American Journal of Food Science and Technology, 2025, Vol. 13, No. 4, 93-99
Available online at http://pubs.sciepub.com/ajfst/13/4/2
Published by Science and Education Publishing
DOI:10.12691/ajfst-13-4-2

Physicochemical, Microbiological, and Organoleptic Characterization of a Nutritional Recovery Flour Formulated and Produced in Benin

Guevara Nonviho[1], Gamèli Justin Gandeho[2,*], Moufidath Arikè El Hadj Abd Razak[1], Maïco Camara[2], Mégnonhou Noumonvi[3], Bernadin Jean Robert Klotoe[1], Amoussatou Sakirigui[4]

[1]Multidisciplinary Research Laboratory for Technical Education (LARPET), National University of Science, Technology, Engineering, and Mathematics (UNSTIM), Abomey, Benin
[2]Unit for Food Engineering Processes, Equipment and Technology Incubation (UPEGA-IT) of the Food Science and Technology Laboratory (LaSTA) at the Faculty of Agricultural Sciences of the University of Abomey-Calavi (FSA-UAC) 01BP: 526 Cotonou Benin
[3]Laboratory of Animal and Fisheries Sciences (LaSAH), Aquaculture and Fisheries Management Research Unit (URAGeP), National University of Agriculture (UNA), PO Box: 43 Kétou
[4]Kaba Research Laboratory in Chemistry and Applications (LaKReCA), University of Technical Sciences, Engineering and Mathematics (UNSTIM), PO Box 266 Natitingou, Republic of Benin.
*Corresponding Author: gamelijusting@gmail.com

Received July 04, 2025; Revised August 06, 2025; Accepted August 13, 2025

Abstract Malnutrition remains a public health issue in several countries around the world. The objective of this study was to formulate a porridge flour from locally available ingredients to promote nutritional recovery in malnourished children and elderly people. After determining an appropriate formula, the recovery flour was produced and its physicochemical, nutritional, microbiological, and organoleptic parameters were analyzed. It should be noted that MANIBA flour (corn-cowpea-baobab) was produced in 5 hours and 20 minutes from a formulation composed of 76.3% corn, 8.5% cowpea, 8.5% baobab pulp, and 6.8% sugar, with a production yield of 84%. Physicochemical and nutritional analyses revealed that 100 g of flour contains calcium (95.08 ± 0.13 mg), magnesium (204.05 ± 0.45 mg), iron (0.15 ± 0.00 mg), and zinc (0.11 ± 0.01 mg). In terms of nutritional substances, it contains protein (10.08 ± 0.21%), lipids (4.27 ± 0.24%), carbohydrates (70.27 ± 0.52%) and has an energy value of 648.76 ± 1.93 kcal/100 g. Microbiologically, MANIBA flour complies with the standards of the *Codex Alimentarius* Commission. After sensory evaluation, MANIBA flour and its porridge were generally more appreciated and better accepted by consumers than other flours of the same category available on the Beninese market. These characteristics of MANIBA flour show that it can be validly included in the nutritional recovery diet of target populations.

Keywords: *Nutritional recovery, Infant flour, Energy value, Nutrition, Formulation*

Cite This Article: Guevara Nonviho, Gamèli Justin Gandeho, Moufidath Arikè El Hadj Abd Razak, Maïco Camara, Mégnonhou Noumonvi, Bernadin Jean Robert Klotoe, and Amoussatou Sakirigui, "Physicochemical, Microbiological, and Organoleptic Characterization of a Nutritional Recovery Flour Formulated and Produced in Benin." *American Journal of Food Science and Technology*, vol. 13, no. 4 (2025): 93-99. doi: 10.12691/ajfst-13-4-2.

1. Introduction

In underdeveloped countries, a large number of children do not receive adequate nutrition during early childhood [1]. According to UNICEF statistics, malnutrition or emaciation is the leading cause of mortality and morbidity. It accounts for 45% of deaths among children under the age of 5 each year [2]. The elderly are not spared from the harmful effects of malnutrition. As their bodies become more fragile with age, a specific diet should accompany the stability of their health. Among other solutions, the World Health Organization (WHO) recommends exclusive breastfeeding of newborns until the age of six months as an excellent way to combat infant malnutrition. After six months, liquid foods such as infant cereal porridge, fruit juices, and purées are recommended [3]. During weaning, a sufficiently varied diet (solid, semi-solid, and soft foods from a variety of whole foods) should be introduced at frequent meals to meet the child's nutritional needs as a supplement and gradual replacement for breastfeeding. In Benin, scientists have proposed food formulations to address the problem of malnutrition. Examples include the formulation of infant cereal based on fonio and local ingredients by Syka et al., [4]; the formulation and commercial production of infant flours by state structures such as the Beninese Food Technology Unit (UBETA) and private structures such as the Oasis Children's Center. These local solutions do not seem to meet the expectations of international institutions in terms of eradicating malnutrition in the country [5]. The choice of foods for nutritional recovery is a real problem due to the lack of variability in the agri-

food production on offer. People are resorting to food preparations and products of dubious origin, which is leading to a deterioration in their health.

However, Benin's agricultural sectors offer a diversity of crops that present real opportunities for investors, particularly in the agri-food industry. Benin produces up to 132,500 tons of cowpeas and 1,580,750 tons of corn per year [6]. Corn is a cereal that generally provides the energy necessary for the body to function thanks to its high carbohydrate content. Cowpeas are a readily available legume, rich in the proteins needed for the growth and renewal of our tissue cells (cell construction and repair). Cowpeas also contain certain micronutrients (iron, magnesium, and vitamins) [7]. Despite these agricultural achievements, malnutrition still persists among different segments of the Beninese population. According to the United Nations [8], the results of the Multiple Indicator Cluster Survey (MICS) revealed that in 2014, more than one in three children in Benin suffered from stunted growth, known as chronic malnutrition. Although this trend appears to have improved slightly over the years, the latest report from INSTaD (National Institute of Statistics and Demography) states that from 2021 to 2022, more than 45% of infant mortality is due to malnutrition in various forms [8]. Children living in rural areas are more affected by stunted growth (35%) than those living in urban areas (25%).

Improving the nutrition of infants, young children, and the elderly is clearly a priority. To achieve this, particular attention must be paid to the nutrition of these vulnerable segments of society through the development of varied and balanced foods. The present study set out to formulate a porridge flour called “MANIBA” from local ingredients (corn, cowpea, and baobab) for the nutritional recovery of children and the elderly.

Specifically, the aim was to (i) formulate MANBA nutritional recovery flour; (ii) evaluate the technological performance of MANIBA flour production; and (iii) characterize this flour in terms of its physicochemical, microbiological, and organoleptic properties.

2. Materials and Methods

2.1. Study Materials

- Plant material and ingredients (Figure 1): These included white corn and red cowpeas, supplied by the food crop storage services of the International Institute of Tropical Agriculture (IITA-Benin), pulp collected from baobab fruits purchased from field collectors, and sugar purchased from supermarkets.
- The production equipment included: basins, sieves, pots, a mill, buckets, water, dishcloths, a ladle, a trash can, a dryer, packaging, and a scale. These items were available at the Food Science and Technology Laboratory (LaSTA) of the Faculty of Agricultural Sciences at the University of Abomey-Calavi (FSA-UAC).
- The laboratory equipment consisted of standard equipment for physical, chemical, microbiological, and sensory analysis.



Figure 1. Plant material used in the study: white corn (a), red cowpea (b), baobab pulp (c)

2.2. Methods

2.2.1. Formulation and Production of Flour

■ Theoretical formulation of MANIBA flour

Formulas were developed to achieve the best quality. For this work, the 2019 version of the West African Food Composition Table, FAO [9] was used to determine the nutritional composition of the ingredients used and to theoretically estimate their nutrient content, Solver software was used to create different combinations of raw materials, taking into account the following matrices: the price of each raw material; the macronutrient composition of the raw materials (protein, fat, and energy); the recommended macronutrient content per 100g of infant flour according to the *Codex Alimentarius* (Table 1).

Table 1. Recommended macronutrient and mineral content per 100g of infant flour

Nutriments	Values	Minerals	Values
Energy	400 kcal	Calcium	500 mg
Protein	15 g	Magnesium	76 mg
Lipids	10-25 g	Iron	16 mg
Fibers	< 5	Zinc	3,2 µg

Source: CODEX CAC/GL08.1991 18. [10]; µg = microgram

■ Theoretical composition of the formulated flour

Table 2 shows the theoretical nutritional value of the flour obtained based on the nutrient composition of the ingredients used in the formulation.

Table 2. Theoretical nutrient composition of MANIBA flour (100 g of DM)

Ingredients	Proportions (%)	Energy (kcal/ 100g)	Protein (g)	Fat (g)
White corn	76,3	350	9,5	3,7
cowpeas	8,5	336	22,3	1,2
Baobab pulp	8,5	127	2,68	0,52
Sugar	6,7	27,2	-	-
Total	100	840,2	34,48	2,03
standard	------	400	15	10 à 25

MS=dry matter; Kcal=kilocalories

■ Application of infant flour formulas

Table 3. Proportions of ingredients for different formulated infant flours

Food groups	Ingredients	Proportions	Final quantity formulation
Cereals	White corn	76,3%	3815g
Legume	cowpeas	8,5%	425g
fruit	Baobab powder	8,5%	425g
Flavor enhancer	Sugar	6,8%	340g

Table 3 shows the proportions of each raw material used in the composition of the formulated infant flour.

2.2.2. Technological Processing of Ingredients Used in the Formulation

■ Unit operations and production yield of formulated infant flour

Depending on the raw material concerned, various unit operations were carried out in chronological order, culminating in grinding. The production process diagram (Figure 2) summarizes the operations performed to produce the formulated flour. During production, critical points such as the selection and sorting of raw materials and ingredients, temperature and time control during heat treatments, and the selection of sterile packaging were necessary to prevent contamination of the flour at the end of production. The various unit operations resulted in final quantities of ingredients that were lower than the initial quantities. The production yield is determined by the following formula (1):

$$\textbf{Productionyield} = \frac{\textbf{finalquantityofingredients}}{\textbf{Initialquantityofingredients}} x100 \quad (1)$$

Production was carried out three times, and each of the flours obtained was used as a sample for microbiological, physicochemical, nutritional, and organoleptic analyses. Each sample was analyzed three times.

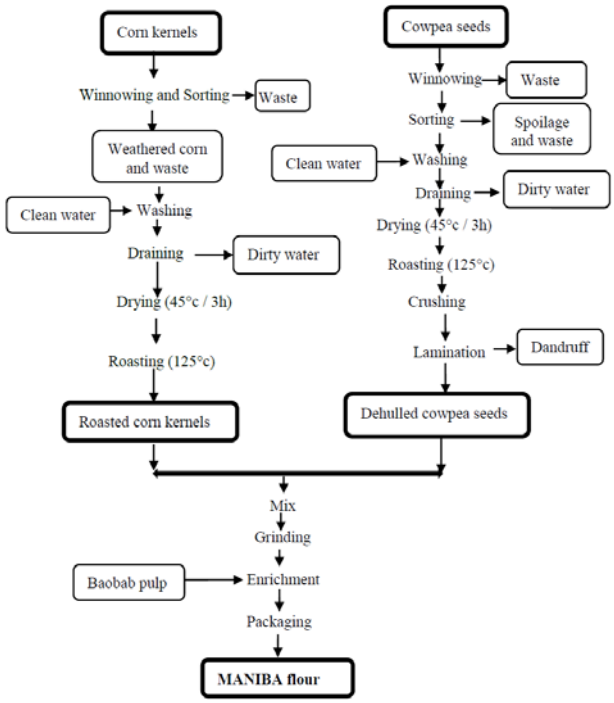


Figure 2. Technological diagram of MANIBA flour production

2.2.3. Evaluation of Nutritional and Physicochemical Parameters

The protein content is determined using the Kjeldahl method, the reference method [11]. The lipid, carbohydrate, and ash content of the formulated flour was determined using the appropriate methods described by AOAC-2000, [12]. To determine the fiber content of the infant flour produced, the chemical reagent treatment method was used according to the protocol described by Tchekessi, [13] for the determination of crude fiber. The energy value (EV) of the samples was calculated using Atwater's specific coefficients for protein, lipids, and carbohydrates. It was expressed in KJ/g, calculated and converted according to the following formula (2):

EB (KJ/g) = 23.65 × (% protein / 100) + 40 × (% lipid / 100) + 16.8 × (% carbohydrate / 100) (2)

EB = gross energy

The microelements (iron, calcium, magnesium, zinc) were measured by atomic absorption spectrophotometry. The samples submitted for analysis were reduced to powder. The powder was incinerated in an oven at 550°C for 24 hours. The resulting ash was dissolved in water, in 2 ml of HCL (6N), which was evaporated on a hot plate at 125°C. The more or less viscous residue obtained was dissolved again in a flask containing 100 ml of a 0.1 mol/l molar concentration HNO3 solution. The solution obtained was used to measure the metals by atomic absorption spectrophotometry. The dry matter (DM) content of the various samples of infant formula was determined using the AOAC method [12].

The pH and titratable acidity were determined using the AACC 14.022 method adopted by Tchekessi, [13].

2.2.4. Microbiological Analyses

Four samples of infant formula were analyzed under the conditions described in Table 4. The bacteria counted were total mesophilic aerobic bacteria (TMAB) according to ISO 4833, [14], in order to assess the level of contamination of the product by microorganisms. Yeasts and molds were counted according to standard NF V 08-059: 2002, adopted by Nonviho et al., [15] to assess the effectiveness of heat treatments that may or may not have been applied to raw materials and intermediate products during production. Enterobacteria were tested in accordance with standard NF V 08-059: 2002 in order to determine whether hygiene conditions had been respected during the production of infant formula.

Table 4. Culture media and incubation conditions

Milieux de culture	Microorganismes of interest	Incubation temperature (C°)	incubation time (h)
PCA	GAMT	30	48
SABC	Yeasts and molds	25	72
VRBG	Enterobacteriaceae	37	24

2.2.5. Sensory Analysis

The sensory evaluation was carried out by a panel of 40 tasters selected at random using hedonic testing methods. This allowed the panel members to assess the organoleptic quality of the porridges prepared from infant flours formulated according to the following parameters: taste, texture, color, smell, aroma, and consistency. They rated the porridges on a seven-point scale ranging from “extremely inferior” to “extremely superior.” They also assigned an overall preference score from 1 to 9 to the porridges prepared from MANIBA flour and an authorized reference flour available on the market. Composed of a diverse group of 40 randomly selected individuals of both sexes. Each panel taster was presented with two identical bowls, labeled MANIBA and control. Each bowl contained an equal amount of

porridge corresponding to the label. Participants were asked to rate each porridge using the following scale: 1 = extremely inferior, 2 = very inferior, 3 = moderately inferior, 4 = slightly inferior, 5 = identical to the reference sample, 6 = slightly better, 7 = moderately better, 8 = better, and 9 = extremely better. At the same time, based on each of the criteria mentioned above, the taster chose the best porridge according to their preferences, without assigning a score.

2.2.6. Statistical Analysis of Data

The Solver function in Excel was used to determine the quantity of ingredients used. Microsoft Excel 2013 was used to calculate the results of the laboratory analyses of the physical and chemical parameters. Color, taste, smell, consistency, and aroma were scored according to the following ratings. The means and standard deviations were calculated using Excel to determine whether there were significant differences in the average degree of appreciation between the samples. The level of significance was set at 5% ($p<0.05$) using SAS Version 9.2 software and the Student Newman-Keuls test for comparing means.

3. Results and Discussion

3.1. Technological Aspects and Yield of MANIBA Flour Production

Figure 2 shows the physical appearance of MANIBA flour, which was formulated, produced, and packaged in 200 g bags. For 5 kg of ingredients (details of which are given in Table 5), 4.2 kg of MANIBA recovery flour was produced, representing a yield of 84%. The production cycle for flour based on this cereal was approximately 6 hours.

After formulation, it was found that the production of MANIBA flour required unit operations. All of these unit operations have a production cycle of approximately six (6) hours. This cycle is short and could allow for rapid intervention in emergencies to correct acute malnutrition, especially in children. The production yield obtained (84%) is relatively low compared to the 90% yield obtained by Sika et al., [4], who produced infant flour formulated from fonio, corn, owpea, supplemented with cow's milk, baobab pulp, and other local ingredients. This difference could be explained by the fact that during sorting, a significant amount of waste, such as damaged seeds that constitute antinutritional factors, is discarded and has not been compensated for by the addition of baobab pulp alone.



Figure 3. Physical appearance of MANIBA nutritional recovery flour

Table 5. Quantity of ingredients before and after each unit operation

Ingredients	Unit operations	Operations time (minutes)	Initiale quantity (g)	Final quantity (g)	Yield (%)
Maize and cowpea	Sorting	30	4240 of which (corn 3815) and (cowpea 425)	3493,78 (corn 3179.03 and (cowpea 318.75)	81,25 of which (corn 83.33) et cowpea 75)
	Washing	15			
	Draining	45			
	Drying	180			
	Roasting	20			
Cowpea	Crushing/screening	20			
Maize and cowpea	Grinding	5			
Baobab pulp	Screening	5	425	403,75	95
Total		320 or 5 h 20 min	4665	3897,75	84

%= percentage; min= minutes*; h = hours*

3.2. Nutritional and Physicochemical Characteristics of MANIBA Flour

Table 6 shows the average macronutrient and trace element content of MANIBA flour. Based on the analysis of this table, it appears that the flour is sufficiently rich in macronutrients (proteins, lipids, and calories) and minerals (calcium, magnesium, iron, and zinc) to cover the recommended nutritional intake for an individual.

The physicochemical characteristics of the flours produced revealed a high dry matter content (90.49 ± 0.26%). For children, this type of porridge is a source of energy that can promote weight gain. Indeed, the higher the dry matter content, the thicker and more energy-rich the porridge. The incorporation of cowpea and corn into the formula resulted in an energy density of 648.76 ± 1.93 kcal/100 g. These results are consistent with those of Elenga et al., [16], who showed that incorporating malt and calcium carbonate into fermented corn and peanuts made it possible to prepare porridges with a recommended consistency of 120 mm/30 s for a dry matter content of 20%. According to these authors, this porridge, intended for infants and young children, has an energy value of 400 kcal/100 g, as recommended by the CAC standard [7]. Furthermore, the consumption of foods that are sources of vegetable protein, such as cowpeas and certain legumes, should be encouraged as they are readily available and inexpensive. In addition, the fortification of cereals with cowpeas has increased the protein content of MANIBA flour to 10.08 ± 0.21/100g. These results are consistent with those of Solomon [17] and Onilude [18], who found in their studies that the protein content of combined cereals and legumes is better than that produced from cereals alone. The lipid content of MANIBA infant formula is 4.27 ± 0.24/100 g. This content is below the Codex Alimentarius standard, which is 10 to 25 g/100 g. This could be explained not only by the fact that the ingredients used are low in lipids but also by the absence of a lipid source such as peanuts in the formula. These results are consistent with those obtained by Kayode et al. [18], who showed that porridge made from sorghum, soybeans, and fretin had the highest lipid content (5.4%) compared to porridge made from sorghum, cowpeas, and peanuts (0.85%). With regard to minerals and trace elements, the calcium and iron content of MANIBA flour is below the Codex Alimentarius standard. This could be related to the composition of the ingredients and raw materials used. Indeed, the source of minerals used was baobab pulp. The mineral content of this ingredient, as determined by Aïda [20], (2 mg of iron, 1 mg of magnesium, 2,310 mg of calcium, and 10 mg of zinc in 100 g of pulp), is still too low to fully meet the recommended daily intake. The slight deficiencies in Ca, Fe, and Zn in MANIBA flour could be compensated for by other carefully selected foods to accompany the porridge prepared from this flour.

Table 6. Nutritional and physicochemical composition of MANIBA flour

PARAMETERS PHYSICO-CHIMICAL			NUTRITIONAL PARAMETERS		
Parameters	Values	RAD	Parameters	Values	RAD
Dry matter (%)	90.49 ± 0.26	-	Energiy (kcal/100g)	648.76 ± 1.93	400 kcal/100g*
pH	4.19 ± 0.04	-	Crude Fiber (%)	3.70 ± 0.28	-
Titrable Acidity (%)	2.64 ± 0.02	-	Ash (%)	2.17 ± 0.05	-
Proten (%)	10.08 ± 0.21	15g/100g*	Calcium (mg /100g)	95.08 ± 0.13	121
Fat (%)	4.27 ± 0.24	10-25g/100g*	Magnesium (mg/100g)	204.05 ± 0.45	23
Carbohydrate (%)	70.27 ± 0.52	-	Iron (mg /100g)	0.15 ± 0.00	9
Water Activity	-	-	Zinc (mg /100g)	0.11 ± 0.01	4-9

RDA = Recommended Daily Allowance; kcal = kilocalories; g = gram: * = Codex Alimentarius Commission standards

3.3. Microbiological characteristics

Table 7 shows the microbiological characteristics of MANIBA flour formulations. Analysis of this table reveals that MANIBA flour is of satisfactory microbiological quality, as the contamination levels of mesophilic aerobic bacteria (MAB), enterobacteria at 37ºC, yeasts, and molds remain below the regulatory limit set by the *Codex Alimentarius* Commission.

Table 7. Comparison of the microbiological characteristics of formulated infant flour

Parameters analyzed	Results (UFC/g)	N. (CAC) [10]
Mesophilic aerobic Germs (MAG)	$1{,}02\ 10^2$	$<10^5$
Enterobacteroceae at 37ºC	$1{,}0\ 10^1$	$< 10^2$
Yeast	$1{,}9\ 10^1$	$< 10^3$
Moid	$2{,}3\ 10^1$	$< 10^3$

N. (CAC)= Codex Alimentarius Commission Standard

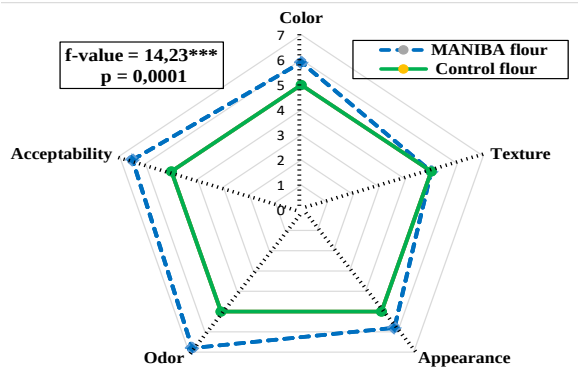
Microbiological analyses show that there is no significant contamination of MANIBA flour compared to CAC [10] standards, considering the microbiological parameters GAMT, enterobacteria, yeasts, and molds. This shows that the flour was produced in accordance with good hygiene and manufacturing practices.

3.4. Sensory Characteristics of MANIBA Flour Compared to a Control Product

Figure 4 and Figure 5 show the sensory profile of the MANIBA recovery flour formulated and produced (Figure 4), as well as that of its porridge (Figure 5). These profiles are obtained by comparing the average scores assigned to each organoleptic parameter at the 5% threshold. Analysis of the sensory evaluation results revealed that MANIBA flour was generally better accepted by the sensory evaluation panel than the control flour purchased on the market. In particular, all sensory parameters, namely color, appearance, and odor, were significantly more appreciated for MANIBA flour than for the control flour purchased on the market, at the 5% threshold ($p<0.05$). However, consumers reported that the flours (MANIBA and control) had the same texture (Figure 4).

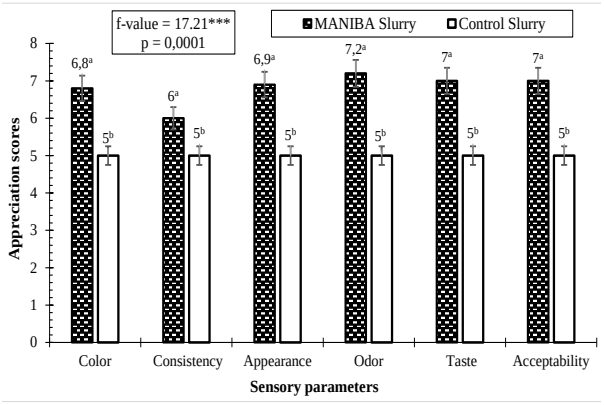
Furthermore, according to the observations made by the tasters, the porridge made with MANIBA flour was

significantly more appreciated at the 5% threshold ($p<0.05$) due to its sensory characteristics (color, texture, appearance, smell, and taste) and was more accepted than the porridge made with the control flour at the 5% threshold (Figure 5).



***=highly significant difference; p=probability

Figure 4. Organoleptic profile of MANIBA flour and the control flour purchased on the market



Averages with different letters are significantly different at the 5% threshold ($p\leq0.0001$); ***=highly significant difference; p=probability

Figure 5. Organoleptic profile of porridge made with MANIBA flour and the control flour purchased on the market

The results of the sensory analysis revealed that porridge made from MANIBA flour is of better organoleptic quality and has significantly higher acceptance than the control flour purchased from the market. MANIBA flour can therefore be included in the diets of both children and the elderly.

4. Conclusion

At the end of this study, it should be noted that "MANIBA" porridge flour is formulated and produced from corn, cowpea, and baobab pulp with a yield of 84%.This flour is of good nutritional, physicochemical, and microbiological quality. Porridge made from MANIBA flour is highly appreciated by consumers and can be included in the nutritional recovery diet of children and the elderly.

ACKNOWLEDGEMENTS

The authors would like to thank the Multidisciplinary Research Laboratory for Technical Education (LARPET) of the National University of Science, Technology, Engineering, and Mathematics (UNSTIM) for its support in carrying out this research work.

Conflict of Interest

This study does not present any conflicts of interest

References

[1] UNICEF Bénin, La malnutrition, un facteur de risque de mortalité et de morbidité chez l'enfant, Fiche de Plaidoyer, 2020. 11p https//www.unicef.org.

[2] Adrien Noel, Fanny B. Morel, Rachel Marion-Letellier, La malnutrition aiguë sévère : de la physiopathologie à la prise en charge, *Nutrition Clinique et Métabolisme*, 38 (1): 2-10. March 2024.

[3] Kouassi KAAA. Adouko AE. Gnahe DA. Grodji GA. Kouakou BD. Gnakri D, « Comparaison des caractéristiques nutritionnelles et rhéologiques des bouillies infantiles préparées par les techniques de germination et de fermentation », *International Journal of Biological and Chemical Sciences*, 9(2): 944-953. Juillet 2015.

[4] Sika Andrée Emmanuelle, Beugré Romuald Léonce Kadji, Koffi Martin Dje, Fankroma Thierry Martial Kone, Soumaïla Dabonne, Amenan Rose Koffi-Nevry; «Qualité nutritionnelle, microbiologique et organoleptique de farines composées à base de maïs (*Zea mays*) et de safou (*Dacryodes edulis*) produites en Côte d'Ivoire », *Int. J. Biol. Chem. Sci. 13(1): 325-337*2019. Mai *2019.*

[5] DSA / MAEP, Rapport de Performances du Secteur Agricole, 2020; Série de culture DEP (Evolution de la production du niébé au Bénin); Archives électronique d'information; *Ministère de l'Agriculture de l'Elevage et de la Pêche du Bénin*; 2020. 144p. https://api.sitetest.agriculture.gouv.bj/media/63ce97ee5fb31_11_Rapport%20de%20performance%20du%20secteur%20agricole_gestion%202020.pdf.

[6] Belete Kuraz Abebe, Mulugeta Tesfaye Alemayehu, A review of the nutritional use of cowpea (Vigna unguiculata L. Walp) for human and animal diets, *Journal of Agriculture and Food Research*, 10. 100383. December 2022.

[7] Nations Unis, Mobilisation du Gouvernement et ses partenaires contre la malnutrition chronique Les 1000 premiers jours de vie : les défis de la malnutrition chronique au Bénin; https://benin.un.org/fr; 13 juin 2015.

[8] Institut National de la Statistique et de la Démographie (INStaD), Rapport de l'analyse de l'enquête MICS Bénin 2021-2022, 3023 515p. https://instad.bj/actualites/530-rapport-de-l-analyse-de-l-enquete-mics-benin-2021-2022.

[9] FAO, FAO/INFOODS Food Composition Table for Western Africa (2019) User Guide & Condensed Food Composition Table; Rome, 2020; 556p: Last update: 20-10-2022 05:26. https://www.fao.org/infoods/infoods/tables-et-bases-de-donnees/bases-de-donnees-faoinfoods-sur-la-composition-des-aliments/fr/.

[10] CAC (Commission Codex Alimentarius), Lignes directrices pour la mise au point des préparations alimentaires complémentaires destinées aux nourrissons du deuxième âge et aux enfants en bas âge, CAC/GL08-1991.Adoptée en 1991, Révisée en 2013, https://referentiel.actia-asso.eu/site/referentiels.php.

[11] Gbogouri Grodji Albarin, Mandoué Stephanie Bamba, Dogoré Yolande Digbeu, Kouakou Brou, « Elaboration d'une Farine infantile composée à base d'ingrédients locaux de Côte d'Ivoire : quelles stratégies d'enrichissement en acides gras polyinsaturés oméga 3 », *Int. J. Biol. Chem. Sci*. 13(1): 63-7. Mai *2019*.

[12] AOAC, Official Methods of Analysis. 15th Edition, Association of Official Analytical Chemist, *Washington DC*, 1990. https://archive.org/details/gov.law.aoac.methods.1.1990.

[13] Tchekessi, C.K., Bokossa, A., Agbangla, C., Azokpota, P., Daube, G., Scippo, M.L., Korsak, N., Angelov, A. and Bokossa, Y.I, « Production and Microbiological Evaluation of Three Types of "Dèguè", a Local Fermented Drink Made from Milk in Benin », *International Journal of Multidisciplinary and Current Research*, 2, 714-720. November 2014.

[14] ISO 4833-1, Microbiologie de la chaîne alimentaire : Méthode horizontale pour le dénombrement des micro-organismes Partie 1: Comptage des colonies à 30 °C par la technique d'ensemencement en profondeur, 2013, 9p .https:// www.iso.org/ fr/standard/53728.html.

[15] Nonviho Guevara, Assou Sidohoundé, Justin G. Gandeho, Agathe M. E. Assogba, Papin S. Montcho, Jean-Marc Gnonlonfoun, and Celestin C.K. Tchekessi, « Bio-preservation of atan, a wine extracted from palm trees in Benin, using orange peelings », *International Journal of Innovation and Applied Studies*, 43. 1089-1096. Octobre 2024.

[16] Elenga Michel., Massamba Joachim., Silou Thomas, «Effet de l'incorporation de malt sur la fluidité et la densité énergétique des bouillies de maïs-arachide destinées aux nourrissons et aux jeunes enfants», *Journal of Applied Biosciences*, 55. 3995– 4005. Juillet 2012.

[17] Solomon M, « Nutritive value of three potential complementary goods based on cereals and legumes », *Agriculture Nutritive*, 5(2). 1-14. March 2005.

[18] Onilude AA, « Microbiological and chemical changes during production of malted and fermented Cereal- legume weaning foods », Advances in Food Sciences, 31(3):139-145. 2009. URL: .https:// content.e-bookshelf.de/ media/reading/ L-806870-0f3f357cba.pdf.

[19] Kayode Femi, Obielodan Omotayo, Ogunduyile Sunday, « Relationship between the Use of Language on Billboard Advertisements and Consumers' Urge to Purchase Products in Lagos State, Nigeria », *International Review of Developing Societies*, 1(3).April 2012.

[20] Aïda Gabar Diop, Mama Sakho, Manuel Dornier et Mady Cissé« Le baobab africain (Adansonia digitata L.): principales caractéristiques et tilisations », Fruits, vol. 61, no 1, janvier 2006, p. 55–69.

© The Author(s) 2025. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0/).