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ORIGINAL ARTICLE

Elaboration and characterization of a food supplement with babassu mesocarp flour

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Abstract

Food supplements commonly present nutritional quality, especially in plant-origin foods, contributing to the population's quality of life. The use of babassu mesocarp flour in the preparation of food supplements contributes to human nutrition as it is a nutritionally balanced food concerning carbohydrates, proteins, lipids, and minerals. Babassu fruits were collected in five municipalities in the state of Maranhão/Brazil, and the mesocarp was extracted to develop four food supplement formulations per municipality. Firstly, babassu mesocarp flour was prepared in a drying and sterilization process and, subsequently, the manufacturing process of the babassu coconut flour food supplement was added with natural soy extract. The samples were subjected to proximate composition analysis to determine the percentages of carbohydrates, lipids, proteins, moisture, lignin, and energy values (kcal/100 g). The study presented a product rich in carbohydrates (86%), protein values above 10% in the composition, and an average of 19% lipids, presenting a nutritional balance suitable for daily use by the population and even high-performance athletes.

Keywords: Nutrition; Babassu; Soy; Farinaceous; Food; Carbohydrate.

Highlights

- A food supplement prepared with babassu mesocarp flour added with natural soy extract has an adequate nutritional balance
- The food supplement has a high energetic value
- The use of soy extract enriched the product with vegetable protein

1 Introduction

Food supplements are not medicines and, therefore, cannot be used to treat, prevent or cure diseases. Supplements are intended for healthy people, aiming to provide nutrients, bioactive substances, enzymes or

probiotics in addition to food (Brasil, 2020). The use of natural supplements prepared through food may be a healthy alternative to contribute to quality of life.

The nutritional quality of foods of plant origin can be assessed by their main attributes, notably their acidity, soluble solids, sugar content, volatile compounds, protein content, lipids, and vitamins, among others (Chitarra & Chitarra, 1990). People have used food supplementation because the majority's routine not allow enough time to prepare their food (Santana et al., 2018).

Babassu is a palm tree in which its fruit (coconut) is made up of four parts: epicarp, mesocarp, endocarp and almonds. Babassu mesocarp is made up of 3.5% crude protein, 9.4% crude fiber, 55.4% neutral detergent fiber, 19.8% acid detergent fiber, 10.8% cellulose, and this mesocarp comprises a gross energy of 4354 kcal/kg (Reis, 2009) and contains 60% starch (Cruz, 2021), but its composition varies depending on the origin. Given this rich nutritional composition, the inclusion of mesocarp flour in the diet may represent a strategy to overcome possible nutritional deficiencies in the population (Cinelli et al., 2014).

Beyond to the coconut kernel, the mesocarp attracts great interest in the babassu product chain and involves a large number of workers in Maranhão, with strong social inclusion. According to Porro (2021), almost 30% of the Brazilian production of vegetable extractives came from the babassu fruit, reaching around 82 thousand coconut breakers in 63 thousand Brazilian households.

The main product from coconut cracking is the almond, used mainly for oil production (Queiroga et al., 2015). The mesocarp, generally neglected, is processed and used as a food supplement for humans and animals due to its high starch content (Carneiro et al., 2009; Maniglia & Tapia-Blácido, 2016). Babassu mesocarp is highly energetic and contains anti-inflammatory, analgesic, and therapeutic properties (Silva et al., 2021; Moura et al., 2023). According to Debia et al. (2024), it could be noted that plant species are continually studied for their potential development of products with pharmaceutical properties due to their primary and secondary plant metabolites. Primary constituents such as fatty acids, carbohydrates and amino acids are crucial macromolecules that aid in the survival and structural development of plants. Meanwhile, secondary metabolites, derived from primary metabolism, play important roles in physiological processes and act as a defense mechanism against biological or chemical agents, such as polyphenols, capable of eliminating or neutralizing reactive species or radicals (Pott et al., 2019), which explains, at least in part, its antioxidant, anti-inflammatory and antimicrobial properties of babassu mesocarp.

Babassu mesocarp flour is rich in fiber, minerals, vitamins, and starch. Babassu mesocarp flour constitutes a food with interesting energy value to meet the nutritional needs of the population (Santana et al., 2008). Given this rich nutritional composition, the inclusion of mesocarp flour may represent a strategy to overcome possible nutritional deficiencies in the population (Silva, 2011), although there is no information about the quality of mesocarp-based products currently sold, nor the origin of the feedstock related to the different ecological conditions of the state of Maranhão.

Therefore, the present work aimed to develop a food supplement for humans using babassu flour from fruits collected in different regions of the state of Maranhão (Brazil) and evaluate its nutritional characteristics through proximate analysis, thus determining the most appropriate formulation in its composition. It is worth mentioning that the creation of the dietary supplement resulted in the filing of a patent with the National Institute of Industrial Property (Instituto Nacional de Propriedade Intelectual - INPI), which is a Brazilian agency responsible for registering and protecting brands and patents.

2 Material and methods

2.1 Collection of samples

The research was carried out with babassu coconut fruits collected from palm trees in five municipalities in the state of Maranhão/Brazil (Buritirana, Cantanhede, Coroatá, São Luís, and Viana), from October to November 2021, duly geo-referenced with GPS and Trex10 (Figure 1).

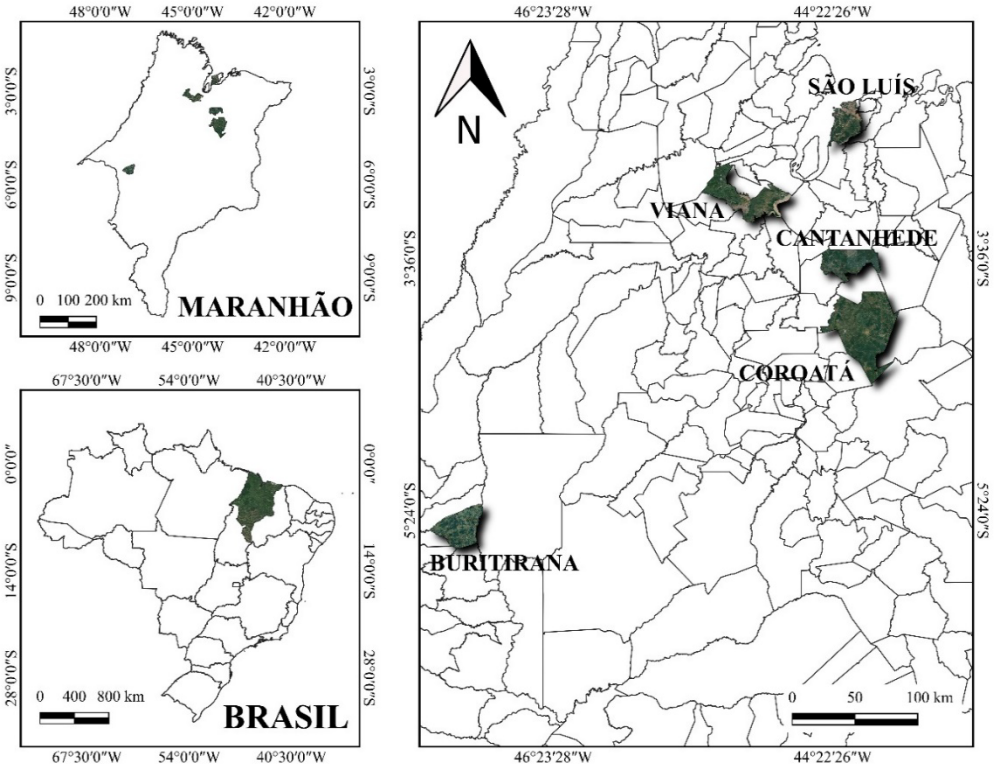

Figure 1. Location of five municipalities concerning babassu coconut collection, Maranhão, Brazil.

The collected fruits were placed in 60kg nylon bags, identified, stored for two days, and taken to the Association of Women Breaking Coconuts in Povoado Candiba, municipality of Cantanhede/MA, for extraction of the mesocarp and almonds (Figure 2). The extraction was carried out using mechanized equipment to "break" the coconut and divide its parts, which consists of a saw bench with a 2CV engine according to technology described by Sousa (2020).

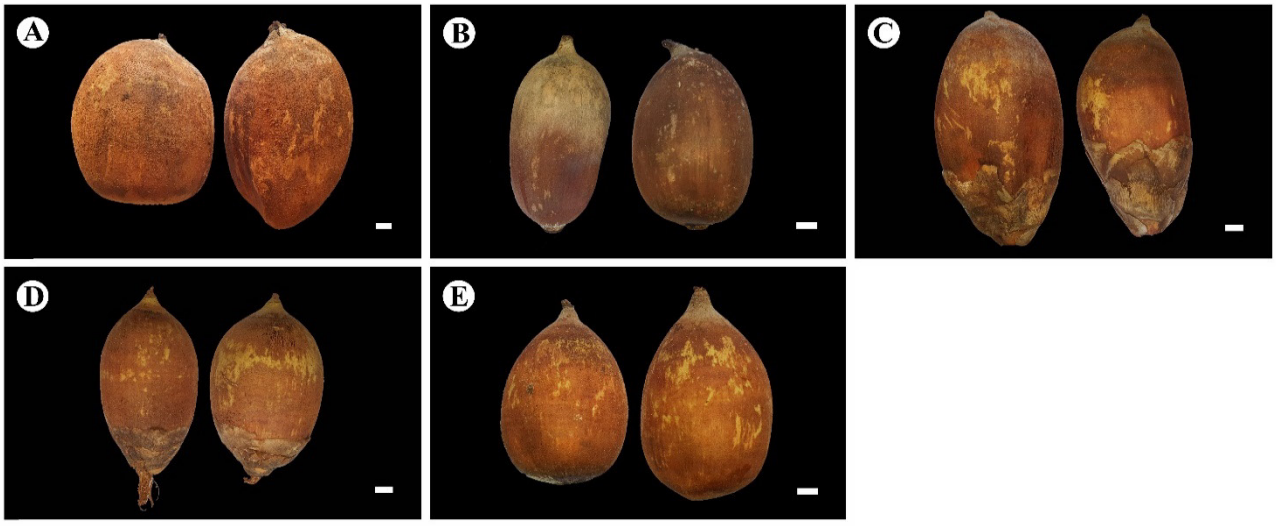

Figure 2. General aspects of the fruits collected in the municipalities of Buritirana (A), Cantanhede (B), Coroatá (C), São Luís (D) and Viana (E). Bar: 1 cm.

The extracted mesocarp was placed in a plastic bag identified by area/municipality, weighed, and stored in the Phytotechnics and Post-harvest Laboratory (LAPOC) at the State University of Maranhão, under controlled temperature conditions at 10 ºC (50 ºF).

The formulations of the babassu coconut mesocarp food supplement were developed at the agribusiness Biolife Produtos Naturais LTDA, located in Povoado Coquilho II in the city of São Luís-Maranhão (MA), Brazil.

2.2 Preparation of babassu mesocarp flour

The extracted mesocarp was sieved (on a 95 mesh screen) to remove the fibers and subsequently sieved (on a 120 mesh screen) to generate mesocarp flour powder. After this phase, the flour was dried in a refractory oven at a constant temperature of 175 ºC (347 ºF) for 10 minutes to remove moisture. It was then cooled in a controlled environment for the product to be ready for the preparation of the food supplement, according to the flowchart below (Figure 3).

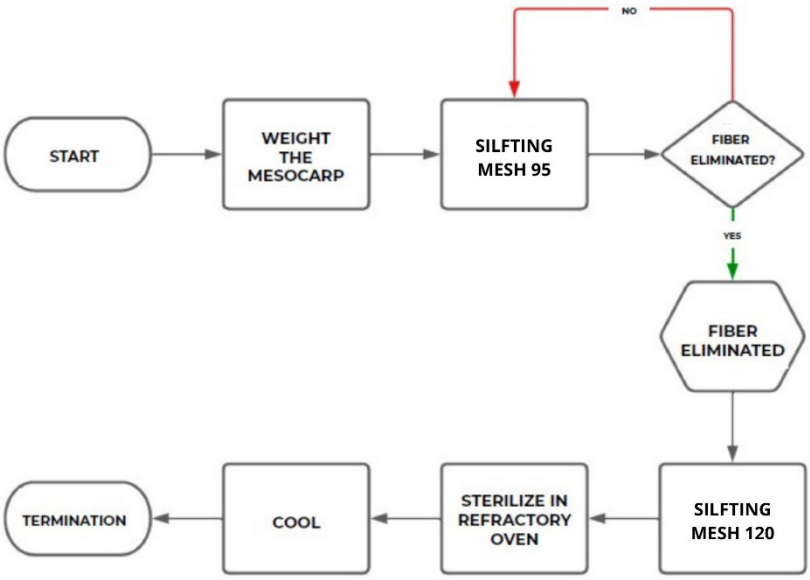

Figure 3. Flowchart of the extracted mesocarp preparation process

2.3 Food supplement mixing process

Four formulations have been developed to prepare the babassu coconut mesocarp flour food supplement for each municipality sampled, totaling 20 samples with six replications (Table 1).

Table 1. Formulations for preparing 100 g of the food supplement based on babassu coconut mesocarp flour.

Formulations	Babassu flour (g)	Natural soy extract (g)
90:10	90	10
80:20	80	20
70:30	70	30
60:40	60	40

The food supplement preparation process has begun by weighing the ingredients (babassu coconut mesocarp flour and natural soy extract) on a digital scale (Bel Engineering). The proportions were mixed with manual stirring and subsequently homogenized in an industrial stainless-steel blender (6 liters) for 10 seconds. At this

point, babassu oil was added as an emulsifier in the proportion of 10% of the weight of the mesocarp flour and weighed on a digital scale. The mixture was finished for another 10 seconds in the industrial blender. The final weighing of the product was carried out for packaging and storage at the Phytotechnics and Post-harvest Laboratory (LAPOC) at the State University of Maranhão, under room temperature conditions (Figure 4).

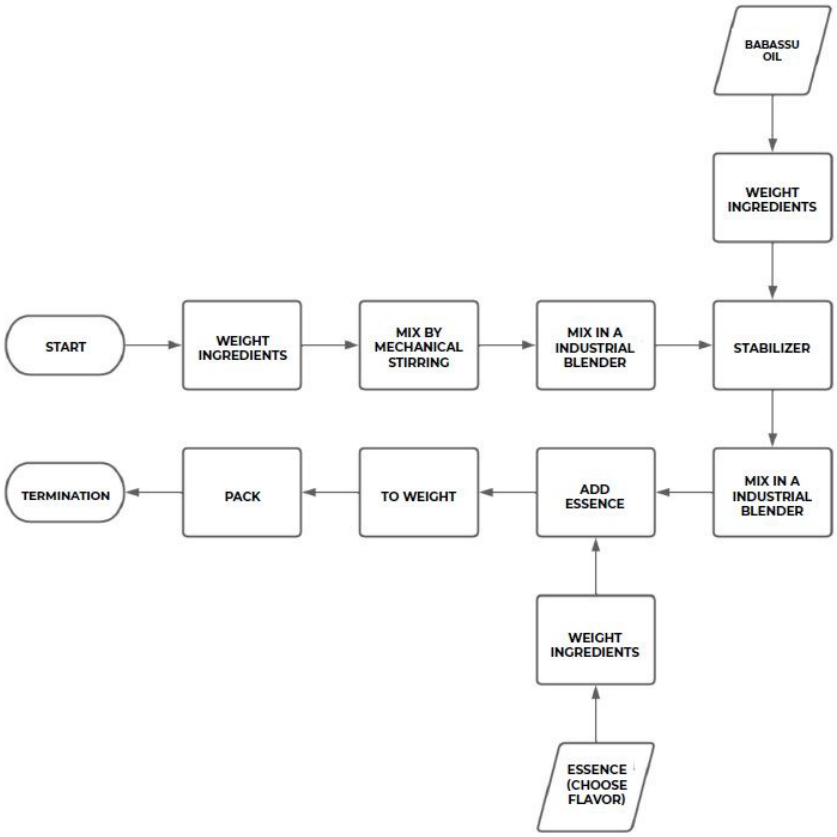

Figure 4. Flowchart of the babassu coconut mesocarp food supplement preparation process.

2.4 Proximate composition of babassu coconut flour food supplement samples

Physical and chemical analyzes were performed and conducted in triplicate by the Food and Beverage Laboratory of the Federal University of Maranhão and by the Bromatology Laboratory of the State University of Maranhão.

Ash analysis was carried out following the methodology described by the Association of Official Analytical Chemists (Association of Official Analytical Chemists, 1990). The fiber content through acid-digested lignin has been determined according to the methodology of Van Soest et al. (1991).

To determine the moistures, protein and carbohydrate content of the samples, the methodology of the Adolfo Lutz Institute (Instituto Adolfo Lutz, 1985) has been adopted. The fat or ether extract content has been determined by direct extraction in a Soxhlet apparatus according to the Adolfo Lutz Institute methodology (Instituto Adolfo Lutz, 2008).

The caloric value has been obtained by Equation 1.

$$\text{Calorific Value} = (\%\ \text{Carbohydrates} \times 4) + (\%\ \text{Lipids} \times 9) + (\%\ \text{Proteins} \times 4) \quad (1)$$

2.5 Statistical analysis

The food supplement regarding proximate composition results have been expressed as averages. The means have been compared using Tukey's test. The significance level adopted has been 5% probability using the ASISTAT 7.0 software.

3 Results and discussion

The food supplement obtaining process has resulted in a soluble product with a good appearance and aroma, due to the process of forming standardized mesocarp flour, maintaining a good particle size, as highlighted by Gomes et al. (2020). Particle size is an important aspect of flour standardization. The uniform size of the granules allows for better solvent absorption, particle dispersibility, and better extraction time for pectic substances. Table 2 presents the results of the simple proximate composition of pure babassu mesocarp flour concerning the collecting municipalities.

Table 2. Babassu coconut mesocarp flour proximate composition.

Cities	Parameters						
	Moisture	Total dietary fiber	Ashes	Proteins	Lipids	Carbohydrates	Energetic Value
	%						(kcal/100 g)
Coroatá	9.07	4.6	2.9	0.92	2.0	80.51	355.8
Buritirana	10.0	0.19	1.1	0.66	0.34	87.71	398.14
Cantanhede	14.82	5.0	3.26	0.41	5.41	71.1	329.73
São Luís	6.72	3.02	3.96	0.71	2.6	82.99	360.83
Viana	13.36	3.0	2.7	1.36	0.18	79.4	342.56

Babassu coconut mesocarp flour is predominantly composed of carbohydrates (Table 2). The babassu coconut mesocarp is the starchy part of the fruit which, according to Cruz & Nunes (2011), can have an average starch composition of 50% to 68%. However, there was a variation in carbohydrate content between municipalities and, in particular, the municipality of Buritirana presented the highest percentage of carbohydrates (87.71%) consisting of light-colored flour that contains a lot of starch. It is also noteworthy the highest average value of proteins (1.36%) found in the municipality of Viana and lipids (5.41%) in Cantanhede.

The results regarding the proximate characterization of the food supplement formulation by municipality are presented in Table 3.

All formulations have demonstrated a predominance of carbohydrates, with values ranging from 60.6% to 86%, thus demonstrating that it is a food with high energy content. The mixture of mesocarp flour from Buritirana obtained the highest carbohydrate values (Table 3).

The results obtained in the analysis of the formulations demonstrated that the composition of the food supplement based on babassu mesocarp complied with RDC nº 263/2005 (Agência Nacional de Vigilância Sanitária - ANVISA), whose flours must have a maximum humidity of 15%, which favors greater preservation and shelf life of the food (Vaclavik et al., 2014).

In the study carried out by Oliveira (2019), in which babassu mesocarp flour was characterized with around 86% of total carbohydrates, the formulations presented percentages of carbohydrates similar to or higher than the levels found in wheat flour (47 to 70%) (Oliveira et al., 2014), cassava (49 to 82%) (Menegassi & Leonel, 2006) and rice flour (76%) (Franco et al., 2018).

The inclusion of natural soy extract provided an increase in proteins in the formulations. The 60:40 (BMF:SS) formulations from the municipalities of Buritirana, Cantanhede and Viana had protein levels above 10% in their composition (Table 3). In a study by Kissell & Yamazaki (1975), it has found that the use of protein flour, as a soy extract, makes the food more nutritionally balanced. In studies with proximate analysis of breads enriched with soy extracts, a protein percentage of 10 to 15% was observed in their composition, in addition to the presence of other nutrients such as fiber and lipids (Meneses et al., 2020).

Table 3. The food supplement proximate composition based on a mixture of babassu coconut mesocarp flour (BMF) and natural soy extract (SS).

Cities	Proportion (BMF:SS)	Parameters						
		Moisture	Total dietary fiber	Ashes	Proteins	Lipids	Carbohydrates	Energetic Value
		%						(kcal/100 g)
Coroatá	60:40	8.54^{aC}	6.64^{aA}	3.73^{aB}	10.60^{aA}	20.65^{bA}	71.61^{abB}	421.12^{cA}
	70:30	8.53^{aD}	5.18^{abA}	3.07^{bB}	8.09^{abA}	30.81^{aA}	62.87^{bC}	446.44^{bAB}
	80:20	8.16^{bC}	5.97^{aA}	2.84^{bB}	7.88^{abA}	19.03^{bB}	75.97^{aAB}	458.83^{aA}
	90:10	8.35_{abC}	3.29^{bB}	2.57^{bB}	5.98^{bAB}	32.16^{aAB}	65.60^{abAB}	443.30^{bA}
Buritirana	60:40	9.17^{dB}	0.19^{aD}	2.91^{aC}	11.09^{aA}	12.64^{bB}	80.34^{abAB}	407.16^{aB}
	70:30	9.52^{cC}	1.03^{aB}	2.39^{bC}	8.59^{abA}	11.65^{bD}	84.93^{abA}	400.12^{bD}
	80:20	9.89^{bB}	1.85^{aB}	1.90^{bcC}	7.10^{bcA}	10.79^{bC}	86.39^{aA}	382.85^{cE}
	90:10	10.33^{aB}	0.74^{aC}	1.50^{cC}	5.32^{cAB}	26.42^{aBC}	74.12^{bAB}	386.04^{cB}
Cantanhede	60:40	10.16^{bA}	5.64^{abAB}	4.43^{aA}	13.37^{aA}	7.61^{cB}	82.58^{aAB}	397.73^{cC}
	70:30	10.15^{bB}	3.58^{bA}	3.14^{bB}	8.07^{bA}	27.74^{bAB}	65.63^{bBC}	439.66^{aB}
	80:20	9.85^{cB}	3.96^{abAB}	3.06^{bB}	5.96^{bcA}	11.17^{cC}	77.01^{aAB}	419.39^{bC}
	90:10	10.52^{aB}	6.18^{aA}	2.92^{bAB}	5.14^{cB}	33.94^{aA}	62.73^{bB}	438.29^{aA}
São Luís	60:40	7.59^{bD}	3.02^{aC}	4.01^{aAB}	10.81^{aA}	13.10^{bB}	78.64^{aAB}	423.10^{cA}
	70:30	7.55^{bE}	4.05^{aA}	3.88^{aA}	8.57^{bA}	22.35^{aBC}	60.66^{bC}	447.17^{abA}
	80:20	8.25^{aC}	2.72^{aB}	3.67^{abA}	7.67^{bcA}	20.14^{aAB}	73.02^{aB}	448.85^{aB}
	90:10	8.36^{aC}	1.83^{aBC}	3.34^{bA}	5.66^{cAB}	21.02^{aCD}	73.42^{aAB}	441.63^{bA}
Viana	60:40	10.39^{dA}	3.78^{abBC}	3.51^{aB}	12.01^{aA}	10.52^{cB}	83.67^{aA}	413.59^{bB}
	70:30	10.82^{cA}	3.44^{bAB}	2.85^{bBC}	8.59^{bA}	18.08^{bCD}	76.24^{abAB}	423.30^{aC}
	80:20	12.88^{bA}	5.72^{aA}	2.58^{bB}	6.50^{bA}	26.43^{aA}	69.34^{bB}	393.88^{cD}
	90:10	13.42^{aA}	5.76^{aA}	2.66^{bB}	6.82^{bA}	17.82^{bD}	76.93^{abA}	367.51^{dC}

*Means followed by the same lowercase letters in the row and uppercase letters in the column do not differ from each other by the Tukey test at 5% probability.

Ash contents are related to the amount of inorganic compounds in the sample. The formulations of the food supplement analyzed present levels of 1% to 4%, indicating that babassu mesocarp flour may have an abundance of minerals such as calcium, phosphorus, potassium, magnesium, copper, iron, chlorine and manganese (Oliveira, 2019).

The babassu oil addition to the composition of the food supplement favored an increase in lipid levels in the formulations (ranging from 7 to 33%); lipid concentrations were expressed in pupunha palm flour (7.19%) in studies by Oliveira et al. (2020), while dende flour had a low lipid content (0.91%) (Simas et al., 2010).

Concerning the fiber content present in the supplement, the municipalities of Coroatá and Cantanhede presented the highest levels, from 3 to 6% in the composition, while the municipality of Buritirana presented the lowest fiber contents in the formulations. Due to the maturity of the babassu fruit, the “older” the greater the amount of lignin in the structure of the cell wall, such as the lignin content in the fibers of coconut fruits (*Cocos nucifera* L.) which varies depending on age, rotating between 20% in young coconut fibers and approximately 35% in mature fruit (Passos, 2005). Lignin harms the human digestion of Fe, aggravating iron deficiency anemia, very common in children from regions of the Northeast, being a determining factor for attendance at Brazilian institutional programs such as the National School Feeding Program (Programa Nacional de Alimentação Escolar – PNAE) (Fioroto, 2013).

Nutritional balance is the relationship between the three main classes of nutrients: carbohydrates, lipids, and proteins. In a normal diet, there should be around 60% carbohydrates, 15% proteins, and 25% of fats (Rocha et al., 2014), observing approximate values presented in all formulations in a proportion of 60:40.

High-performance athletes need a small increase in protein consumption (Lima & Santana, 2014). And the consumption of carbohydrates by these athletes is linked to muscle glycogen deposits, used during physical exercise (Lima-Silva et al., 2007). Carbohydrates and lipids are important for energy metabolism while proteins are important for construction metabolism. The daily energy need depends on the person's gender, age, and size (Silva & Garcês, 2020).

In general, the municipalities presented similar averages to those recommended in the nutritional balance of a normal diet at the formulations of the food supplement based on babassu mesocarp. However, there was no determining factor for the selection of raw material for the preparation of the food supplement.

4 Conclusion

The babassu mesocarp flour food supplement presented a viable technological manufacturing process due to the ease of obtaining raw materials and available technology. The richness of carbohydrates in the mesocarp stands out, that is, ranging from 76% to 97%. The formulations developed expressed predominant results of carbohydrates in their composition (60 to 86%), an increase in protein content with the addition of soybean extract and the mineral fraction with values within the averages of other vegetable products. The municipality of Buritirana presented the product with the highest starch content in the food and all formulations, regardless of the region, presented nutritional contents within the recommended daily parameters. The 60:40 (FMB:SS) formulation is recommended as it presents the best nutritional balance of a normal diet.

Acknowledgements

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