context of the local resources available.

Keywords: Complemented food; Consistency; Nutritional quality; Energy density; Fermented corn gruel

Introduction

Malnutrition is public health problems, which prevail in the developing countries [1]. In Republic of Congo, nearly 4470 children are malnourish of which 26% suffer from chronic malnutrition, 6.6% are emacies and 14.5% have a ponderal insufficiency [2]. This infantile malnutrition appears, in the majority of the cases, at the age of the introduction of the complemented foods to the mother's milk [3]. In the development countries, this complemented foods are, in the majority of the cases, prepared starting from the local food products, in particular the starch products such as the cassava and the maize which, do not undergo any preliminary enzymatic treatment and only use the clothes industry of the local gruels. It follows that such gruels have low contents of proteins and lipids, and their energy density is low [3,4]; they are thus unable to meet the nutritional and energy requirements in complement for the mother's milk. Technological treatments likely to modify the properties of swelling of the starch are often used to improve the energy density of the gruels, it acts in particular industrial amylases [5], the germinated cereal amylases [4,6], cooking-extrusion [7,8]. The barley malted could be a solution adapted to the improvement of the fluidity of the gruels and consequently of the energy density of the gruels. But, the amylase activity can be influenced by the acid character of fermented maize dough. The addition of a salt in particular the calcium carbonate can be used to make it possible amylase to act on the starch. The addition with cereals of leguminous plants or the proteo-oilseeds is often used to improve nutritional quality of the gruels. Thus, the groundnut seeds are appropriate like food more adapted to the context of Congo. It is within this framework that the present study is registered. Our work will consist in enriching in nutrients (lipids and proteins) the dough's maize fermented by the addition groundnut seeds during fermentation and to improve fluidity of the gruels by implementing the precooking, the calcium carbonate addition and the incorporation of malt. The current recommendations concerning the minimal energy density of the gruels are of 84 Kcal/100 g of gruels for the 9-11 month old children profiting from a normal breast-feeding and two gruels meals per day [9]. This

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Received May 14, 2012; **Accepted** June 01, 2012; **Published** June 07, 2012

Citation: Michel E, Simon K, Vital M, Joachim M, Charles KS, et al. (2012) Improvement of the Nutritional Quality and the Energy Density of the Fermented Gruels Maize Used Like Complemented Food of Infant. J Nutr Food Sci 2:146. doi:10.4172/2155-9600.1000146

present work aims the following objectives: to improve the contents of proteins, lipids and ashes of the dough's and maize fermented gruels by the addition with maize seeds the groundnut seeds; to improve the energy density of the gruels by incorporation of groundnut seeds barley malt; to evaluate the biological effectiveness (weight, profit of weight) of the pulps enriched on the level by the rats.

Materials and Methods

Food material

The food material used is consisted the maize seeds and the groundnut seeds, both, of white variety. The choice of maize of white variety is justified by its use by the producing ones of the fermented maize dough.

Methods

Supply of the food raw material: The maize seeds and the dry groundnut seeds were bought on the level of the deposits of the railway station of Pointe-Noire, they were used for the production of the fermented maize dough, manufactured by us even at the laboratory in order to control all the stages of the transformation.

Production of the dough: The groundnut beforehand dried and peeled were soaked one night before crushing, so that the seeds reabsorb water. They were mixed before crushing with the maize seeds soaked beforehand during 4 days in the proportions of groundnut seed 25% for soaked maize seed 75%. The quantity of water of steeping was fixed at 16 L for approximately 8.5 kg of maize used, quantity of maize which corresponds to a bucket (Figure 1).

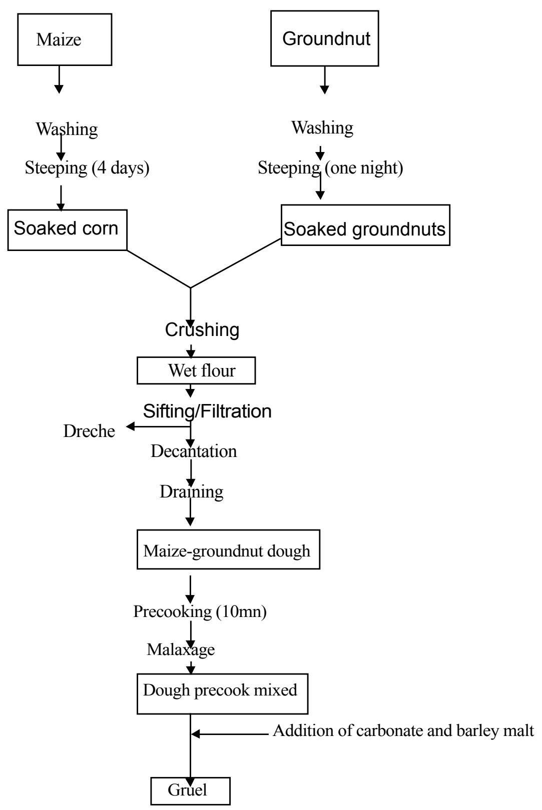

Figure 1: Diagram of manufacture of dough of maize-groundnut and the point of incorporation of malt.

The mixture was stirred up manually so that the two ingredients keep a homogeneous distribution facilitating crushing. After crushing, the wet flour obtained was treated in the same way that at the time of the traditional process of production of fermented maize dough. Part of the dough obtained underwent a precooking 10 min after it reached 85°C, the other part did not undergo any.

Preparation of the gruels: A quantity of dough, having undergone or not a precooking, likely to give a gruels having 20.9 g/100 g of gruel was mixed with 1, 2, 3, 4, 5% of malt and to 0.5% of calcium carbonate, the whole was versed in cool water. The mixture was heated gradually either without withdrawing the pot of fire, or the pot is withdrawn from fire, at various temperatures (45°C, 55°C, 65°C, 75°C, 85°C) of heating during 5 min and then replaced on a source of heat. In both cases, the duration of cooking was fixed at 10 min after the mixture reached 85°C.

Measure of pH: The pH of the samples of maize dough was measured using a portable pH-meter of the type HI9214 Bio block scientific.

Measure of the consistency: The consistency of the gruels was given using the viscosimeter of Bostwick. Thus, the compartment delimited by a system of the guillotine type is filled with a given volume (100 ml) with gruel. To t=0, the gruel is released and the parameter of consistency retained corresponds to the distance covered by the gruel face after 30 seconds of flow. The only condition of controlled measurement was the temperature of the gruel, which is to say approximately 45°C, temperature close to that of the consumption of the gruels.

Measure content of dry matter: The content of dry matter was determined by drying with the etuve to 105°C until constant weight.

Determination of the content total rock salt (ashes): Total rock salt was determined by incineration with the four to 530°C.

Determination of the lipids: The total lipids are proportioned by the method of Soxhlet [10] by using hexane as solvent of extraction.

Determination of fibres: The fibres are determined by the method of Van Soest [11].

Determination of glucids: The glucids are determined by difference.

Calculation of the energy density: The energy density was determined by calculation and is expressed in kcal/100ml of gruel by estimating that 1 g dry matter brings 4 kcal [12].

Constitution of the batches of animals and control of the experimentation: Young rats of stock wistar, old from 40 to 60 days and weighing on average 56 g, are used for the animal experimentation. They set out again on the basis of their weight in cages with metabolism at latticed funds. Fifteen rats were used because of five rats per mode. The animal experimentation was done according to the model of Afass [13] and lasted 16 days and comprised two phases: a phase of adaptation which lasted 2 days and a phase of growth which lasted fourteen days.

Control of the experimentation and measurements taken: The meets are distributed once per day, more precisely the morning and at the fixed hour, in the wafer shape. They are consisted the mode with casein (pilot mode), the mode with the simple maize gruel (traditional complemented food), the mode with the maize-groundnut gruel (improved complemented food). Water is been used at will and renewed for two days interval. The animals are weighed the first day of the experiment and thereafter every two days until the last day of the experiment.

Expression of the parameters of studies of the nutritional value of the meets been used for the rats

Curve of growth: The curve of growth by mode is carried out thanks to the weighing carried out.

Profit of weight: The profit of weight expressed in g/j is the difference between the final weight and the initial weight reported to the number of day of the experiment.

Statistical analysis of the results: The calculation of the average of each series of results of the nutritional quality of the traditional dough and the improved dough as well as the statistical analysis were carried out using the software Groph Pad InStat version 3.0. The data of each experimentation were analyzed first of all by the test of analysis of variances (ANOVA). The post test of Turkey was applied in order to determine if the various series of values were significantly different between them, if test ANOVA was significant at least with the threshold $p < 0.05$

Results

Total composition and mineral composition of the maize-groundnut dough

The total composition and mineral composition of the maize-groundnut dough are given by Table 1. This table shows that the content of proteins increase from 6.62 in the traditional dough to 12.44 g/100 g of MS for the maize-groundnut dough and that of the lipids increase from 4.21 in the traditional dough to 15.73 ± 0.64 g/100 g of MS. The energy value increase from 410.01 ± 0.05 Kcal for the traditional dough to 471.45 ± 0.82 Kcal/100 g for the maize-groundnut dough.

	Witness (fermented maize dough)	Modified (maize-groundnut dough)
Proteins (g/100g of dry matter)	6.62	12.44***
Lipids (g/100g of dry matter)	4.21 ± 0.00	15.73 ± 0.64***
Fibres (g/100g of dry matter)	2.22 ± 0.01	1.27 ± 0.69***
Ashes (g/100g of dry matter)	0.54 ± 0.00	0.53 ± 0.85 ns
Glucids (g/100g of dry matter)	86.41 ± 0.01	70.03 ± 0.64***
Energy value (Kcal/100g)	410.01 ± 0.05	471.45 ± 0.82***

The values are the mean ± standard deviation for n = 3; ***p<0.001; ns p>0.05; p = probability

Table 1: Total composition and mineral composition of the maize-groundnut dough.

Quantity of dough (g)	Malt rate (%)	Rate of flow (mm/30s)	Matter dries (g/100g of gruel)
62	1	0	20.9 ± 0.62
62	2	0	20.91 ± 0.34
62	3	0	20.92 ± 0.45
62	4	0.3 ± 0.1	20.93 ± 0.97
62	5	0.6 ± 0.2	20.94 ± 0.88

The values are the mean ± standard deviation for n = 3

Table 2: Consistency of the gruels to which the malt is added before cooking.

Consistency of the gruels

Evolution of the consistency of the gruels prepared without shrinking of the pot out of fire according to the malt rate: The Table 2 present the results the consistency (Bostwick flow distance) of the gruels to which the malt is added before the cooking of the dough precook. This table shows that the carbonate and malt addition without shrinking of the pot of fire almost does not involve the fluidity of the gruel. This result could be explained by the fact why during cooking, the fast rise of the temperature involves the destruction of amylase contained in malt.

Evolution of the consistency of the gruels without precooking prepared with shrinking of the pot out of fire with 45°C, 55°C, 65°C, 75°C, 85°C: The results of the consistency (Bostwick flow distance) of the gruels to which the pot was withdrawn out of fire at various temperatures are presented in Table 3. This table shows that the shrinking of the pot out of fire during 5 mIn during cooking gave a certain time to the enzyme to degrade the starch partially. The Bostwick flow distance varies according to the temperature to which the malt is added. The temperature of 65°C present the Bostwick flow distance better than the others. The α-amylasic activity seems to be maximum for the temperatures close to 65°C. However all the gruels did not give the flow distance acceptable (120 mm/30s).

Consistency of the gruels precook to which the pot is withdrawn out of fire with 65°C during 5mn with carbonate addition: The consistency (Bostwick flow distance) of the gruels to which the pot was withdrawn from fire with 65°C during 5 mn with carbonate addition is presented by Figure 2. This figure shows that the malt rate likely to give gruels having a desired consistency (120 mm/30s for 20.9 g of dry matter/100 g of gruel) is approximately 2.4%.

Evolution of the consistency of the gruels containing dough precook with addition of malt and/or not of carbonate according to the content of matter dries: The evolution of the consistency (Bostwick flow distance) of the gruels containing dough precooks with addition of malt and/or not of carbonate according to the content dry matter is given by Figure 3. This figure shows that the gruels to which there was or not the carbonate addition have an identical evolution.

Ponderal growth of the rats: The curves of evolution of the rats according to the time of the experimentation are presented in Figure 4. The curve of growth of the rats nourished with the mode of casein is largely higher than that of the rats nourished with the maize-groundnut mode which appeared in its turn higher than that of the rats nourished with the maize mode alone. The weights in end of the experimentation are significantly different ($p < 0.005$).

Malt rate (%)	Quantity of dough prepared (g)	Gruel (withdrawn pot of fire with 45°C		Gruel (withdrawn pot of fire with 55°C)		Gruel (withdrawn pot of fire with 65°C)		Gruel (withdrawn pot of fire with 75°C)		Gruel (withdrawn pot of fire with 85°C)	
		Mat. Dries (g/100 of gruel)	Ecoulmt mm/30s	Mat. Dries (g/100g of gruel)	Ecoulmt mm/30s	Mat. Dries (g/100g of gruel)	Ecoulmt mm/30s	Mat. Dries (g/100g of gruel)	Ecoulmt (mm/30s)	Mat. Dries (g/100g of gruel)	Ecoulmt (mm/30s)
1	62	20.91 ± 0.22	0	20.92 ± 0.27	0	20.90 ± 0.57	0	20.90 ± 0.44	0	20.91 ± 0.71	0
2	62	20.91 ± 0.71	0	20.91 ± 0.13	0	20.91 ± 0.29	0	20.92 ± 0.73	0	20.92 ± 0.69	0
3	62	20.90 ± 0.28	0	20.92 ± 0.21	29 ± 1.3	20.93 ± 0.77	34 ± 1.8	20.93 ± 0.62	0	20.93 ± 1.01	0
4	62	20.90 ± 0.17	26.5 ± 0.9	20.92 ± 0.46	48 ± 0.7	20.93 ± 0.68	55.5 ± 1.5	20.94 ± 0.10	17 ± 0.3	20.94 ± 0.57	0
5	62	20.90 ± 0.36	33 ± 1.2	20.93 ± 0.33	68.5 ± 2.2	20.93 ± 0.81	75.5 ± 2	20.95 ± 0.23	17.5 ± 0.4	20.94 ± 0.86	0

The values are the mean ± standard deviation for n = 3; Ecoulmt: Speed of flow; Mat. Dries: Content of matter dries; Speed of flow: gruel

Table 3: Evolution of the consistency (Bostwick flow distance) of the gruels to which the pot was withdrawn from fire during 5 min during cooking.

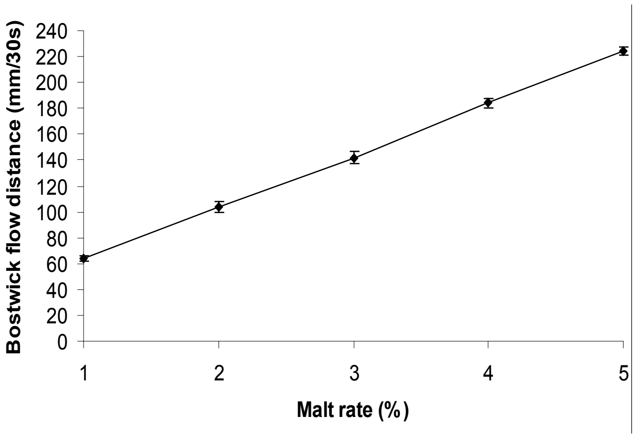

Figure 2: Evolution of the consistency (speed of flow) of the gruels to which the pot was withdrawn from fire during 5 min during cooking. The values are the mean ± standard deviation for n = 3

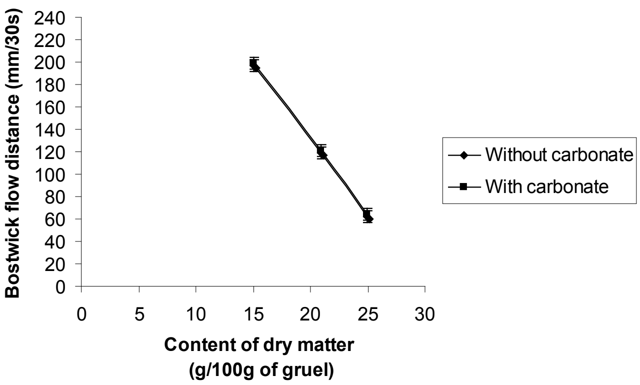

Figure 3: Evolution of the consistency of the gruels containing dough precook with addition of malt and/or not of carbonate according to content of dry matter. The values are the mean ± standard deviation for n = 3

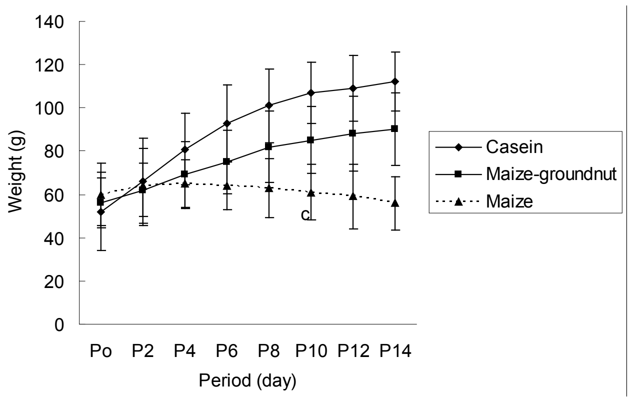

Figure 4: Evolution of the body weights of the rats nourished to the three modes according to time . The values are the mean ± standard deviation for n = 3

Profit of weight: The profit of weight of the rats nourished with the various modes is given in Table 4. This table shows that the rats nourished with the mode of casein have a profit of weight of 3.76 ± 0.28 g/j, those nourished with the maize-groundnut mode have a profit of weight of 2.12 ± 0.12 g/j, whereas those nourished with the simple maize mode have a profit of weight of – 0.25 ± 0.14 g/j.

Discussion

The results obtained on the nutritional quality of the maize-groundnut dough show the importance to associate cereals with leguminous plants or the proteo-olagineux ones in the improvement of the nutritional state of the children in period of complementary food. These results are in agreement with those of other authors who had to add leguminous plants or proteo-oilseeds in the manufacture of food additional containing cereals [4,14-19]. The protein value of maize is made up mainly of the zeine which has a very low content of two essential amino-acids in particular tryptophan (80 mg/100 g of ms) and lysin (331.4 mg/100 g of ms) and of niacine, vitamin of the group B synthesized starting from tryptophan [20]. This deficiency can be surmounted while adding to maize of leguminous plants or the proteo-oilseeds which have these overdrawn nutrients of maize. The structure of the starch confers particular properties to him which result in a considerable rate of swelling. It follows that the gruels containing starch-based food not having undergone a preliminary technological treatment, tend to contain very little dry matter and to have an energy weak density thus. The energy density of the traditional gruels generally weak, it is around an average of 50-60 Kcal/100g of [4,6,21]. Such gruels, taking into account the low volume of the stomach about 30 g (ml)/kg of body weight [22], are not able to efficiently meet the nutritional needs for the infant and the young child in complement of the mother's milk especially that the frequency of daily consumption of the gruels is 2 times/day. The incorporation of malt made it possible to prepare gruels having a flow distance of 120 mm/30s for a content of dry matter higher than 20 g of Dry matter/100g of gruel It is noted that the malt rate likely to give a gruels having a Bostwick flow distance of 120 mm/30s is of 2.4%. This rate seems weaker than that obtained by Treche [21] having worked on another substrate which is the manioc and to which the germinated corn rate is approximately 18%. This same study reveals as to obtain a gruel having a desired viscosity, it is necessary respectively to use 3 times, 2 times ½ and 2 times more cornstarch germinated with the gruels of rice, maize, and millet that with a gruel of cassava. So this light difference could be explained by nature different from the substrate used. Another study carried out by Traoré et al. [23] watch which the red sorghum germinated seems more interesting as d'α-amylases source for the formulation of the infantile flours than the millet germinated which seems in its turn more interesting than germinated maize. This increase in the fluidity characterized by the increase of flows distance's explain to the α-amylase action which hydrolyzes the large starch molecules in molecules smaller (maltodextrines) which have a water holding capacity reduced. The temperature of incorporation of malt influences the consistency of the gruels considerably. Indeed, the temperature of withdrawal of pot out of fire with 65°C, allowed fluxing of the gruels. This factor is amplified with the carbonate addition. That is in agreement with work of Trèche [21] according to which the α-amylases of barley malt have an optimal activity at a temperature around 65-70°C. The carbonate of calcium would have raised the pH of the dough, which would support the action of α-amylase to hydrolyze the starch,

Mode	Profit of weight (g/j)
Casein (pilot)	3.76 ± 0.28
Maize-groundnut	2.12 ± 0.22
Maize	-0.25 ± 0.14

The values are the averages ± standard deviation for n = 3

Table 4: Profit of weight of the rats.

which would explain consistencies obtained. The rats nourished with the corn-groundnut mode presents a higher body weight compared to those nourished with the simple maize mode. This difference could be explained by the high percentage of proteins in the maize-groundnut dough compared to the simple dough. Indeed, Rehman and Shah [24] showed that the nutrients necessary to the growth of the bodies are the proteins and rock salt.

Conclusion

The modifications of the traditional process of production of the fermented corn dough that we introduced, by carrying out the production of the dough containing corn and of groundnut in the respective proportions of 75% and 25%, involved a significant growth of the contents of proteins and lipids. The incorporation of calcium malt and carbonate to the dough having undergone the precooking made it possible to prepare gruels having a consistency recommended (120 mm/30s for a content of matter dries higher than 20 g of dry matter/100 g of gruel). The maize-groundnut gruels present a better nutritional value and cause a ponderal catch for the rats. These results appear adapted within the framework of the fight against infantile malnutrition in the context of the local resources available.

References

1. Joseph B, Rebello A, Kullu P, Raj VD (2002) Prevalence of malnutrition in rural Karnataka, South India: a comparison of anthropometric indicators. J Health Popul Nutr 20: 239-244.
2. EDS-Congo (2006) Enquête Démographique et de Santé au Congo (EDSC-I). Rapport préliminaire.
3. Cornu A, Trèche S, Massambba JP, Massambba J, Delpeuch F (1993) Alimentation de sevrage et interventions nutritionnelles au Congo. Cahiers Santé 3: 168-177.
4. Elenga M, Massamba J, Kobawila SC, Makosso VG, Silou T (2009) Evaluation et amélioration de la qualité nutritionnelle des pâtes et des bouillies de maïs fermenté au Congo. Int J Biol Chem Sci 3: 1274-1285.
5. Tchibindat F, Trèche S (1995) Vitafort: An infant flour of high energy density in Congo. Proceedings of a workshop WHO / ORSTOM cross-country. Senghor University, Alexandria 177-188.
6. Zannou-Tchoko VJ, Ahui-Bitty LB, Kouame K, Bouaffou Kouamé GM, Dally T (2011). Utilisation de la farine de maïs germé source d'alpha-amylases pour augmenter la densité énergétique de bouillies de sevrage à base de manioc et de son dérivé, l'attiéké. Journal of Applied Biosciences 37: 2477-2484.
7. Mouquet C, Trèche S (2001) Viscosity of gruels for infants: a comparison of measurement procedures. Int J Food Sci Nutr 52: 389-400.
8. Mouquet C, Salvignol B, Van Hoan N, Monvois J, Trèche S (2003) Ability of a "very low-costextruder" to produceinstant infant flours at asmallscale in Vietnam. Food Chem 82: 249-255.
9. Dewey KG, Brown KH (2003) Update on technical issues concerning complementary feeding of young children in developing countries and implications for intervention programs. Food Nutr Bull 24: 5-28.
10. Association of Official Analytical Chemists (1980) Official Methods of analysis. (11th edn.) AOAC, Washington, DC, USA.
11. Soest V (1963) Use of detergents in the analysis of fibrous feeds. A rapid method for the determination of fider and lignin. T assoc ogg Anal Chem 46: 829-835.
12. Trèche S (1994) Techniques pour augmenter la densité énergétique de bouillies. LNT (UR 44). Centre Orstom, Montpellier (France) : 124-149.
13. Afass (2002) Les fibres alimentaires: définition méthodes de dosage allégations nutritionnelles. Rapport du comite des experts spéciales Nutrition humaine.
14. Tou EH, Mouquet-Rivier C, Picq C, Traoré AS, Trèche S, et al. (2007) Improving the nutritional quality of ben-saalga, a traditional fermented millet based gruel, by co-fermenting millet with groundnut and modifying the processing method. LWT 40: 1561-1569.
15. Abiodun IS, Anthony AO, Omolara TI (1999) Biochemical composition of infant weaning food fabricated from fermented blends of cereal and soybean. Food chem 65: 35-39.
16. Mouquet-Rivier C, Icard-Vernière C, Guyot JP, Tou el H, Rochette I, et al. (2008) Consumption pattern, biochemical composition and nutritional value of fermented pearl millet gruels in Burkina Faso. Int J Food Sci Nutr 59: 716-729.
17. Yomadji-Outangar O (1995) Manufacture of enriched flour from local foods in Chad. Complementary feeding of young children. Proceedings of a workshop WHO / ORSTOM cross-country at Senghor University, Alexandria, Egypt.
18. Phuka JC, Maleka K, Thakwalakwa C, Cheung YB, Briend A, et al. (2009) Postintervention growth of Malawian children received 12 months dietary complementation a lipid-based nutrient supplement or maize-soy flour. Am J Clin Nutr 89: 382-390.
19. Oyareku MA, Akinyele IO, Trèche S, Eleyinmi AF (2008) Amylolytic lactic acid bacteria fermentation of maize-cowpea ogi. J Food Process Pres 32: 286-305.
20. Souci SW, Fachmann W, Kraut H (2000) The composition of foods. Tables of nutritional values. (6th edn.) CRC Press, Boca Raton, USA.
21. Trèche S (1995) Techniques to increase the energy density of porridges. Proceedings of a workshop WHO/ORSTOM Complementary feeding of young children. Senghor University, Alexandria, Egypt.
22. Sanchez-Griñan MI, Peerson JM, Brown KH (1992) Effect of dietary energy density on total ad-libitum energy consumption by recovering malnourished children. Eur J Clin Nutr 46: 197-204.
23. Traore T, Mouquet-Rivier C, Icard-Vernière C, Rochette I, Traoré AS, et al. (2007) Influence of the technological know-how of producers on the biochemical characteristics of red sorghum malt from small scale production units in Ouagadougou (Burkina Faso). Int J Food Sci Nutr 58: 63-76.
24. Rehman Z, Shah WH (2005) Thermal heat processing effect on antinutritions, proteins and starch digestibility of food legumes. Food chem 91: 327-331.