ISSN: 2347-467X, Vol. 11, No. (2) 2023, Pg. 742-750

Current Research in Nutrition and Food Science

www.foodandnutritionjournal.org

Assessment of the Adequacy of the Energetic Contribution of the Macronutrients Determined in the Local Infant Flours Sold in Ouagadougou to the Needs of Children Aged 6 to 23 Months

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Abstract

Breast milk becomes insufficient from the sixth month of a child's life, considering the quality and quantity, and must be supplemented with nutritionally dense foods. Thus, introducing adequate complementary foods in the child's diet is essential for his development. Very few studies have looked at the compliance of local infant flours with compositional standards. The objective was to evaluate the macronutrient adequacy of local infant flours sold in Ouagadougou for the needs of children aged 6-23 months. Nutritional parameters were determined using reference methods. The modeling was performed using Excel 2016 software. Fats content ranged from 6.16g to 16.76g, proteins from 6.18g to 22.08g, carbohydrates from 63.4g to 70.96g, and energy values from 406.02 kcal/100g to 458.92 kcal/100g. The modeling showed that the contributions of the different nutrients to the overall energy value of 70% of the local infant flours were by the recommendations. The energy contributions of fats and proteins were mainly high. Respectively 75% and 95% of local infant flours evaluated meet the recommendations, while all the infant flours evaluated showed carbohydrate energy contributions within the recommendations. The overall quality assessment showed that the overall energy values of the evaluated local infant flours were within the WHO guidelines.

Article History

Received: 17 May 2023

Accepted: 15 August 2023

Keywords

Dietary Needs;

Infant Flour;

Macronutrient;

Ouagadougou;

Standards.

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Doi: http://dx.doi.org/10.12944/CRNFSJ.11.2.24

Introduction

The complementary feeding period represents a delicate dietary transition due to the immaturity of the child's digestive system.[1] Therefore, exclusive breastfeeding is recommended for the first six months of the child's life,[2] followed by the introduction of nutritionally adequate and safe complementary foods to supplement breast milk to ensure optimal infant growth and health.[3] Dietary diversification necessarily begins with solid foods in a liquid or semiliquid form (porridge, juice, puree) because of the absence of a solid dental apparatus combined with the fragility of the infant's digestive tract. In Burkina Faso, porridges, in general, are widely consumed by children, and a large proportion are traditional porridges.[4] However, most traditional porridges consumed by children are low in energy density and therefore do not meet their protein, fat, and micronutrient needs.[5] To compensate for the low nutrient content of traditional porridges, local production of infant flours to prepare more energy-dense porridges is increasingly present in the local market.[6] Concerning these flours, equivalent of infant cereals in Western countries, specialized treatments (fermentation, germination) favoring the rupture of the glycosidic bonds of the starch should be applied to reduce the swelling rate and consequently increase their fluidity and energy density during cooking.[7,8] However, limitations have been documented concerning the quality of local infant flours, which would negatively influence their optimal use.[9,10] Some flours did not undergo any prior enzymatic treatment, others lacked vitamins or minerals, and others lacked essential protein sources, such as milk or legumes.[11] The stomach volume of the child is minimal, approximately 30 ml/kg of body weight,[12] so the consumption of a small amount of porridge is sufficient to make the child feel full. This situation gradually leads to nutrient deficiencies for the child's normal growth.[13] Therefore, the availability of locally produced infant flour of good nutritional quality would address one of the leading causes of malnutrition.[14] In recent years, many locally produced infant flours have been marketed in Burkina Faso. However, very few studies have evaluated the contribution of locally produced infant flour to meeting standards for children's food and nutritional needs,[13,14] which motivated this study. The objective of this study was to evaluate the macronutrient adequacy of local infant flours sold in Ouagadougou for the dietary needs of children aged 6 to 23 months. The interest of the study is therefore to provide recent data on the quantitative composition of macronutrients and their contribution to the overall energy value of locally produced infant flours. The main focus of the study was the evaluation of essential physicochemical parameters and macronutrient compositions and the assessment of the adequacy of the nutritional composition to the dietary needs of children.

Materials and Methods

Study Site and Period

Samples of local infant flour were collected from stores in the city of Ouagadougou from January to June 2022.

Sampling of Infant Flour

The sampling was carried out using the simple random method. Sixty representative samples of 500 g to 1000 g of different brands of local infant flour were collected from several productions. The samples were collected, randomly, coded, packed in boxes, and transported to the laboratory for analysis. Samples were taken under aseptic conditions.

Evaluation of Nutritional Parameters of Infant Flour

Fats were determined with the standard Soxhlet extraction method with hexane as a solvent according to the international ISO-6492 process.[15]

Carbohydrates were determined with the spectrometric method of determination with sulfuric orcinol. Absorbances were read at 510 nm using a JENWAY 6715 UV/Vis spectrophotometer.[16]

Total proteins (TP) were determined with the differential method of Egan *et al.*[17] according to the following formula:

TP (g) = 100 - [Sugar content (g) + Water content (g) + Fat content (g) + Ash content (g)]

The energy value (E) was calculated using the coefficients of Atwater *et al.*[18] according to this formula:

E (kcal/100g)= [carbohydrate content (g) *4 (kcal) + protein content (g) * 4 (kcal) +fat content (g) * 9 (kcal)]

Modeling the Contribution of Local Infant Formula Macronutrients to Total Energy

The calculation of the percentage of the contribution of each macronutrient towards the total energy intake was performed in Excel 2016 software using the macronutrient composition of each sample, the dietary needs of the children aged 6 to 23 months,[19] and the energy equivalence of each macronutrient through the coefficients of Atwater *et al*.[18] The results obtained were compared with the recommended daily allowances described by certain authors in the literature.

Data Processing

The data were entered into Excel 2016 software for the calculation of averages and mean deviations. The contributions of each macronutrient to the overall energy value were also calculated using Excel 2016.

Table 1: Raw material composition of infant's flours and main treatments

Brand name	Code	Composition in raw materials	Treatments
Natavie	F1	Millet, sorghum, peanut, soybean, sugar, pain de singe, iodized salt, vitamins and minerals complex, amylase BAN 800MG	Sorting, washing, roasting cereals and legumins, mixing, grind into powder, sieving, enriching and packaging
Kasona Plus	F2	Millet, soybean, peanut, iodized salt, sugar	Sorting, washing, roasting cereals and legumins, mixing ingredients, grind into powder, sieving and packaging
Kid Food Blé	F3	Rice, wheat, peanut, sugar, iodized salt	Sorting, washing, roasting cereals and legumins, mixing ingredients, grind into powder, sieving and packaging
Kids Lac	F4	Millet, milk, peanut, sugar, iodized salt	Sorting, washing, roasting cereals and legumins, mixing ingredients, grind into powder, sieving and packaging
Kid Food Maïs	F5	Corn, cassava, peanut, sugar, iodized salt, cookies	Sorting, washing, roasting corn and legumins, mixing ingredients, grind into powder, sieving, and packaging
Vitazom	F6	White corn, peanut, soybean, cowpea, sugar, vanilla, iodized salt, vitamins and minerals complex, amylase BAN 800MG	Sorting, washing, roasting corn and legumins, mixing ingredients, grind into powder, sieving, enriching and packaging
Fanutri Sorgho	F7	Sorghum, soybean, peanut, pain de singe, sugar, iodized salt, minerals and vitamins, amylases enzymes	Sorting, washing, roasting cereals and legumins, mixing ingredients, grind into powder, sieving, enriching and packaging
Kids Food Non Sucré	F8	Corn, cassava flour, peanut, sugar, iodized salt, cookies	Sorting, washing, roasting corn, mixing ingredients, grinding, sieving and packaging
Ya Noogo Standard	F9	Yellow corn, sorghum, peanut, cowpea, rice, sugar, iodized salt	Sorting, washing, roasting cereals and legumins, mixing ingredients, grind into powder, sieving and packaging
Ya Noogo Moringa	F10	Yellow corn, sorghum, peanut, cowpea, rice, sugar, iodized salt, Moringa	Sorting, washing, roasting cereals and legumins, mixing ingredients, grind into powder, sieving and packaging
Ya Noogo Baobab	F11	Yellow corn, sorghum, peanut, cowpea, rice, sugar, iodized salt, pain de singe	Sorting, washing, roasting cereals and legumins, mixing ingredients, grind into powder, sieving and packaging
Fanutri Maïs	F12	Corn, soybean, peanut, pain de	Sorting, washing, roasting cereals and

		singe, sugar, iodized salt, minerals and vitamins, amylases enzymes	legumins, mixing ingredients, grind into powder, sieving, enriching and packaging
Vita Casui Biscuité	F13	Corn, wheat, palm oil, sugar, milk, yeast, vitamins and minerals	Sorting, washing, roasting cereals, mixing ingredients, grind into powder, cooking, sieving, enriching and packaging
Vita Casui Instantané	F14	Millet, palm oil, sugar, milk, vitamins and minerals	Sorting, washing, roasting cereals, mixing ingredients, grinding, sieving, enriching and packaging
Vitaline Instantané	F15	Yellow corn, sugar, peanuts, soybean, milk, vitamins and minerals	Sorting, washing, mixing ingredients, cooking-extrusion, cooling, grind into powder, sieving, enrichment and packaging
Super Léo	F16	Yellow corn, soybean, sugar, milk, palm oils, iodized salt, vitamins and minerals	Sorting, washing, mixing ingredients, cooking-extrusion, cooling, grind into powder, sieving, enrichment and packaging
Petit Gourmet Maïs	F17	White corn, peanut, soybean, sugar, sesame, iodized salt, vitamins and mineral complex, amylase BAN 800MG	Sorting, washing, roasting cereals and legumins, mixing ingredients, grinding, cooking, grind into powder, sieving, enriching and packaging
Fanutri Céréales	F18	Cereals, soybean, peanuts, pain de singe, sugar, iodized salt, minerals and vitamins, amylases enzymes	Sorting, washing, roasting cereals and legumins, mixing ingredients, grind into powder, sieving, enriching and packaging
Maam Binré Complet	F19	Corn, millet, rice, tiger nuts, soybean, peanut, sugar, vitamins and minerals, iodized salt	Sorting, washing, roasting cereals and legumins, mixing ingredients, grind into powder, sieving, enriching and packaging
Misola	F20	Millet, soybean, peanut, iodized salt, sugar, vitamins and minerals complex	Sorting, washing, roasting cereals and legumins, mixing ingredients, grind into powder, sieving, enriching and packaging

Results

Raw Material composition of local infant flours

A total of 20 brands of flour from different productions were sampled (Table 1). The primary raw materials were cereals found in 100% (20/20) of formulations, legumins used in 70% (14/20) of formulations and oilseeds incorporated in 85% (17/20) of formulations. Concerning the use of cereals, corn was used in 60% (12/20) of formulations and millet in 30% (6/20) of formulations. Regarding the use of legumins, soybean was found in 55% (11/20) of formulations and cowpea in 20% (4/20). About oilseeds, peanuts were used in 85% (17/20) of formulations and sesame in 5% (1/20) of formulations. As for fortifying ingredients, minerals and vitamins were present in 60% (12/20) of formulations, iodized salt in 85% (17/20) of formulations, pain de singe in 25% of formulations, palm oil in 15% of formulations and Moringa in 5% of formulations. Concerning ingredients for improving taste, texture, flavor and digestibility, sugar was present in all formulations, enzymes in 30% of formulations, milk in 25% of formulations, cassava in 5% of formulations, yeast in 5% of formulations and vanilla in 5% of formulations.

Evaluation of Nutritional Parameters of Infant Flour

The nutritional characteristics evaluated were fats, carbohydrates, proteins and energy value of infant flour (Table 2). Fats contents varied from 6.16g± 0.05 to 16.76g± 0.04, with an average of 11.85g while total proteins contents ranged from 6.18 ± 0.25g to 22.08 ± 0.17g, with an average of 15.64g. Carbohydrates contents varied from 63.4g ± 0.52 to 70.96g ± 0.36, with a mean of 66.82g. In terms of calorific value, the values ranged from 406.02 kcal/100g ± 0.12 to 458.92 kcal/100g ± 0.1, with an average of 436.47 kcal/100g. In general, proteins, fats and carbohydrates were high and could be explained by the use of carbohydrate-rich local cereals and protein- and fat-rich legumes.

Table 2: Nutritional characteristics of infant flour

Samples	Fats (g)	Proteins (g)	Carbohydrates (g)	Calorific values (kcal/100 g)
F1	12.5±0.04	14.64±0.42	67.15±0.43	439.66±0.12
F2	10.62±0.02	18.39±0.53	65.98±0.7	433.06±0.13
F3	6.18±0.03	22.08±0.17	65.52±0.26	406.02±0.12
F4	6.16±0.05	21.5±0.45	66.44±0.57	407.2±0.32
F5	8.07±0.01	16.77±0.21	70.26±0.31	420.71±0.06
F6	11.57±0.05	15.26±0.53	66.85±0.71	432.57±0.19
F7	13.74±0.03	10.73±0.42	69.26±0.58	443.62±0.14
F8	10.53±0.02	20±0.30	64.04±0.44	430.97±0.13
F9	16.38±0.02	6.18±0.25	70.96±0.36	456.02±0.11
F10	16.38±0.03	12.6±0.08	64.92±0.07	457.46±0.15
F11	16.76±0.04	7.29±0.52	69.73±0.69	458.92±0.1
F12	14.27±0.05	12.4±0.12	66.99±0.12	445.95±0.15
F13	11.12±0.05	19.87±0.17	65.7±0.25	442.36±0.13
F14	6.88±0.04	21.51±0.48	66.15±0.59	412.52±0.24
F15	7.27±0.04	19.58±0.45	67.32±0.5	413.03±0.16
F16	13.22±0.05	13.28±0.38	67.34±0.52	441.46±0.13
F17	12.4±0.03	17.07±0.48	66.24±0.59	444.88±0.2
F18	14.31±0.04	11.87±0.23	67.16±0.33	444.91±0.11
F19	12.82±0.04	18.61±0.34	63.4±0.52	443.42±0.08
F20	15.8±0.05	13.19±0.15	64.92±0.15	454.64±0.23
Mean	11.85±3.47	15.64±4.66	66.82±1.99	436.47±16.66
Standard	> 8.5*	> 12.7*	≥ 58.8**	≥ 400**

Values are presented as the means ± MSD (mean standard deviation).
*NBF 01-198 (2014) 20; **OMS/FAO (2006) 21.

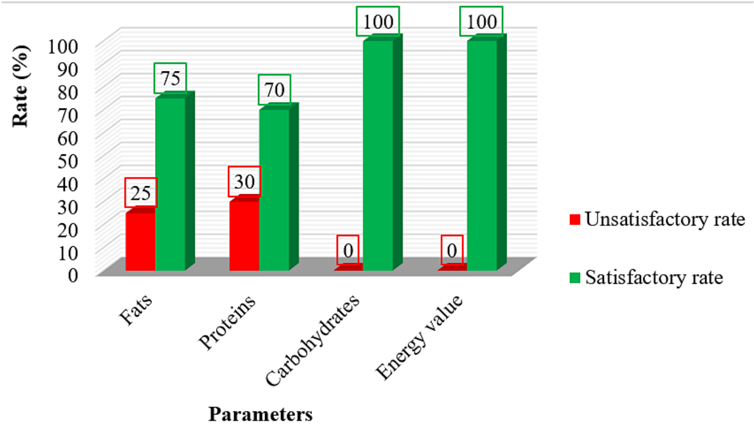

Fig. 1: Assessment of nutritional quality

In terms of evaluations (Fig. 1), 75% of the flours complied with the limits set by the Burkina Faso standard, while 25% of the flours were below the limits set by the standard concerning the fat content. Regarding protein content, 70% of flours complied with the limits set by the Burkina Faso standard, while 30% of flours were below the standard limits. In terms of the carbohydrate content and energy values, all flours complied with the limits set by national standards in Burkina Faso. Overall, only 45% of flours met all the requirements of the Burkina Faso standard.

Table 3: Modeling energy intake by macronutrient

Samples	Fats (%)	Proteins (%)	Carbohydrates (%)	Energy values (kcal/100g)
F1	25.59	13.32	61.09	439.66
F2	22.07	16.99	60.94	433.06
F3	13.7	21.75	64.55	406.02
F4	13.61	21.12	65.27	407.2
F5	17.26	15.94	66.8	420.71
F6	24.07	14.11	61.82	432.57
F7	27.88	9.67	62.45	443.62
F8	21.99	18.56	59.44	430.97
F9	32.33	5.42	62.24	456.02
F10	32.23	11.02	56.77	457.46
F11	32.87	6.35	60.78	458.92
F12	28.8	11.12	60.09	445.95
F13	22.62	17.97	59.41	442.36
F14	15.01	20.86	64.14	412.52
F15	15.84	18.96	65.2	413.03
F16	26.95	12.03	61.02	441.46
F17	25.09	15.35	59.56	444.88
F18	28.95	10.67	60.38	444.91
F19	26.02	16.79	57.19	443.42
F20	31.28	11.6	57.12	454.64
Recommended daily intake	≥ 20[a]	≥ 6[b]	50-75[c]	356-1028[d]

a: OMS/FAO (2008) [22], b: WHO/FAO/UNU (2007) [23], c : Mann *et al*. (2007) [24], d: Trèche (2004) [25].

Modeling the Contribution of Local Infant Formula Macronutrients to Total Energy

The results of the modeling show that the contribution of fats was between 13.61% and 32.87% while the contribution of proteins was between 5.42% and 21.75% (Table 3). The contribution of carbohydrates varied between 56.77% and 66.8% while the energy value was between 406.02 and 458.92 kcal/100g of porridge.

Overall energy values were within the energy limits recommended for complementary foods. However, the energy contribution of certain macronutrients to the overall energy value was below the recommendations. Evaluation of the energy contribution of each nutrient shows that 25% of infant flours had fat intakes below the recommended limits[22] (Table 4). As for the energy contribution of proteins, 5% of infant flours had proteins contribution below the recommended limits.[23] However, overall, 75% of infant flour complied with the energy contribution of fats to total energy value, and 95% of infant flour complied with the contribution of total proteins to total energy value. In terms of carbohydrates, all infant flours complied with recommendations.[24] By combining all nutritional criteria, 70% of local infant flours met recommendations.[22-24]

Discussion

The large number of local infant flour brands evaluated is greater than the number generally evaluated in the literature,[26,27] which provides a broader view of these products in the city of Ouagadougou. The carbohydrates contents obtained in this study are satisfactory as all flours complied with the WHO standard.[21] The values were close to those obtained in Côte d'Ivoire by Sika *et al*. (2019),[26] with a variation from 69.73% to 74.94% as well as those of Amoin *et al*. (2015),[7] with a variation from 67.8% to 69.20%. These satisfactory rates could be explained by the high use of cereals in the formulations. However, regarding fats contents and proteins contents, 25% and 30% of the flour respectively had contents below the limits set by the standards.[20] The fats contents obtained in the present study are higher than those obtained previously in Burkina Faso in 2018, with contents ranging from 5.8g to 11.5g[10] and the values obtained in Côte d'Ivoire in 2016, with contents ranging from 3.76g to 9.64g.[28] Regarding total proteins, the values obtained in this study were higher than those obtained by Dimaria *et al*. (2018)[10] in Burkina Faso, with values ranging from 8.5g to 16.6g and those obtained in Côte d'Ivoire, with values ranging from 7.01g to 15.57g.[28] Energy values were also higher than those obtained in Côte d'Ivoire, with values ranging from 397.27 kcal/100g to 400.86 kcal/100g[26] but lower than those obtained by another study in Burkina Faso in 2016, with values ranging from 423.46 kcal/100g to 472 kcal/100g.[27] The total energy requirements of children aged 6 to 23 months range from 749 to 1117 kcal per day.[19] Breast milk provides around 217 kcal/day for children aged 6 to 8 months and 90 kcal/day for children aged 12 to 23 months in developing countries, with the remainder (356 kcal/day to 1028 kcal/day) provided by complementary foods.[25] Modeling has shown that some of the infant flours evaluated had lower intakes than the recommended limits for energy requirements from each of the main macronutrients.[22-24] This imbalance could be explained by a lack of knowledge of production, packaging and labeling guidelines for cereal-based infant flours by some local infant flour producers, and the lack of qualification of some production managers in local production companies. Indeed, some authors had already pointed to shortcomings in formulations resulting from the lack of essential qualifications of employees in certain infant flour production companies.[6] As a result, there is low use of raw materials that are sources of fats and the low incorporation of additional fats. As for proteins, their contribution is quite interesting, with the high incorporation of legumes, which have contributed to a substantial increase in the energy contribution of proteins in the overall energy value. This high use of legumes could be partly explained by the high prevalence of protein-energy malnutrition, which varies between 12.1% and 32.2% in Burkina Faso, and which has guided NGO interventions in the field of infant flour formulation and child nutrition.[29]

Table 4: Evaluation of the compliance of the formulations of the local infant flour

	Fats	Proteins	Carbohydrates	Energy values
Compliance rate (%)	75	95	100	100
Intakes below the limit (%)	25	5	0	0
Recommended Intake	≥ 20[a]	≥ 6[b]	50-75[c]	356-1028[c]

a: OMS/FAO (2008) [22], b: WHO/FAO/UNU (2007) [23], c : Mann *et al*. (2007) [24], d: Trèche (2004) [25].

Conclusion

The carbohydrates contents and energy values were also within the standards for all the infant flours evaluated. However, for fats and proteins contents, 25% and 30% of infant flours respectively were below the limits set by the Burkina Faso standards. Modeling of the contribution of the different types of nutrients also showed that 30% of the local infant flours evaluated did not comply with the WHO recommendations. This study showed that local producers are making great efforts to have good quality products that meet the standards. However, the details show many shortcomings in the formulations of local infant flour. It is therefore in the interest of producers to improve their formulations by taking into account the available nutritional composition tables in compliance with the recommendations in this area.

Acknowledgement

The author would like to thank, (Insert university name and Dept. name) for their guidance and support to complete this article.

Funding
The author(s) received no financial support for the research, authorship, and/or publication of this article.

Conflict of Interest
The authors do not have any conflict of interest.

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