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ORIGINAL ARTICLE

Household production and energy content of infant flours for children aged 6 to 11 months in two rural settings in southern Benin

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Abstract

Background: Homemade complementary foods which are prepared from staples by the mothers or caregivers are mostly used in Africa including Benin. These foods are not adequately enriched and hygienic conditions are sometimes poor. **Aims:** The aim was to describe household production methods of infant flours and to estimate their macronutrient content in Benin. **Methods:** From August to October 2020, 20 mothers of children aged 6 to 11 months were selected in the municipalities of Covè and Djakotomey to examine the process of domestic production of infant flours and porridges. Data were collected using a touch screen questionnaire and the energy content of the flours produced by the mothers was calculated and evaluated using the FAO/INFOODS food composition table for West Africa. **Results:** The main process units for the production of the infant flours were milling:100 %, sorting: cereals 60 % and legumes: 33 %, roasting: cereals 70 %, and legumes: 91.7 %. Mothers had poor hygienic practices regarding Material: 20 %, Manipulator: 20 %, and Milieu: 35 % during the preparation of infant porridges. Four of the 20 formulas produced had an acceptable energy content, two had a standard fat content (10 – 25 g/100 g flour) and 12 had a standard protein content (15 g/100 g flour). **Conclusions:** This study showed that the main production methods of infant flours need to be improved. More, the overall energy content from these flours was lower than the recommended macronutrients contents by the standard FAO/WHO/UNICEF and the standards references. It is therefore important to maintain and strengthen nutritional interventions in order to improve the nutritional quality of homemade infant flours.

Keywords: Infant flour, household production, nutrition, hygiene.

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1 Introduction

The World Health Organization (WHO) and the United Nations of International Children's Emergency Fund (UNICEF) recommend exclusively breastfeeding infants during the first six months of life to achieve optimal growth, health, and development [1, 2]. Beyond the first semester, the infant should be provided with nutritionally adequate and safe complementary foods, concomitantly to breastfeed until the age of two years or more [3]. At the start of the weaning, other foods that are introduced to babies should meet their nutritional needs whereas breast milk's portion as a source of nutrients gradually decreases[3]. These novel foods, generally in liquid or semi-solid forms, must provide in balanced proportions both the macronutrients, namely proteins, carbohydrates, lipids, and micronutrients such as vitamins and minerals to meet energy and other nutritional needs for optimal growth [4]. The complementary foods given to infants or young children should adequately consider the inherent quality of the foods i.e., nutritional composition, energy density, organoleptic properties as well as the child's characteristics i.e., health status, gastric capacity, and adaptation, and the caregiver.

In Africa, homemade complementary foods which are prepared from staples by mothers or caregivers are mostly used, in contrast to other settings where all industrially processed and pre-packaged commercial complementary food are common [5]. The first-introduced homemade complementary foods are usually gruels based on cereals, roots, or tubers as staples, with or without added sugar [6, 7] and occasionally enriched with legumes (peanut paste or roasted soy flour), dried milk, or fish powder [8]. Hence, their nutritional and hygienic quality depends on maternal education, knowledge, and community involvement [9, 10].

In Benin, food insecurity remains persistent in 9.6 % of households, and undernourishment concern 7.4 %. Prevalence of stunting, wasting, underweight and anemia among children under 5 years were 32 %, 5 %, 17 %, and 71.5 % respectively. Exclusive breastfeeding was 42 % [11].

Only 15 % of children aged 6 – 23 months are fed according to best practices in infant and young child feeding [12]. When food diversification begins, complementary foods are produced by mothers and are widely used. This homemade production is affordable and allows to obtain large quantities of flour. It is also based on locally available foods. However, the nutrient content of

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these flours may be inadequate if there is no micronutrient enrichment. In 2016, a study in rural and urban Southern Benin on the characterization of the feeding of young children aged 6 to 36 months revealed that local infant flours were poorly enriched with protein, and consumption frequencies were low [8].

To help combat malnutrition in Benin, CARE International Benin/Togo Non-Governmental Organization, through its Collective Impact For Nutrition (CI4N) project - 2018 to 2020 - is conducting community nutritional interventions in low-resource areas of the departments of Zou, Couffo, and Ouémé [13]. Cooking demonstration sessions or the production of enriched infant flours is one of the activities of the entire project, whose main objective is to introduce mothers to appropriate culinary practices so that they can feed their children optimally.

It is unsure whether homemade complementary foods in Benin meet the nutritional and energy needs of infants. In addition, little is known about the hygienic conditions in which the foods are prepared in the households. The objective of this study was to evaluate the energy and macronutrient contents of the homemade complementary foods produced in two municipalities of Southern Benin (Zou & Couffo). We also described the domestic methods of production of infant flours and additionally assessed the practice of hygiene rules by mothers during the preparation of porridges.

2 Materials and Methods

2.1 Settings

The study took place in the municipalities of Covè (Zou) and Djakotomey (Coffo), which are Care International intervention's zones in Benin. The municipality of Covè is located in the southeast of Benin (about 150 km from Cotonou, the economic capital) [14]. The main food crops are peanuts and corn. They represent respectively 39.9% and 19.1% of the areas cultivated annually. The municipality of Djakotomey is located in southwest of Benin (about 140 km from Cotonou) [15]. The main crops grown in this municipality are maize, cassava, peanuts, soya, and cowpea.

2.2 Study design and population

We designed a cross-sectional and descriptive study, conducted from August to October 2020. The study population consisted of mothers with children aged 6 to 11 months who had lived in the two municipalities for at least 6 months, after giving birth.

2.3 Sampling techniques

Mothers included in the study were those who declared that their infant flours were depleted and wanted to renew their stock. These mothers were therefore followed throughout the process of replenishing their stock. A total of 20 mothers who gave their consent were surveyed i.e., 10 mothers in Covè and 10 in Djakotomey using the purposive sampling technique.

2.4 Data collection

Data were collected using a pre-established and tested questionnaire and an observation grid. The questionnaire included the mother's socio-demographic, information such as age, ethnicity, education, marital status, occupation, monthly income, and membership in a savings and loan group. The observation grid included the ingredients used by mothers in the production of infant flour with their respective measurements, and the various observations pertaining to hygiene during the preparation of the porridge using Diagram of Ishikawa: Milieu (porridge production environment), raw Material (water and infant flour), Method (search for cross-contamination, cooking time), Material (container, cooking utensils, kitchen linen...) and Manipulator (handler: hand washing, clothes).

The direct observations and weighing were made at home with the mothers. During these observations, the different ingredients used by the mothers for the production of the formulas were weighed before milling. After milling, the quantity of flour obtained was also weighed for each production. This allowed for estimation of the amounts of food in 100 g flour composition, taking into account the quantities of ingredients previously measured and considering that losses during the milling process were negligible.

The energy content of flours (numbered N°1 to 20), was assessed according to the standard CAC/GL 08 – 2013 of FAO/WHO/UNICEF in the estimation of macronutrients contents of complementary food for infants aged 6-24 months and for young children [16]. Thus, an infant flour was considered to be of "good energy quality" when the minimum energy density of that flour was 400 kcal per 100 g of flour, the protein and lipid contents were ≥ 15 g and 25g per 100g of flour, respectively.

Hygienic practices were assessed on the basis of the level of non-compliance with the 5M provisions (Milieu, Raw Material, Method, Material, and Manipulator). A diagnosis of the hygienic violations was made by scoring according to the method described by Compaoré *et al.*, in Burkina Faso [17]. A score of « 1 » was given for good hygienic behaviors and a score of « 0 » for poor hygienic practices. A summation of the scores was used to determine the percentage of "Good Hygienic Behavior (GHB)" observed at each M. The level of hygienic practice was adjudged "low" when the percentage of GHB was between 0 and 30 %; it was "medium" when the percentage was between 31 and 66 %; and "high" when the percentage was between 67 and 100 %.

2.5 Statistical analysis

The data obtained were entered using the KoboCollect application (Harvard Humanitarian Initiative, MA), a data collection tool developed under the Harvard Humanitarian Initiative and available for use on Android-powered devices [18]. Macronutrients composition and energy density of flour produced by mothers were calculated using the FAO/INFOODS food composition table for West Africa 2019 [19] from the different amounts of food in the 100 g of each flour produced by the mothers observed. Statistical analyses were carried out with STATA 16.0 (StataCorp, College Station, TX, USA). Continuous variables were expressed as mean ± standard deviation. Categorical variables were expressed as percentages and 95% confidence interval (CI).

2.6 Ethical considerations

Administrative and ethical authorizations for data collection were obtained from the local authorities of these municipalities and the leaders of the NGO Care Benin-Togo. Informed verbal consent of both the mother and the father was obtained prior to

the investigation and observation of the process of producing infant flours. All data were collected anonymously and processed confidentially.

3 Results

3.1 Socio-demographic characteristics of the study population

The average age of mothers was 28.5 ± 9.5 years with a minimum of 19 years and a maximum of 38 years. The women were mostly from the Adja (50.4 %) and Mahi (44 %) ethnic groups. All mothers were married; 57.6 % were with no formal education, and 85% had a monthly income of less than 40,000 XOF (≈80 USD) (Table 1).

Table 1. Socio-demographic characteristics of the mothers surveyed in Covè and Djakotomey (n=20).

Characteristics	Covè	Djakotomey	Total
	n	n	n
Age (years)			
< 25	3	3	6
25-34	5	7	12
> 35	2	0	2
Ethnicity			
Mahi	10	0	10
Adja	0	10	10
Education level			
Primary and high school	4	3	7
No schooling	6	7	13
Marital status			
Married	10	10	20
Single/ Widowed/ Divorced	0	0	0
Profession			
Cultivator	2	1	3
Reseller	3	5	8
Artisan	4	3	7
Housewife	0	1	1
Official	1	0	1
Monthly income			
< 40,000 XOF*	8	9	17
≥ 40,000 XOF	2	1	3
Membership in a savings and credit group			
Yes	7	10	17
No	3	0	3

*40 000 XOF ≈ 80 $ US

3.2 Processes of infant flours production

The observation of the formula production process by the mothers made it possible to identify the various operations carried out. The main unit operations were: milling (100%), sorting of cereals (60 %), roasting of cereals (70 %), and roasting of legumes (91.7 %). None of the mothers dehulled the soybeans.

In the municipality of Djakotomey, the mothers did not wash or dry the cereals. They did not sort legumes or wash small fish (fry) also (Table 2).

Table 2. Operations of producing infant flour formulas by mothers in Covè and Djakotomey (n = 20)

Food	Operations	Covè (n = 10)	Djakotomey (n = 10)	Total (n = 20)
		n	n	n
Cereals (n=10)	Sorting	6	6	12
	Washing	9	0	9
	Drying	9	0	9
	Roasting	9	5	14
	Milling	10	10	20
	Operations	Covè (n = 6)	Djakotomey (n = 6)	Total (n = 12)
		n	n	n
Legumes	Sorting	4	0	4
	Roasting	6	5	11
	Decortication	0	0	0
	Milling	6	6	12
	Operations	Covè (n=10)	Djakotomey (n=10)	Total (n=20)
		n	n	n
Small fish	Washing	2	0	2
	Milling	10	10	20

3.3 Hygiene practice during the preparation of infant formulas (5M)

For Materiel and Manipulator, 40 % of mothers had a high level of hygiene practice. Regarding the Milieu, 35 % of mothers had a high level of hygiene practice. Materiel and Manipulator's hygiene practice levels were poor in the municipality of Djakotomey compared to Covè (Table 3).

3.4 Energy content of produced flours (Carbohydrate, Protein, Lipid)

The energy intake of the flours ranged from 300.2 kcal to 444.3 kcal per 100 g. Of the 20 formulas, only four (N° 6, 8, 9, and 13) had an energy intake of 400 kcal/100 g of flour (Table 4). Two formulas (N° 9 and 13) had a fat content between 10 and 25 g/100 g of flour. Eleven formulas (N°1, 7, 8, 9, 11, 12, 13, 14, 16, 17, and 18) had a protein content of 15 g/100 g of flour. In addition, there were only two (2) formulas (N° 9,13) that had the minimum energy content and the minimum amounts of macronutrients recommended (Table 4).

4 Discussion

To the best of our knowledge, this is the first study to examine the quality of infant flours produced by mothers in rural areas of Benin. It was also interested in hygiene practice during the preparation of infant porridges.

Mothers surveyed were in majority young (28.5 ± 9.5 years), had no schooling (65 %) and their monthly income was < 80 $US in majority (85 %). These characteristics reveal a low socio-economic status that could limit access to industrialized infant flours.

Table 3. Hygiene level during infant flour formulas production in mothers, (Covè and Djakotomey, n = 20)

Municipalities	Raw Materials		Material		Manipulator		Method		Milieu	
	N (%)	CI	N (%)	CI	N (%)	CI	N (%)	CI	N (%)	CI
Covè										
Low	0 (0)	0 – 30.8*	1 (10)	0.2 – 44.5	0 (0)	0 – 30.8*	0 (0)	0 – 30.8*	3 (30)	6.6 – 65.2
Medium	0 (0)	0 – 30.8*	6 (60)	26.2 – 87.8	6 (60)	26.2 – 87.8	0 (0)	0 – 30.8*	3 (30)	6.6 – 65.2
High	10 (100)	69.1 – 100	3 (30)	6.6 – 65.2	4 (40)	12.1 – 73.7	10 (100)	69.1 – 100	4 (40)	12.1 – 73.7
Djakotomey										
Low	0 (0)	0 – 30.8*	3 (30)	6.6 – 65.2	4 (40)	12.1 – 73.7	0 (0)	0 – 30.8*	4 (40)	12.1 – 73.7
Medium	1 (10)	0.2 – 44.5	2 (20)	2.5 – 55.6	2 (20)	2.5 – 55.6	0 (0)	0 – 30.8*	3 (30)	6.6 – 65.2
High	9 (90)	55.4 – 99.7	5 (50)	18.7 – 81.2	4 (40)	12.1 – 73.7	10 (100)	69.1 – 100	3 (30)	6.6 – 65.2
Total										
Low	0 (0)	0 – 16.8*	4 (20)	5.7 – 43.6	4 (20)	5.7 – 43.6	0 (0)	0 – 16.8*	7 (35)	15.4 – 59.2
Medium	1 (5)	0.1 – 24.8	8 (40)	19.1 – 63.9	8 (40)	19.1 – 63.9	0 (0)	0 – 16.8*	6 (30)	11.9 – 54.3
High	19 (95)	75.1 – 99.8	8 (40)	19.1 – 63.9	8 (40)	19.1 – 63.9	20 (100)	83.1 – 100	7 (35)	15.4 – 59.2

*One-pided, 97.5 % CI

Table 4. Energy intake and quantity of macronutrients contained in 100g of flour formulas produced (Covè and Djakotomey, n = 20)

Municipalities	N° Flour	Energy intake (Kcal)	Carbohydrate (g)	Lipid (g)	Protein (g)
Covè	1	368.3	55.2	8.0	18.7
	2	320.8	62.8	3.3	9.9
	3	324.0	64.5	3.3	9.0
	4	356.8	71.0	3.6	9.9
	5	337.8	54.3	8.3	11.3
	6	444.3	89.0	4.6	11.6
	7	374.2	53.4	8.8	20.4
	8	414.6	63.2	9.8	17.9
	9	440.9	52.5	14.6	24.7
	10	303.8	57.9	3.0	11.2
Mean ± SD		368.5 ± 47.6	62.4 ± 10.5	6.7 ± 3.6	14.5 ± 5.2
Djakotomey	11	329.3	44.4	8.4	19.0
	12	336.5	48.4	7.7	18.4
	13	410.0	40.5	16.1	25.7
	14	354.1	56.8	7.0	15.9
	15	376.7	69.7	4.3	14.8
	16	360.7	16.5	7.6	56.6
	17	353.5	52.5	7.5	19.1
	18	314.2	48.3	6.5	15.5
	19	300.2	57.6	3.2	10.0
	20	316.3	59.9	3.9	9.9
Mean ± SD		345.2 ±31.2	49.5 ± 13.6	7.2 ± 3.4	20.5 ± 12.8
Covè + Djakotomey (Mean ± SD)		356.8 ± 41.9	55.9 ± 13.8	6.9 ± 3.5	17.5 ± 10.2
Standards (CAC/GL 08-2013 of FAO/WHO /UNICEF)		400	-	10-25	15

Regarding the process of infant flours production, we found that 60% of mothers sorted the cereals and 45 % washed and dried them; 33.3% sorted pulses; small fish washing was done by 10 % of them; and finally, milling was done by 100 % of the mothers. Besides, "roasting", which is a pre-cooking operation of ingredients and partial starch degradation [16], was carried out by 70% of mothers for cereals and 91.7 % of mothers for pulses. Dehulling of soybeans to reduce and, if possible, eliminate phytates, trypsin, and chymotrypsin-inhibiting agents that are anti-nutritional's factors [16, 20] was not performed by any mother. Finally, all the mothers milled the ingredients, an operation that is necessary to obtain the flours. These operations carried out by mothers are similar to those used by Fogny *et al.,* for the production of enriched infant flours in Benin [21]. However, in their study, the raw materials after washing were drained before drying, the peanut was dehulled after roasting and all the flours were cooled after milling [21]. In light of these results, it would be desirable for mothers to be more aware of the operations and treatments in order to produce good quality flour formulas.

The assessment of the level of hygiene showed that mothers had a high level of hygiene practices related to the Method and raw Material. For Material, Manipulator, and Milieu, the hygiene level was poor; so increased awareness of healthy practices and promotion of health campaigns are essential to mothers and children's health. Moreover, improving their socio-economic conditions through income-generating activities can help them to better equip themselves for good hygiene practices during the production process.

Of the 20 formulas produced by mothers, only four had a minimum energy content recommended by the Codex Alimentarius (400 kcal/100g flour). The energy densities of three formulations of flour tested by Fogny *et al.,* in Benin were high (495 to 498.72 kcal compared to the standard (400 kcal/100g flour) [21]. In another study conducted by Sanou *et al.,* in Burkina Faso, the energy values of 40 formulas analyzed ranged from 381.1 to 411.3 kcal/100 g [22].

The infant flours studied had lipid content ranging from 3 to 16.1 g/100 g and 2 flours had a lipid content that was in accordance with the standard (10 – 25 g/100 g of flour). These findings are consistent with those of Rocquelin *et al.*, who reported that complementary foods in Africa are low in fat and essential fatty acids [23]. In contrast, the three formulas analyzed by

Fogny *et al.*, had a lipid content in accordance with the standard (13.4 g, 10.6 g, and 12.8 g/100 g of flour) [21]. These results suggest that few fat-producing ingredients were used by mothers in the production of flour.

Eleven (11) infant flours had protein content in accordance with the standard. Their contents exceeded international standards, contrary to the protein contents of the flours analyzed in a study conducted by Elysée *et al.,* in Burkina Faso [24]. The high protein content of these flours can be explained by the combination of peanut, soybean, or small fish.

Macronutrient's content was adequate for only two of the 20 flours. Most of the formulas studied did not have the recommended minimum energy content, although protein levels were generally higher than the standards. Formulas had at least one protein source ingredient, which proves that mothers, thanks to the nutritional interventions of NGO CARE International are able to formulate flours enriched with protein materials. However, the poor distribution of the proportions of ingredients considerably reduces the energy content of the finished product. Low maternal income may explain this outcome.

This study has some limitations. The first is the small sample size in each municipality due to the inclusion criteria in the study and the second, is that we did not evaluate micronutrient contents. The main strengths of our study were the possibility to evaluate hygienic conditions concomitantly to nutritional quality, especially in a rural area.

5 Conclusion

This study has revealed that the main operations of ingredient treatment need to be promoted to improve household production of infant flours in Covè and Djakotomey in the south of Benin. Infant flours produced by mothers for their children's porridges had a low overall energy density and lipid content. It is therefore important to carry out appropriate nutritional interventions in these municipalities in order to improve the nutritional quality of infant meals produced by mothers.

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