Journal of Food Research; Vol. 9, No. 1; 2020
ISSN 1927-0887 E-ISSN 1927-0895
Published by Canadian Center of Science and Education

Corn Flour Formulation and Fortification Tests: Evaluation of Acceptability of Local Derived Product Called "Kabato" *Case of Napalakaha, Nibolikaha and Tiangakaha of Region of Korhogo*

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Received: October 3, 2019 Accepted: October 28, 2019 Online Published: January 7, 2020

doi:10.5539/jfr.v9n1p41 URL: https://doi.org/10.5539/jfr.v9n1p41

Abstract

The good use of food is one of the fundamental points of the food security of the populations especially in the developing countries. Therefore, for convincing results, the methods of strengthening nutritional knowledge by improving the culinary practices of vulnerable populations must take into account the dietary habits of the targets.

The objective of the present study was to contribute to the consumption of the project crops to develop food formulations. In practice, eight (8) cornmeal formulas using soybeans and orange-fleshed sweet potatoes have been proposed and submitted to the grantees. The different proportions of ingredient to be mixed were obtained by the Pearson's Square method. Analysis of the sensory evaluation data was possible to the Statistical Package for Social Sciences (SPSS) software version 21 and the different results were presented in the form of radar graphs.

The results showed that simultaneously flours and "kabato" accepted by the populations of the study area were formulations of:

- E: 72.26 percent of maize flour and 27.74 percent of sweet potato flour

- F: 53.76 percent of corn flour and 46.24 percent of sweet potato flour

- G: 89.3 percent of composite flour (maize and sweet potato) and 10.7 percent of soya flour

- H: 78.09 percent of composite flour (maize and sweet potato) and 21.91 percent of soya flour

So, it can be envisaged to implement a strategy for a better vulgarization of these methods.

Keywords: corn, orange-fleshed sweet potato, Pearson's Square, Sensory analysis, soy

1. Introduction

Healthy eating is a fundamental component of overall health as it reduces the risk of chronic nutrition-related illness (Santé Canada, 2013). However, according to FAO estimates in 2018, Africa remains the continent most affected by the prevalence of undernourishment, with nearly 21% of the population or more than 56 million people (Food and Agriculture Organization of the United Nations [FAO], The International Fund for Agricultural Development [IFAD], World Health Organization [WHO], World Food Program [WFP] & United Nations Children's Fund [UNICEF], 2018).

In Côte d'Ivoire, nearly 12.6% of rural households are food insecure, ie 1.2 million people, 232,602 of whom are reported to be severely food insecure. Moreover, the results of this same study show that several regions of the country, particularly the North, have a level of global acute malnutrition exceeding the 5% threshold (FAO, 2010).

All these elements justify a contribution to food security in the northern regions of Côte d'Ivoire. To this end, food supplementation would be a palliative to nutritional problems recurring in developing countries. However, the choice of foods offered to the target group must take into account several criteria, one of the most important of which is acceptance (Lateur, Planchon & Moons, 2001)

Thus, this current work, with the objective of helping the consumption of crops of nutritional interest (soybean, sweet potato with orange flesh) of the project has proposed formulations based on corn flour. The study consisted specifically to:

- Elaborate soy flour and sweet potato with orange flesh;

- Determine using Pearson's square the different proportions to be mixed;

- Evaluate the acceptability of flours and “kabato” by the beneficiaries.

2. Materials and Methods

2.1 Materials

The formulations used in this study consist of yellow corn powder, orange-fleshed sweet potato flour and / or soy flour. These flours were obtained from field raw materials (sweet potato tubers and soya beans) and households from villages concerned (yellow corn flour).

2.2 Flour Making

The details for this section have been summarized in the diagrams below:

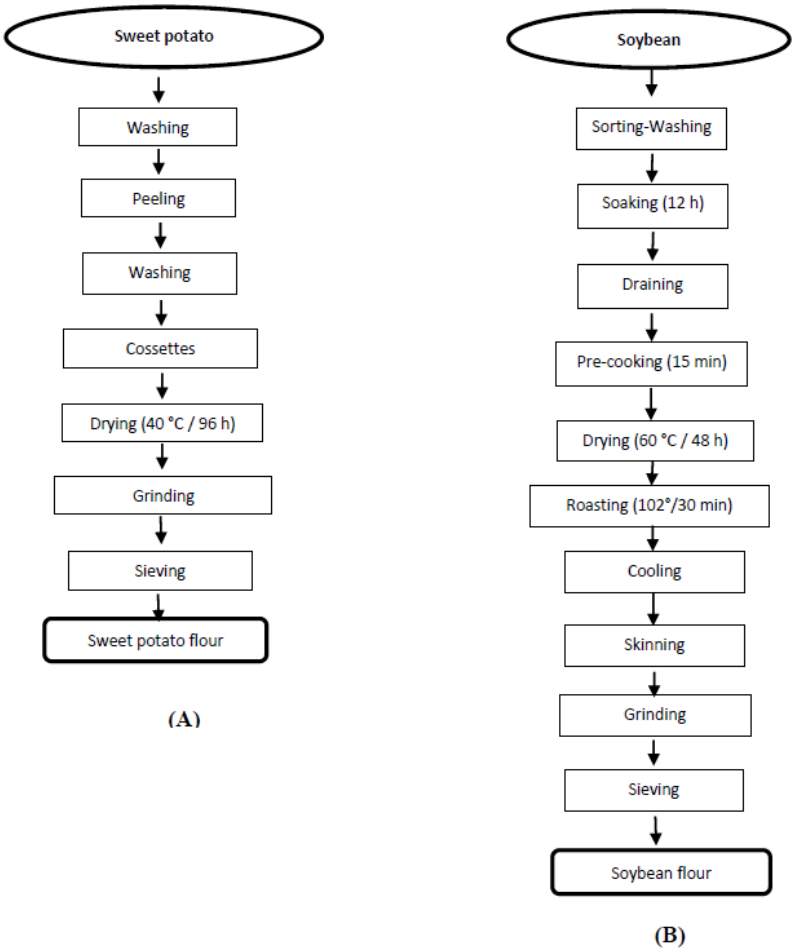

Figure 1. Flour production diagram from sweet (A) potato and soybean (B)

2.3 Preparation of Formulations

Eight (8) formulations were made using the Pearson's Square method (Figure 2). This method was used to determine the quantities of corn powder, soybean and orange-fleshed sweet potato flour to be mixed (Table 1) (Lee, 2009).

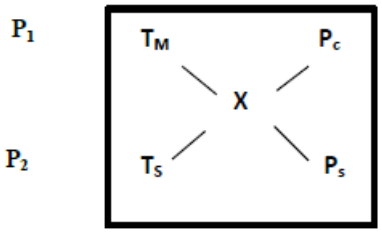

Figure 2. Representation of Pearson's Square

X: is the nutritional need in protein or provitamin A to be satisfied in this study

TM and **TS / TP**: represent protein or provitamin A levels of corn and soybean / sweet potato to meet the protein or provitamin A requirement

P_C: is the part of corn in the mixture; it is the difference between TS / TP and X without taking into account the sign

Ps: is the proportion of soya or sweet potato in the mixture; it is the difference between TM and X without taking into account the sign.

The proportion of Maize **P_1** (%) is determined as follows:

$$P_1 = \frac{P_c}{P_c + P_s} \times 100$$

The proportion of soybean or sweet potato **P_2** (%) is determined as follows:

$$P_2 = \frac{P_s}{P_c + P_s} \times 100$$

Table 1. Different proportions of the mixture

Formulations	T_M (%)	T_S (%)	$T_{P30+M70}$	$T_{Mixture}$	T_P (µg/100 g)	X (%)	P_C	P_s	P1 (g/100g of the mixture)	P2 (g/100g of the mixture)
A	4.61	21.94		5.95		6	15.94	1.39	91.98	8.02
B	4.61	21.94		7.08		8	13.94	3.39	80.44	19.56
C	4.61	21.94		12.82		12	9.94	7.39	57.36	42.64
E	0			14.37	54.07	15	39.07	15	72.26	27.74
F	0			22.53	54.07	25	29.07	25	53.76	46.24
G		21.94	4.091	12.03		6	15.94	1.91	89.3	10.7
H		21.94	4.091	11.41		8	13.94	3.91	78.09	21.91
I		21.94	4.091	7.87		12	9.94	7.91	55.69	44.31

Note

Corn and soy formulations

A: 91.98 % of maize flour and 8.02 % of soy flour; B: 80.44 % of maize flour and 19.56 % of soy flour; C: 57.36 % of maize flour and 42.64 % of soy flour.

Corn and sweet potato formulations

E: 72.26 % of maize flour and 27.74 % of sweet potato flour, F: 53.76 % of corn flour and 46.24 % of sweet potato flour.

Corn, sweet potato and soy formulations

G: 89.3 % of composite flour (maize and sweet potato) and 10.7 % of soya flour, H: 78.09 % of composite flour

(maize and sweet potato) and 21.91 % of soya flour, I: 55.69 % of composite flour (maize and sweet potato) and 44.31 % of soya flour.

$T_{Mixture}$ which is protein or beta carotene content of the mixture.

$T_{P30+M70}$ which is protein content of the mixture of corn (70 percent) and sweet potato (30 percent).

2.4 Sensory Evaluation

These tests were carried out according to the modified method of MEITE and collaborators (Meite, Kouame, Coulibaly, & Offoumou 2008). In practice, they were carried out on samples coded by letters (flours, kaboto) after an interview in local language with the panelists on the meaning descriptors. The hedonic test was performed on flours with thirty naive panelists. During the evaluation, flours were presented simultaneously and randomly to each panelist who was to give the degree of appreciation of the color and smell of the flours.

The descriptive test was used for the assessment of kabato. It consisted of giving each trained taster (twenty) monadically sequential according to a rating criterion ranging from 1 to 10. The various criteria were related to color, odor, taste and consistency.

However, a control sample (maize flour and derived kabato) was introduced to better assess the panelist's ability to assess.

2.5 Data Analysis

The collected data was captured using the Census and Survey Processing System (CSPro) 7.0 software and exported to the Statistical Package for Social Sciences (SPSS) version 21 software for calculation of average scores and tabulation. The tables were then exported to the Excel MS for making radar graphs.

3. Results

3.1 Hedonic Test

The hedonic test was carried out on formulated flours. The results obtained are summarized in the following tables 2 and figure 3 (i, ii, iii, iv). It's showed that the panelists of all the localities gave scores higher than 2 to the different formulations. However, formulations with scores below 2 are I (1.8 for both sensory attributes), B (1.6 for odor), F (1.7 for color) in Napalakaha, and C, I formulations (1.9 for color) in Nibolikaha.

Table 2. Hedonic test of the formulated flours

Flours	Napalakaha		Nibolikaha		Tiangakaha		All the localities	
	Color	**Odour**	**Color**	**Odour**	**Color**	**Odour**	**Color**	**Odour**
A	2,4	2	2,9	2,7	2,8	2,9	2,7	2,5
B	2,2	1,6	2,9	2,9	2,9	2,8	2,7	2,4
C	2,1	2,9	1,9	2,2	2,4	2,2	2,1	2,4
D	2,6	2,6	3	2,9	2,9	2,9	2,8	2,8
E	2	2,7	2,8	2,8	2,9	2,9	2,6	2,8
F	1,7	2,3	2,6	2,7	2,8	2,7	2,4	2,6
G	2	2,2	2,6	2,7	2,4	2,3	2,3	2,4
H	2,4	2,3	2,5	2,8	2,6	2,8	2,5	2,6
I	1,8	1,8	1,9	2,2	2,3	2,2	2,0	2,1

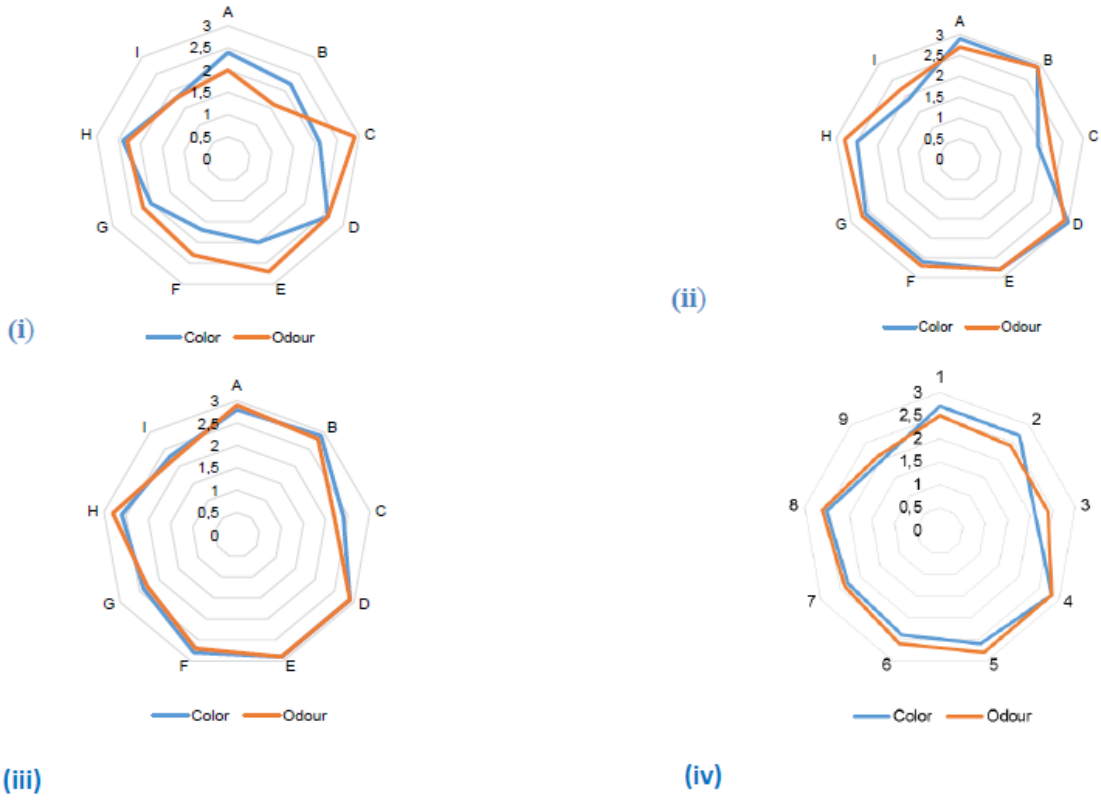

Figure 3. Average value of sensory attributes for (i) Napalakaha, (ii) Nibolikaha, (iii) Tiangakaha, (iv) all localities

3.2 Descriptive Test

The descriptive test was carried out on the kabato resulting from the different formulations.

The results obtained are summarized in the following table 3 and figure 4 (a, b, c, d).

The analysis showed that for all localities, 3/8 kabato in particular A, B and C received ratings of less than 5 for all sensory attributes (color, smell, taste and consistency). However, in Tiangakaha all kabatos evaluated by the panelists obtained an average between 5.77 and 7.4**.**

Table 3. Average sensory attributes by kabato type

Kabato	Napalakaha				Nibolikaha				Tiangakaha				All the localities			
	Co	**O**	**T**	**Cn**	**Co**	**O**	**T**	**Cn**	**Co**	**O**	**T**	**Cn**	**Co**	**O**	**T**	**Cn**
A	4,2	3,5	3,0	4,5	5,1	4,7	4,1	3,3	5,4	5,5	6,1	6,6,	4,9	4,6	4,4	4,8
B	3,1	3,8	3,4	4,6	5,4	4,8	5	4,2	6,3	5,8	6,9	5,3	4,9	4,8	5,1	4,7
C	4,4	4,2	4,2	5	5,2	6,1	6	6,3	5,2	5	5,2	5,7	4,9	5,1	5,1	5,7
D	4,2	4,7	5,2	4,7	5,6	5	4,5	5,2	6,4	6,2	7,4	7,5	5,4	5,3	5,7	5,8
E	5,4	5,5	6,4	7,8	7,3	7,1	7,7	7,4	6,6	7	8,6	7	6,4	6,5	7,6	7,4
F	4,6	5,9	6,1	6,5	7,4	6	6,7	6,8	6,5	7,5	8,5	7,1	6,2	6,5	7,1	6,8
G	5,2	4,7	6,2	5,9	6,5	7	7,5	7,4	5,4	6,2	7	6,8	5,7	6,0	6,9	6,7
H	5,4	5	5,9	6,1	6,3	7,3	7,3	7	5,9	5,5	8	6,6	5,9	5,9	7,1	6,6
I	5,1	6,5	6,8	7,1	6,4	6,4	7,5	6,7	4	5,7	6,6	6,8	5,2	6,2	7,0	6,9

Note. Co: Color, O: Odor, T: Taste, Cn: Consistency

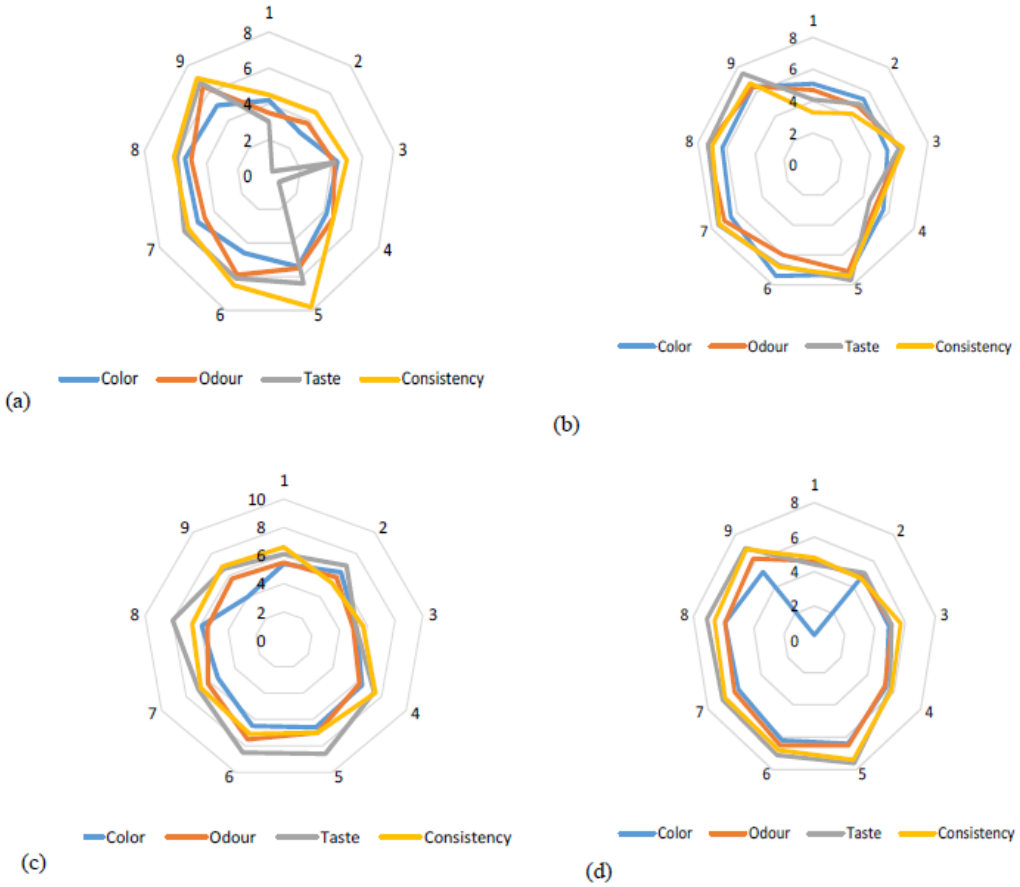

Figure 4. Average value of sensory attributes for (a) Napalakaha, (b) Nibolikaha, (c) Tiangakaha, (d) all localities

4. Discussion

This study was carried out with the aim of improving the protein content (6%, 8%, 12%) and adding value to the maize flour used in the study area, including beta carotene (15%, 25%). Thus, three types of formulations were developed, namely corn-based formulations containing soy (A, B, C), corn-based formulations containing sweet potatoes with orange flesh (E, F) and those containing both soy and sweet potato (G, H, I). Formulations A, B, C with soy incorporation levels of 8.02%, 19.56% and 42.64%, respectively, improved corn protein content from 4.61% to 5.95% for A, 7.08% for B and 12.82% for C. These rates are satisfactory for a Recommended Dietary Nutrient Intake of 0.83 g/kg/day (Agence Française de Sécurité Sanitaire des Aliments [AFSSA], 2007). In addition, according to Endres and collaborators. (Endres, Welch, Ashraf, Banz, & Gower, 2000); the soy proteins are of good quality because of their biological value similar to those of animal proteins. As a result, the addition of soybeans to corn flour would be beneficial to rural communities. Indeed, the value of a protein is justified by the quality of the amino acids which constitute it and their bioavailability (that is to say the proportion of amino acids which after digestion and absorption becomes accessible to the metabolic phenomena) (Agence Nationale de sécurité sanitaire, alimentation, Environnement et travail [ANSES], 2016). As a result, the essential amino acids specifically lysine would be higher in soybean than in many other plant sources. In addition, regular consumption of soy products would reduce the risk of prostate cancer; breast cancer; kidney disease and heart disease. This beneficial effect would be possible by bioactive compounds such as isoflavones that act as estrogens, antioxidants and / or enzyme regulators (Hubert, 2006). Formulations E and F, by adding 27.74 percent and 46.24 percent of orange-fleshed sweet potato flour, were obtained; 14.37 µg / 100 g (E) and 22.53 µg / 100 g (F) of beta carotene in a corn meal which was free of it. Formulations G, H, I were obtained by incorporation of 10.7 percent, 21.91 percent, 44.31 percent of soybeans into a composite flour (corn, sweet potato) containing 30% sweet potato flour. orange flesh. Thus, they contain simultaneously proteins and beta-carotene levels respectively of 5.27 percent, 6.58 percent and 8.89 percent (proteins) and 12.03 µg/100 g (G). 11.41 µg/100g (H), 9.87 µg/100 g (I) (béta-carotène). So these formulations may be important for vision,

growth, reproduction, resistance to bacterial or fungal infections (normal development of skin and mucous membranes) (Bulvestre, 2007). In addition to these properties, they would protect cells against oxidative stress and thus against chronic diseases such as cancer, cardiovascular diseases, osteoporosis and diabetes (De carbon, 2015). So, the proposed formulations would be of great interest to the populations of the North, particularly those in the Poro region, where the prevalence of vitamin A deficiency is estimated at 24%, with a higher rate in rural areas (28%) than in the middle urban area (20%) (Sangare, Koffi, Akamou. & Fall, 2009).

The organoleptic tests of this study were carried out in order to highlight through the choice of target populations the appropriate formulations for an extension. The radar diagrams obtained for the different sensory characters analyzed are presented in the different figures. The evaluation of sensory attributes of flours focused on color and odor. The score showed that the panelists from the three localities appreciated flours A, D, E, F, G, and H (Figure 7). However, the flours retained by locality are H, D for Napalakaha; D, E, F, G, B, A for Nibolikaha and A, B, D, E, F, G, H for Tiangakaha.

As for the test carried out on “kabatos”, the sensory attributes were essentially based on color, odor, taste and consistency. The radar analysis shows that the subjects of Napalakaha did not have homogeneous responses. However, three “kabatos” received at least a score of 5 for the 4 sensory attributes especially: E, H, I. Nibolikaha's panelists made their choice on the “kabatos” of the formulations E, C, F, G, H, I. However, samples enriched in soy (A, B) obtained the lowest average justified by the depreciation of taste, odor and consistency. This observation could be due to the method used for the preparation of the flour. Indeed, according to the work of Tshite and collaborators (Tshite, Mulamba, & Ndianabo, 2015); soybean meal obtained by the dry method as in this study would have a brown color and a very pronounced soy aroma. In addition, the poverty of polysaccharide soy flour could justify the depreciation of the consistency of kabatos that contain it. Indeed, according to the work of Kadji (Kadji, 2018) the richness of a polysaccharide meal would be at the origin of a high water absorption capacity. This characteristic would improve with the heat treatment giving this type of flour a better viscosity and therefore a satisfactory consistency. Finally, the analysis of Tiangakaha subjects' responses reveals that most formulations obtained a minimum score of 5/10 for all sensory attributes except the formulation I whose color received a rating of 4/10. This could be attributed to the high proportion of soybeans, 44, 31 percent in the mix. Indeed, the soybeans having been subjected to roasting, slightly brown colored flours were obtained. As a result, these flours in large quantities in the mix could affect the color of *kabato*. However, from their choice spring out formulations D, E, F. Thus, at the end of the descriptive test; the kabatos appreciated by all the localities are: E, F, G, and H, I (Figure. 11) with a maximum average of 6, 97 for the formulation E.

5. Conclusion

It should be noted that this study was carried out with the aim of proposing a maize flour of improved nutritional value which would be accepted by the population of the study area. Thus, the results show that eight formulations could be developed during this study, which are: Corn and soy formulations (A, B and C), Corn and sweet potato formulations (E and F), Corn, sweet potato and soy formulations (G, H and I).

The sensory evaluation of these formulations made it possible to highlight in each locality the formulation of good sensory quality. Thus, the following formulations were retained:

- Napalakaha: Flours H, D and *kabato* E, H and I

- Nibolikaha: flours D, E, F, G, B, A and *kabato* E, C, F, G, H and I

- Tiangakaha: flours A, B, D, E, F, G, H and *kabato* D, E and F

However, the selection criterion for this study is based on the degree of appreciation of the quality of flours and kabatos derived from them; the formulas selected for all the localities are:

- E: 72.26 percent of maize flour and 27.74 percent of sweet potato flour

- F: 53.76 percent of corn flour and 46.24 percent of sweet potato flour

- G: 89.3 percent of composite flour (maize and sweet potato) and 10.7 percent of soya flour

- H: 78.09 percent of composite flour (maize and sweet potato) and 21.91 percent of soya flour

So, it can be envisaged to implement a strategy for a better vulgarization of these methods.

Acknowledgments

This study is part of the project "Operational Strategy for Improving the Productivity of Nutrient Crops for Vulnerable Rural Populations in Côte d'Ivoire".

We would like to thank the ECOWAS Commission, the Spanish Cooperation (Agence Espagnole de Coopération Internationale pour le Développement: AECID) for their financial support in the context of the regional agricultural policy of the ECOWAS, ECOWAP / CAADP. We would also thank Helen Keller International for the financial and technical support in carrying out this study.

Conflict of Interest

The authors declare that there is no conflict of interest.

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