Journal of Agricultural Chemistry and Environment, 2024, 13, 192-207
https://www.scirp.org/journal/jacen
ISSN Online: 2325-744X
ISSN Print: 2325-7458

Design and Production of Infant Flours Based on Pumpkin Pulp Enriched with Cakes Extracted from Its Seeds

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How to cite this paper: Toundoufedouno, K.H., Kourouma, K., Sakho, A.M., Sylla, K.L. and Diallo, A. (2024) Design and Production of Infant Flours Based on Pumpkin Pulp Enriched with Cakes Extracted from Its Seeds. *Journal of Agricultural Chemistry and Environment*, **13**, 192-207.
https://doi.org/10.4236/jacen.2024.132013

Received: March 10, 2024
Accepted: May 12, 2024
Published: May 15, 2024

Abstract

The inclusion of composite flours in infant food at weaning time should be a priority for mothers. The aim of this project is to formulate infant flour based on pulp flour enriched with oilcake from these grains after extraction of the oil. To do this, the elements were combined to obtain a regulatory formulation. Micro- and macronutrients, minerals, vitamins and tasting of the prepared porridge were determined. The results obtained were satisfactory. The moisture content of the fruit pulp was determined using oven-drying techniques: 92.2%, carbohydrates 6.00%, lipids 0.3%, ash 0.80%, proteins 1.10%, calcium 19.8%, phosphorus 42.6% and iron 0.4%. Furthermore, the carbohydrate content of flours composed of 5% insertion is 62.9 g to 48.8 g per 100 g, and the protein content of compound flours with 5% insertion is 15.9 g to 28.25 g per 100 g. On the other hand, the vitamin C and E contents of fresh pulp and oilcake are 25 mg, 13 mg and 21 mg respectively. However, only copper and β-carotene from 5% to 30% insertion remain invariant to the different insertion rates, with a value of 25 mg for copper and 0 µg for β-carotene. In addition, a variation in the degree of swelling of weaning flours compared with the standard from 3.95% at 5% insertion to 3.58 at 30% insertion was observed. The solubility of flours increases on the one hand with increases in the degree of insertion of the cakes. Flour formulated so many toward basicity. But the presence of traces of oil containing fatty acids can reduce this basicity. This study may be an alternative of industrial flours in infant nutrition.

Keywords

Pumpkin, Seeds, Oilcake, Infant Flour, Oil, Micronutrients

1. Introduction

As recommended by the World Health Organization [1], breast milk is considered the best food for newborns from 0 to 6 months. After 6 and 39 months, complementary feeding is essential to prevent malnutrition. To combat malnutrition in children, it is important to know their nutritional needs according to their age group. According to the Food and Agriculture Organization of the United Nations (FAO), the prevalence of malnutrition worldwide affects more than a billion people, 90% of whom live in the least developed and low-income countries [1] [2] [3]. In these countries, child malnutrition is considered one of the main causes of illness. In Africa, several studies have demonstrated the potential for formulating infant milks based on agricultural products [4] [5] [6]. In the Republic of Guinea, the final report on the assessment of the nutritional situation of infants and young children, made it possible to know the level of key indicators: exclusive breastfeeding, 43.7%, early breastfeeding 25.8%, dietary diversity 11.1% and the proportion of children benefiting from a minimum acceptable dietary condition 4.2%. The main results found are 6.7% as the national prevalence of malnutrition in children aged 6 to 59 months [7]. These values show that the prevalence of malnutrition in all its forms in the Republic of Guinea has not increased since the last survey in 2015 [7]. According to the World Health Organization (WHO), this result represents a poor indicator of the child's nutritional situation [4]. Surveyors' values by administrative region show a growth in global acute malnutrition of: 3.3% in the N'zérékoré region; 8.3% in the Kankan and Kindia regions; 7% in the Labé region, the Boké and Mamou regions 5% and 6% respectively, and Conakry 4% [7]. The N'zérékoré, Conakry, Boké and Mamou regions have prevalence percentages below the National Value, while Labé, Kankan and Kindia are above the National Value. Since the liberalisation of trade in the Republic of Guinea, infant food flours are sold in pharmacies and supermarkets, and are inaccessible to the majority of the population due to their high price, whereas traditionally prepared infant flours are made from cereals, tubers, legumes vegetables and oilseeds. This is also the case in most less-developed countries, which see this as an alternative to imported flours, despite the fact that certain health requirements and preparation methods are not respected [8] [9]. However, many WHO studies and recommendations on the manufacture of flours of good nutritional and sanitary quality for weaning have been reported. In addition to current methods of improving the viscosity and energy density of slurries by extrusion cooking, hydrolysis and addition of amylolytic enzymes [10], we propose this work, which focuses on the study of a weaning flour formulated by inserting oilcake from pumpkin seeds into its pulp which important sources of vitamins and minerals [11] [12] [13] [14].

2. Materials and Methods

This work involved determining the macros and micronutrients of raw materials (pumpkin seed pulp and oilcake) and finished products (infant flours), as well as physicochemical and microbiological parameters.

2.1. Plant Material

Pumpkin pulp and seeds were used as raw materials in this work. Dehydrated pulp flour and seed oil cakes were the basic materials used in the formulation of infant flours.

2.2. Equipments

The main equipment used is the drying oven, the oil press, the electric slicer, the electric hammer mill and the Bortsch Viscosimeter.

2.3. Sample Preparation

Squash of the Kègbanadje (name in Guinea) variety at M3 maturity were purchased from the central market of the Guékedou prefecture, some 693 km from Conakry (capital of the Republic of Guinea). Prior to the experiments, the squashes were washed and dried at room temperature in the Food and Nutritional Sciences laboratory of the College of Tourism and hotel trade (Republic of Guinea) for 1 hour to eliminate contaminants.

2.4. Experimental Protocol

a) The squash was peeled, split, seeded and cut into 1.5 - 2 cm thick strips using an electric grater. The strips were placed on trays in a thin layer. The trays were then placed in an oven to dry at 70˚C for 6 hours to a residual moisture content of less than 14% (**Figure 1**).

The dehydrated flakes were finely ground in a hammer mill to extract flour with a particle size of 5 - 8 μm (**Figure 2**).

b) The collected seeds were dried to a residual moisture content of less than 7%. They were then roasted and hulled by hand. They were then extracted in an oil press. The resulting oilcake was dehydrated in an oven at 105˚C to a moisture content of 15%. Proteins make up the largest fraction of the dry matter in oilcake. It accounts for 49% to 59%, or more precisely: 49%. Weaning meals are formulated in the following ratios:

$$\frac{\text{Tourteau}}{\text{Pumpkin flour}} = \frac{5.0}{95}, \frac{10}{90}, \frac{15}{85}, \frac{20}{80}, \frac{25}{75} \text{ and } \frac{30}{70}$$

2.5. Methods

2.5.1. Determining the Macro- and Micronutrient Content of Raw Materials and Finished Products

1) Determining protein content

Proteins were assayed using the Kjeldahl method of standard NF V03-050 [11].

Figure 1. Squash slices on trays introduced into the oven for drying at a temperature of 70˚C.

Figure 2. Extracting pumpkin flour ready for use.

2) Determining lipid content

Lipids were determined by the Soxhlet gravimetric method using the international standard ISO 659, 1988 [11].

3) Determination of total ash content

Ash content was determined using the AACC 08-01 method [15].

4) Micronutrients determination

The micronutrients, calcium, phosphorus, iron and zinc were determined by UV-VIS spectrophotometry (DR 5000; HACH and LANGE, France).

5) Dosage of vitamins: A and C

Vitamins A and C were determined by reverse-phase high-performance liquid chromatography (HPLC) at 280 nm.

2.5.2. Determination of Physicochemical Parameters

All chemicals and reagents were used without purification and were supplied by the Food and Nutritional Sciences Laboratory of the School of Tourism and Hospitality (Republic of Guinea).

1) Determining pH

Take 10 ml of the supernatant previously obtained and measure the pH using a pH meter (HANNA INSTRUMENTS HI98150), reading the pH value directly on the pH meter display.

2) Dosing titratable acidity

Procedure

Take 10 ml of the supernatant previously obtained, and add two (2) drops of phenolphthalein as a color indicator. Titrate the mixture (supernatant + phenolphthalein) with a deionized sodium hydroxide solution until it turns pale pink [1] [16]. The acidity, expressed in milliequivalents per 100 g of sample (meq/100 g), was calculated:

$$A_{m?q/100\text{ g}} = \frac{N_1 \times 10^5}{m}$$

where:

N_1 = Normality of the sampled solution;

m = Sample mass (in grams).

3) Viscosity determination

Slurry viscosity in this study was determined using the Bostwich viscometer, in which flour slurries are cooled to 45˚C after cooking. Tracking flow test of during 30 seconds. The distance at which the slurry flows indicate its viscosity or fluidity) in cm [17].

4) Determination of solubility and swelling power

Gravimetric analysis was used to determine the solubility and swelling power of flours [18].

Procedure

A 0.3 g flour suspension is added to 15 mL distilled water and heated from 50˚C to 95˚C with vigorous agitation. Maintain temperature at 95˚C for 15 min. Followed by centrifugation at 2800 rpm. Next, remove the supernatant and dry at 105˚C for 24 h, then weigh the residue. The solubility (S) of flour corresponds to the percentage of flour dissolved in water [1]. It is determined using the formula:

$$S\% = \frac{m_2 \times 100}{m_1}$$

m_2—mass of supernatant after steaming;

m_1—mass of sample taken;

S%—solubility.

5) Determining swelling power

Swelling power (G) was determined by the formula of Leach and Schoch [14] after weighing and oven-drying (MEMMERT UM 500, MEMMERT Gmbh + Co.KG, Germany-Schwabach) at 105˚C for 24 h of the pellet.

$$\text{Pswelling} = \frac{m_1 - m_2}{m_2}$$

m_1 = mass of wet pellet;

m_2 = mass of oven-dried pellet (g).

6) Determining the energy density of slurries

Energy density is defined as the amount of energy supplied per 100 ml of slurry (Kcal/100 ml). It corresponds to the dry matter content in 5 g of slurry obtained by differential drying for 24 hours at 105˚C. Energy density was obtained by multiplying dry matter by the energy coefficient of carbohydrates [11] [19].

2.5.3. Statistical Processing of Data

A completely randomised block design with three replicates was used to improve the viscosity and energy density of slurries. The variables measured were slurry viscosity (in centimeters) and energy density expressed in kilocalories per 100 ml of slurry (Kcal/100 ml). Analysis of variance was performed using Agro bas software.

2.5.4. Preparing Weaning Sprays

In a saucepan, 25 grams of mixed flours were dissolved in water. Then cook the mixture for 7 minutes. Add 5 ml lemon juice. Slurries were prepared in three replicates (**Figure 3**). Chemical composition values are given in **Tables 1-8**.

3. Results

3.1. Macronutrient Composition of Raw Materials and Compound Flours

The results are: fruit pulp contains 92.2 g% water, 1.1 g% protein, 0.3 g% lipids and 6 g% carbohydrates providing 31.1 Kcal/%g, and 0.6 g% fiber. Ash is: 0.4 g%. Oilcake after seed oil extraction contains 5.4 g%g water, (63.9) protein, (6 g%) lipids, (9.2 g%) carbohydrates and (6.9 g%) fiber, providing 346.4 Kcal/%g. Weaning flours contain 15.9 g to 28.25 g per 100 g for protein, 3.8 g to 4.8 g per 100 g for lipids, 62.9 g to 48.8 g per 100 g for carbohydrates, 7.5 g to 9.2 g per 100g for dietary fiber, 5.0 g to 5.5 g per 100 g for total ash and 349.4 to 349.2 Kcal per 100 g of flour which are represented in **Table 1**.

3.2. Mineral Composition of Raw Materials and Compound Flours

Table 2 shows the results for the micronutrients measured in fresh pulp: calcium, phosphorus, iron, copper and zinc. Their contents are: (19.8 mg) calcium, (42.6 mg) phosphorus, (0.4 mg) iron, (0.7 mg) copper and (0.11 mg) zinc. Oilcake (344 mg) calcium, (312 mg) phosphorus, (3.5 mg) iron, (0.7 mg) copper, (0.11 mg) zinc. The insert contents of compound flours are: calcium 124 mg at 5% and 145 mg at 30%; phosphorus 378 mg at 5% and 396 mg at 30%; iron 11.5 mg at 5% and 10.6 mg at 30%; copper 0.7 mg at 5% and 0.5 mg at 30%; zinc 0.11 mg at 5% and 2.2 mg at 30% (**Table 2**).

3.3. Vitamin Content of Raw Materials and Compound Flours

Our analyses have shown that the raw materials and compound flours obtained contain vitamins which are presented in **Table 3**.

The vitamin contents of fresh pumpkin pulp, pumpkin flour and pumpkin seed oil cake are shown in **Table 3**. Fresh pumpkin pulp contains 1500 µg β-carotene, 0.05 mg thiamine, 0.37 mg riboflavin, 2.6 mg niacin, 25 mg ascorbic

Figure 3. Ready-to-use pumpkin flour slurry.

Table 1. Micronutrient composition of raw materials and compound flours.

Nutrients	Units	Squash			Compound flours						
		Fresh	Flour	Tourneau	5%	10%	15%	20%	25%	30%	Standard
Dry matter	**g%g**	7.8 ± 0.45	95 ± 3.35	94.60 ± 2.67	95.6 ± 3.29	95.71 ± 3.68	96.42 ± 2.72	94.93 ± 2.14	94.64 ± 2.19	**96.25 ± 3.52**	95
Protein	**g%g**	1.1 ± 0.56	13.4 ± 0.64	63.9 ± 1.15	15.9 ± 1.13	18.5 ± 1.75	21.4 ± 1.12	23.5 ± 1.32	26 ± 1.23	**28.6 ± 1.28**	13
Lipids	**g%g**	0.3 ± 0.08	3.7 ± 0.32	6.0 ± 0.65	3.8 ± 0.40	3.9 ± 0.35	4.02 ± 0.26	4,2 ± 0.37	4.3 ± 0.42	**4.4 ± 0.5**	7
Carbohydrates	**g%g**	6 ± 0.91	65.7 ± 2.84	9.2 ± 0.41	62.9 ± 2.84	60.1 ± 2.43	57.2 ± 4.12	54.4 ± 3.8	51.6 ± 4.23	**48.8 ± 4.11**	68
Fibers	**g%g**	0.6 ± 0.07	7.3 ± 0.41	13.6 ± 0.91	7.5 ± 0.11	7.9 ± 0.42	8.2 ± 0.51	8.6 ± 0.35	8.9 ± 0.42	**9.2 ± 0.28**	5
Ash	**mg%g**	0.4 ± 0.05	4.9 ± 0.22	6.9 ± 0.023	5.0 ± 0.04	5.1 ± 0.07	5.2 ± 0.03	5.3 ± 0.07	5.4 ± 0.06	**5.5 ± 0.05**	2
Energy	**Kcal**	31.1	349.7	346.4	349.4	318.3	348.8	349.4	349.1	**349.2**	400
Standards * (codex alimentariste standard)	KJ	130.0	1461.7	1448.0	1460.5	1330.5	1458.0	1460.5	1459.2	**1459.7**	

Table 2. Mineral composition of raw materials and compound flours.

Nutrients	Units	Squash			Compound flours					
		Fresh	Flour	Tourneau	5%	10%	15%	20%	25%	30%
Calcium	mg%g	19.8 ± 0.23	127 ± 1.31	185 ± 2.34	124 ± 1.23	133 ± 1.64	136 ± 1.32	140 ± 1.11	142 ± 1.21	145 ± 1.34
Phosphorus	mg%g	42.6 ± 1.05	374 ± 4.32	451 ± 1.51	378 ± 5.43	382 ± 3.72	386 ± 4.26	388 ± 3.56	390 ± 3.67	396 ± 2.45
Iron	mg%g	0.4 ± 0.13	12.4 ± 0.92	3.5 ± 0.11	11.5 ± 0.14	11.1 ± 0.15	10.6 ± 0.81	12.5 ± 0.21	9.7 ± 0.71	10.6 ± 0.81
Copper	mg%g	0.7 ± 0.05	0.5 ± 0.014	0.7 ± 0.012	0.5 ± 0.013	0.5 ± 0.05	0.5 ± 0.03	0.6 ± 0.02	0.6 ± 0.02	0.5 ± 0.03
Zinc	µg%g	0.11 ± 0.01	2.3 ± 0.03	1.8 ± 0.01	2.3 ± 0.02	2.2 ± 0.03	2.2 ± 03.01	2.0 ± 0.04	2.1 ± 0.03	2.2 ± 0.04

Table 3. Vitamin content of raw materials and compound flours.

Nutrients	Units	Squash			Compound flours					
		Fresh	Flour	Tourneau	5%	10%	15%	20%	25%	30%
β-carotene	µg	1500 ± 20	18300 ± 33	100 ± 9	1700 ± 110	1650 ± 151	1500 ± 110	1430 ± 100	1360 ± 120	1200 ± 130
Thiamin	mg	0.05 ± 0.002	0.42 ± 0.004	0.54 ± 0.002	0.43 ± 0.005	0.43 ± 0.003	0.4 ± 0.006	0.4 ± 0008	0.5 ± 0.007	0.5 ± 0.009
Riboflavin	mg	0.37 ± 0.01	0.18 ± 0.05	0.25 ± 0.001	0.18 ± 0.003	0.19 ± 0.00	0.2 ± .0.001	0.2 ± 0.001	0.2 ± 0.002	0.2 ± 0.003

Continued

Niacin	mg	2.6 ± 0.02	3.3 ± 0.02	5.2 ± 0.01	3.40 ± 0.03	3.49 ± 0.05	3.6 ± 0.04	3.7 ± 0.01	3.8 ± 0.04	3.9 ± 0.03
Ascorbic acid	mg	25 ± 0.56	6.0 ± 0.101	2.0 ± 0.02	5.8 ± 0.06	5.60 ± 0.07	5.4 ± 0.06	5.2 ± 0.08	5.0 ± 0.05	4 ± 0.08
Vitamin E	mg	13 ± 0.49	21 ± 0.37	33 ± 0.52	21.6 ± 0.56	22.20 ± 0.51	22.8 ± 0.72	23.4 ± 0.53	24.0 ± 0.45	24.6 ± 0.51

acid and 13 mg vitamin E. Meal contains 100 µg *β*-carotene; 0.54 mg thiamine; 0.25 mg riboflavin; 5.2 mg niacin; 5 mg ascorbic acid; and 21 mg vitamin E. Weaning flours, their vitamin contents were from 1700 µg 5% to 1200 µg at 30%; *β*-carotene, from 0.54 mg at 5%; 0.5 mg at 30%; thiamine, from 0.18 mg at 5%; 0.20 mg at 30% riboflavin; 2.6 mg at 5% to 3.9 mg at 30% niacin; from 5 mg at 5% to 4 mg at 30% ascorbic acid and from 13 mg 5% to 24.6 mg 30% vitamin E insertion (Table 3).

3.4. Micronutrient Composition of Slurry

In Table 5, the nutritional value of weaning porridges in micronutrients varies from 107 Kcal at 5% insertion to 135 Kcal at 30% insertion for energy value; from 5.1 g at 5% insertion to 10 g at 30% insertion for proteins; from 1.3 g at 5% insertion to 2.4 g at 30% insertion for lipids; from 19.2 g at 5% insertion to 18.4 g at 30% insertion for carbohydrates; from 2.1 g at 5% insertion to 2 g at 30% insertion for dietary fiber and from 1.4 g at 5% insertion to 1.2 g at 30% insertion for total ash (Table 5).

3.5. Mineral Composition of Slurries

The mineralogical contents of porridges made from pumpkin pulp flour with the insertion of pumpkin seed oil cakes are presented in Table 6. As a result, the mineral composition of pumpkin porridges varies from 25 mg at 5% insertion to 48 mg at 30% insertion for calcium; from 36 mg at 5% insertion to 53 mg at 30% insertion for phosphorus; from 3.5 mg at 5% insertion to 3.8 mg at 30% insertion for iron; from 0.2 mg at 5% - 30% insertion for copper and from 0.7 mg at 5% insertion to 0.8 mg at 30% insertion for zinc. However, the vitamin contents of weaning porridges are reported in Table 7.

According to Table 7, the vitamin content of weaning porridges varies from 484 µg at 5% to 0.65µg at 30% insertion for *β*-carotene; from 0.07 mg at 5% to 0.68 mg at 30% insertion for vitamin B1 or thiamine; from 0.08 mg at 5% to 0.150 mg at 30% insertion for vitamin B2 or riboflavin; from 1.6 mg at 5% to 3.2 mg at 30% insertion for vitamin B3 or niacin; from 3 mg at 5% to 10 mg at 30% insertion for vitamin C or ascorbic acid and from 0.1 mg at 5% to 0.17 mg at 30% insertion for vitamin E or tocopherol.

3.6. Physico-Chemical Parameters

The average values for the physicochemical characteristics of weaning flours and their slurries are shown in Table 8 and Figures 1-3, while the results of the tasting protocol for weaning flours and slurries are shown in Table 9. The results

Table 4. Nutrient density of composite flour porridges for the 6 - 12 months age group.

Nutrients	Units	Weaning flours						
		5%	10%	15%	20%	25%	30%	ANC
Protein	g%g	39	48	60	65	75	77	**13**
Lipids	g%g	19	20	23	27	31	34	**7**
Carbohydrates	g%g	28	28	28	27	27	27	**68**
Fibers	g%g	42	42	44	42	42	40	**5**
Ash	mg%g	70	70	70	70	65	60	**2**
Energy	Kcal	14	15	16	17	17	18	**750**
Calcium	mg%g	5	6	7	8	9	10	**500**
Phosphorus	mg%g	10	11	12	13	14	15	**360**
Iron	mg%g	50	50	50	61	49	54	**7**
Copper	mg%g	25	25	25	25	25	25	**0.8**
Zinc	µg%g	12	12	12	12	12	13	**6**
β-carotene	µg	0	0	0	0	0	0	**350**
Thiamin	mg	310	325	340	355	380	415	**0.2**
Riboflavin	mg	25	33	40	43	48	53	**0.4**
Niacin	mg	83	93	107	123	137	290	**3.0**
Ascorbic acid	mg	39	48	60	65	75	77	**50**
Vitamin E	mg	19	20	23	27	31	34	**13**

Table 5. Micronutrient composition of composite flour porridges.

Nutrients	Units	Hybrid pumpkin flour buns						
		0.0%	5%	10%	15%	20%	25%	30%
MS	g%g	29.1 ± 0.69	29.6 ± 1.24	30 ± 1.25	31.6 ± 1.12	32.4 ± 1.15	33.5 ± 1.35	34.1 ± 2.17
Protéins	g%g	4.2 ± 0.12	5.1 ± 0.12	6.3 ± 0.14	7.8 ± 0.13	8.5 ± 0.21	9.7 ± 0.17	10 ± 0.26
Lipids	g%g	1.2 ± 0.03	1.3 ± 0.08	1.4 ± 0.05	1.6 ± 0.07	1.9 ± 0.03	2.2 ± 0.04	2.4 ± 0.02
Carbohydrates	g%g	23.1 ± 0.42	19.2 ± 0.78	18.8 ± 0.83	19.1 ± 0.37	18.5 ± 0.72	18.2 ± 0.68	18.4 ± 0.37
Fibers	g%g	2.3 ± 0.06	2.1 ± 0.03	2.1 ± 0.02	2.2 ± 0.06	2.1 ± 0.04	2.1 ± 0.07	2.0 ± 0.03
Ash	mg%g	1.5 ± 0.03	1.4 ± ± 0.02	1.4 ± 0.01	1.4 ± 0.03	1.4 ± 0.01	1.3 ± 0.02	1.2 ± 0.010
Kcal	Kcal	120 ± 0.07	107.0 ± 8.11	110.1 ± 7.23	117.7 ± 6.84	125.3 ± 9.12	131.0 ± 7.26	135.3 ± 8.12
Kj	Kj		447.1 ± 20	460.2 ± 23	492.0 ± 25	522.9 ± 22	548.3 ± 30	565.8 ± 28

Table 6. Mineral composition of composite flour slurries.

Nutrients	Units	Hybrid flour buns						
		0.0%	5°	10%	15%	20%	25%	30%
Calcium	mg%g	18.7 ± 0.23	25 ± 0.17	32 ± 0.49	37 ± 0.32	41 ± 0.45	43 ± 0.54	48 ± 0.28
Phosphorus	mg%g	38.6 ± 0.26	36 ± 0.23	38 ± 0.42	42 ± 0.28	46 ± 0.42	49 ± 0.35	53 ± 0.47

Continued

Iron	mg%g	0.35 ± 0.36	3.5 ± 0.06	3.5 ± 0.03	3.5 ± 0.02	4.3 ± 0.05	3.4 ± 0.04	3.8 ± 0.02
Copper	mg%g	0.16 ± 0.31	0.2 ± 0.021	0.2 ± 0.01	0.2 ± 0.01	0.2 ± 0.011	0.2 ± 0.012	0.2 ± 0.013
Zinc	µg%g	0.35 ± 0.24	0.7 ± 0.14	0.7 ± 0.11	0.7 ± 0.11	0.7 ± 0.013	0.7 ± 0.014	0.8 ± 0.016

Table 7. Vitamin content of composite flour porridges.

Nutrients	Units	Hybrid squash porridges						
		5%	10%	20%	30%	40%	50%	60%
β-carotene	**µg**	484 ± 12	0.07 ± 0.001	0.62 ± 0.001	0.65 ± 0.01	0.68 ± 0.03	0.71 ± 0.01	0.76 ± 0.02
Thiamin	**mg**	0.07 ± 0.001	0.62 ± 0.002	0.65 ± 0.01	0.68 ± 0.03	0.71 ± 0.04	0.76 ± 0.02	0.83 ± 0.02
Riboflavin	**mg**	0.08 ± 0.001	0.1 ± 0.002	0.13 ± 0.02	0.150.01	0.17 ± 0.010.02	0.19 ± 0.003	0.21 ± 0.01
Niacin	**mg**	1.6 ± 0.12	2.5 ± 0.4	28 ± 0.02	3.2 ± 0.11	3.7 ± 0.050.06	4.1 ± 0.08	5.7 ± 0.07
Vitamin C	**mg**	3 ± 0.11	5 ± 0.13	7 ± 0.12	10 ± 1.2	13 ± 0.5	15 ± 0.4	18 ± 0.6
Vitamin E	**mg**	0.10 ± 0.003	0.13 ± 0.003	0.15 ± 0.004	0.17 ± 0.005	0.20 ± 0.006	0.23 ± 0.005	0.25 ± 0.005

Table 8. Physico-chemical parameters of flour and slurry.

Insertion	Flour				10% boiled			
	Swelling power	Solubility	MS rate	Humidity level	pH	Titratable acidity	**Viscosity (mm/s)**	Energy density
5%	3.95 ± 0.052	80 ± 0.052	21.667 ± 0.416	78.3	6.5 ± 0.052	2.5 ± 0.052	14	69
10%	3.87 ± 0.117	82 ± 0.117	21.733 ± 0.643	78.3	6.4 ± 0.117	2.4 ± 0.117	13	72
15%	3.80 ± 0.055	87 ± 0.055	21.467 ± 0.833	78.5	6.3 ± 0.055	2.3 ± 0.055	12	76
20%	3.73 ± 0.026	90 ± 0.026	22.533 ± 0.503	77.4	6.3 ± 0.026	2.2 ± 0.026	11	85
25%	3.65 ± 0.026	92 ± 0.026	22.933 ± 0.833	78.0	6.2 ± 0.026	2.2 ± 0.026	9	89
30%	3.58±0.035	95 ±0.035	21.832±0.743	78.17 ± 0.631	6.1 ± 0.034	2.1± 0.035	8	92
Standard	**4**	**100**	**20 à 22 %**	**78 - 80**	**≤4.5**	**1.6 - 2.4**		

Table 9. Results of weaning meal and slurry tasting protocol.

Flours	Aspect	Odor	Taste	Color	Texture
Pure squash	6	7	7	6	7
5%	6	6	6	7	7
10%	7	7	7	7	7
15%	7	7	7	7	7
20%	8	8	8	8	8
25%	8	8	8	8	8
30%	9	9	9	9	9
Total	50	51	50	52	53
Average	8	9	8	9	9

show that the degree of swelling of weaning flours varies from 3.95% at 5% insertion to 3.58 at 30% insertion, compared with the norm. Flour solubility increases in proportion to the degree of cake insertion. Compared to the standard (100), it varies from 80 at 5% insertion to 95 at 30% insertion. The dry matter (DM) content of weaner meal varies from 21.667% at 5% insertion to 21.832% at 30% insertion. At the same time, slurry moisture content ranged from 78.3% at 5% insertion to 78.17% at 30% insertion. Slurry pH ranged from 6.5 at 5% insertion to 6.1 at 30% insertion. Slurry acidity ranged from 2.5 at 5% insertion to 2.1 at 30% insertion. Slurry viscosity varies in proportion to the increase in the insertion rate of pumpkin pulp flour cakes. It varies from 118 mm/s at 5% insertion (*i.e.* 14 seconds) to 100 mm/s at 30% insertion (*i.e.* 8 seconds), 13 seconds at 10% insertion, 12 seconds at 15% insertion, 11 seconds at 20%, 9 seconds at 25% insertion. As for slurry energy density, it increases in proportion to the increase in insertion rate from oilcake meal to pumpkin pulp meal. The values are 69 to 5% insertion, 72 to 10% insertion, 76 to 15% insertion, 85 to 20% insertion, 89 to 25% insertion and 92 to 30% insertion (**Table 8**).

3.7. Tasting Protocol and Pumpkin Seed and Flour Porridge

The results are shown in **Table 9** and **Figure 3**.

4. Discussion

Courage pulp has been used in the production of infant flours, enriched with oil cakes extracted from its seeds. Analysis of the macronutrient, mineral and chemical composition of the raw materials and compound flours (**Table 1**, **Table 2**) showed that fruit pulp had a moisture content (%) of 92.2%, carbohydrates 6.00%, lipids 0.3%, ash 0.80%, proteins 1.10%, calcium 19.8%, phosphorus 42.6% and iron 0.4%. These results are close to those found by [20], which are, for example, 91.50% water, *i.e.* a slight difference of 0.7%, 6.50% a difference of 0.50%, ash 0.80 a difference of 0.40%, 1.00 a difference of 0.10%, (0.20%) calcium, (0.40%) iron with the particular presence of zinc at 0.11%. These differences may probably be due to variety, growing environment or climate. The carbohydrate content of flours composed of 5% insertion is 62.9 g to 48.8 g per 100 g. This value is close to the standard indicated by (FAO/WHO) 68% [21]. In addition, the protein content of compound flours with 5% insertion is 15.9g to 28.25 g per 100 g, also in line with the standard indicated by around 15% (FAO/WHO) [21]. The protein content of enriched flours plays an important role in tissue repair [22]. According to [23], flours for infant consumption during weaning should have a lipid content of around 30% of total energy intake for 8%. These values, found to be 3.8 g to 4.8 g per 100 g for lipids, are more or less satisfactory. The results (**Table 3**) show a high content of vitamin C, which helps maintain the immune system, and vitamin E in the fresh pulp (25 mg and 13 mg respectively), compared with the other components. Vitamin E content in oilcake was 21 mg, 8 mg higher than in fresh pulp. This increase in vitamin E in oilcake could probably be attributed to the deshydration of the seeds for grinding and oil extraction.

In **Table 4**, the nutritional density of composite flour porridges for the 6 - 12 months age group, we note a variation in values of 5% - 30% insertion, with only copper and *β*-carotene remaining constant in the face of different insertion rates, with a value of 25 mg for copper and 0 µg for *β*-carotene. The criticism levelled at pumpkin is the very high viscosity of its porridge for children in the age range (6 - 9 months), its decrease being inversely proportional to the increase in the insertion rate from oilcake flour to pumpkin pulp flour, from14 seconds at 5% insertion, 13 seconds at 10% insertion, 12 seconds at 15% insertion, 11seconds at 20% insertion, 9 seconds at 25% insertion and 8 seconds at 30% insertion. And the low energy density is less than that of mother's milk (70 Kcal/100 ml). For it is at this age that the child can develop the ability to chew food [24]. The advantage of porridges during the weaning period is their liquid or semi-liquid state [24] [25]. **Table 5** shows the micronutrient composition of porridges. According to these results, the nutritional value of weaning porridges in micronutrients varies from 107 kcal at 5% insertion to 135 Kcal at 30% insertion for the energy value. At 5% insertion, this value of 107 Kcal is close to the recommended value (110 kcal/100 g) of porridge [26]; from 5.1 g at 5% insertion to 10 g at 30% insertion for protein. These values are below the recommended values (15.35 to 36.46 g/100 dry matter MS) [26]. However, with an increase in the insertion rate to 35%, this value can probably exceed those of recommended flours and even commercial flours [26]. According to FAO/WHO [21], the fiber content of infant flours should not exceed 5 g per 100 g of dry matter. Our results comply with the standard, ranging from 2.3 to 2.0 (**Table 5**), which reduces the saturation of the porridge and facilitates proper digestion. **Table 6** gives the results of the mineral composition of the slurries. The results show that the mineral composition of the pumpkin slurries shows a high content of phosphorus, which is one of the main nutrients required for plant growth and development, ranging from 36 mg at 5% insertion to 53 mg at 30% insertion. It is followed by calcium, which is involved in the bone mineralisation process, with a content varying from 25 mg at 5% insertion to 48 mg at 30%; from 3.5 mg at 5% insertion to 3.8 mg at 30% insertion for iron; from 0.2 mg at 5% - 30% insertion for copper and from 0.7 mg at 5% insertion to 0.8 mg at 30% insertion for zinc, which is involved in brain growth, its immunity to reduce the incidence that diarrhea can cause in children. This variation would certainly be linked to the cell structure and/or processing technique used to extract the oils from its seeds [27] [22]. The vitamin content of weaning porridges is shown in **Table 7**. These values show a very high *β*-carotene content at 5% insertion, *i.e.* 484 µg, then a sawtooth decrease from 10% to 60% insertion. For the other vitamins (**Table 7**), their content increases from the lowest to the highest with the same rates from 5% to 60% insertion. The highest vitamin C content was obtained at 60% insertion (18 mg/100), which is higher than the value indicated by the Codex Alimentarius, which specifies a minimum vitamin C content of around 9.2 mg/100 DM in infant flours [28] [29]. The average values of the physicochemical characteristics of weaning flours and their slurries are shown in **Table 8**. As a result, the degree of swelling of weaning flours varies in relation to the standard from 3.95% at 5% insertion to 3.58 at 30% insertion. Flour solubility increases in proportion to the degree of cake insertion. It varies in relation to the standard (100) from 80 at 5% insertion to 95 at 30% insertion. The flour obtained tends towards basicity (**Table 8**), because after extraction of the seed oils, the remaining traces of oil give it this acidity. In this case, acidity increases, as does titratable acidity. Thus, these values could be considered satisfactory, in that they are close to the values reported by many authors [30]. A slight difference in pH and titratable acidity was observed between the different samples (**Table 8**). The density values obtained are proportional to the rates of increase in the degree of cake insertion, which is in line with recommended standards. The moisture content of the slurries was inversely proportional to their dry matter content, ranging from 77.4% to 78.5%, compared with 75% - 80% for the standard. The tasting protocol for pure pumpkin flour and hybrid flours with 5%, 10%, 15%, 20%, 25% and 30% insertion, as well as the slurries, was carried out on July 10, 2023. In the first phase, the flours were evaluated sensorially. In the second phase, they were then prepared into infant porridges and submitted to a panel of 30 tasters. The results are shown in **Table 9**. Texture is the most decisive factor in product acceptability. Values vary from 5% to 30% of the insertion rate. At 30%, texture is at 9.

5. Conclusion

This present work allowed us to evaluate macro contents, micronutrient contents, mineral composition, vitamins, and formulated infant flour based on squash pulp enriched with oil cakes of extraction of oil from its seeds. The nutritional density of composite flour porridges for the 6 - 12-month age group, composition in micronutrients, mineral elements, vitamins, physico-chemical parameters, followed by a porridge tasting protocol were determined. The results of this analysis show that the flour formulated in this study meets WHO recommendations. The flour contains lipids, proteins, carbohydrates and minerals. It will be necessary to raise awareness among the population in order to promote and introduce this compound flour in infant nutrition.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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