JFBE 6(2): 17-25, 2023

Journal of Food and Bioprocess Engineering

Journal homepage: https://jfabe.ut.ac.ir

Original research

Formulation trial of ready-to-use therapeutic foods and evaluation of their sensory properties: case of caterpillar-cassava-millet based cookies

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A B S T R A C T

The consumption of baked aerated wheat flour products has spread in developing countries. The aim of this research was to determine the proximate, iron content and sensory attributes of cookies produced from different composite flours (cassava, millet, caterpillar). Each raw material was processed separately into flours and these flours were mixed in different proportions. The proximate analysis (proteins, fats, ash, crude fibers, moisture, carbohydrates, energy and iron determination) and the acceptability test was performed as per the protocol described in the literature. Cookies were evaluated for their sensory characteristics by 30 semi-trained panelists made up of students of the Department of Biology, University of Kinshasa. To compare different treatments, Friedman test was used and data were processed using XLSTAT 2011. The findings showed that the protein, fat, ash, crude fiber, moisture, carbohydrate contents and the energy density of the cookies ranged from 2.85% to 740.69%, 23.03 to 27.57%, 0.25% to 0.65%, 20.39% to 23%, 5% to 7.13%, 9.54% to 18.43% and 408.15 to 415.17 kcal respectively. While the iron content ranged from 10mg to 14mg. For sensory attributes, there was no significant difference between different formulas. Consumers reported that these formulas were not golden (color), have a pleasant aroma (aroma), a good taste (taste), moderately sweet (sweetness), quite hard (crispiness) and not appealing (external appearance). The overall acceptability was moderately scored compared to the standards. Cookies produced improved nutrients contents and were acceptable to the assessors. There is a need of improving the sensory attributes of these cookies for future studies.

Keywords: Cookies; Composite flour; proximate analysis; Local products; Formulation

Received 20 Apr 2023; Revised 22 Sep 2023; Accepted 16 Nov 2023

1. Introduction

Nowadays, the consumption of bread and other baked aerated wheat flour products has spread in developing countries (Nwanekezi, 2013). Recently, the consumption of leavened and unleavened wheat flour products has increased tremendously in developing countries due to the increase of demography, urbanization and specifically in changing food habits (Nwanekezi, 2013; Bivan & Eke-Ejiofor, 2019). In this frame, the Food and Agriculture Organization (FAO) encouraged the use of composite flour and blends for the production of aerated products like bread, biscuit, cake, cookie, etc. (Ayoade et al., 2020). In fact, composite flours are blends of different cereals, legumes and tuber flours, rich in starch, protein and other nutrients integrated with or without wheat flour (Noor-Aziah and Komathi, 2009). Therefore, attempts are being made to explore the value-added application of by-products and a proposal is the production of flours to be added to bakery products, such as cookies (Egea et al., 2015). Generally, cookies are popular bakery products made of wheat flour of which formulations have high calories and low fiber content (Chauhan et al., 2015, Park et al., 2015). However, their low moisture content increases shelf life and makes them less susceptible to microbial spoilage (Guyih et al., 2020). Moreover, with consumers' increasing interest in living a healthy life, many researchers have studied health-promoting cookies by using

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https://doi.org/10.22059/JFABE.2023.357780.1142

components with functional properties to replace wheat flour (Egea et al., 2015). So, it should be noted that the use of flour blends from locally grown crops would not only reduce the high cost of importation of wheat but could also promote the use of some locally cultivated crops as flour and increases the nutritional content of food products as well a means of addressing the problem of food insecurity and malnutrition (Hasmadi et al., 2014; Bivan & Eke-Ejiofor, 2019; Eke-Ejiofor et al., 2023).

Famine and malnutrition are scourges that still persist in the 21st century (Webb et al., 2018). This situation affects some countries in the world and precisely in Sub-Saharan Africa (Onyango et al., 2019, Owolade et al., 2022). Fundamentally, malnutrition is a consequence of disease and inadequate dietary intake, but many other elements like poverty, infections, restricted diets, etc. may also play a significant role (Saunders & Smith, 2010, Norman et al. 2021, Wells et al., 2021, Yang et al., 2021). As a result, malnutrition is a major public health problem in the world (Muller & Krawinkel, 2005, Dukhi, 2020).

Several studies reported the necessity to resort to more abundant local products. In order to improve the protein and energy intake of developing countries such as the Democratic Republic of the Congo (DRC), it was essential to turn to the consumption of local products, such as insects (Lavalette, 2013, Mbemba et al., 2013, Van Huis, 2015, Muvundia et al., 2016, Numbi et al., 2022). Edible insects are healthy food alternatives and are rich in proteins, lipids, fibers and have high levels of minerals such as calcium, iron and zinc that can be integrated with staple foods such as poultry, pigs, cattle and even fish (Kelemu et al., 2015, Kourimska & Adamkoya, 2016, Okangola et al., 2016, Raheem et al., 2018, Hlongwane et al., 2020, Ojha et al., 2021, Matandirotya et al., 2022). With their accessibility, technical simplicity of rearing and rapid growth rate; insects offer cheap and effective opportunities to counteract food insecurity by providing emergency food, improving people's livelihoods and the quality of the traditional diet of vulnerable populations (Adegboye et al., 2021; Shah et al., 2022). In this line of ideas, we developed a ready-to-use food based on local products mainly with the edible caterpillar "*Buenaopsis aurantiaca*", which is a species of caterpillar that is the most consumed and the most available in the markets of Kinshasa. We have incorporated the caterpillar flour in the making of cookies, with millet and cassava flours in order to promote local food and thus limiting imports of wheat flour at a certain level. The aim of this research was to make cookies from different composite flours (cassava, millet, caterpillar), and to assess their nutritional value as well as their sensory attributes.

2. Material and Methods

2.1. Biological material

In this study the biological material used consists of: "*Buenaopsis aurantiaca*" caterpillar, millet, cassava and wheat flours. The *Buenaopsis aurantiaca* specimens and the millet flour were purchased at the Rond-point Ngaba market. The wheat flour was provided by MIDEMA (a company supplying wheat flour for different uses) located in Kingabwa, Kinshasa Limete, DRC and the cassava flour was provided by the Laboratory of Applied Microbiology and Nutrition, Department of Biology, Faculty of Science, University of Kinshasa.

2.2. Methods

2.2.1. Obtaining different flours (caterpillar, millet, cassava and wheat)

The caterpillars were bought at Ngaba market, some were live caterpillars which were dried in the oven at 70°C during 24 hours and others already dried were just sorted then washed to avoid the presence of grain of sand in the powder then, dried in the oven at 70°C. After drying, they were pounded with a pestle and mortar. It should be noted that we used mature caterpillars which are already selected and safe to be consumed. So, we exclude the hypothesis of performing any toxicity tests since they are already safe and consumed by the population.

2.2.2. Preparation of cookies

(a) Formula A: Caterpillar + Wheat + Millet

Using a scale, we weighed 100g of caterpillar flour, 250g wheat flour and 150 g millet flour, which were mixed in a tray; then the ordinary sugar was added along with the vanilla sugar, yeast, water and vegetable oil. The dough was shaped using a mold and the dough was placed on a tray for baking for approximately 40 minutes (Villemejane, et al., 2012).

(b) Formula B: Caterpillar + Cassava + Millet

Using a scale, we weighed 100g of caterpillar flour, 250g cassava flour and 150g millet flour. The same procedure was followed as described above for Formula A.

(c) Formula C: Caterpillar + cassava + wheat

We weighed 50g of caterpillar, *200g* of cassava and the 250g wheat flours respectively. The same procedure was followed as described above for Formula A.

It should be noticed that none of these formulations contained cyanogenic glycosides or any other anti-nutritional factors. For cassava, the cyanide content was controlled before use and it was in the standards, and we used a manufactured cassava flour which is used for bread making.

2.3. Analysis of nutritional value

The proximate analysis (moisture, crude proteins, crude fibers, lipids, ash, and Iron determination) was performed as per the protocol described by Mbemba (2013), Bongo et al. (2019) & Oyenike et al. (2022). The carbohydrate content was calculated by difference of major components while the energy content (E) was calculated using the Atwater factor (Sanni et al., 2020) as follows:

$$E = (\text{glucides} \times 4) + (\text{lipids} \times 9) + (\text{proteins} \times 4) \quad (1)$$

All analyses were performed thrice as recommended in the literature

2.4. Acceptability test of different formulas

The procedure described by Nilugin et al. (2015) & Eke-Ejiofor et al. (2023) was slightly modified and used to evaluate the sensory attributes of different formulas of the cookies. Cookies were evaluated for their sensory characteristics by thirty-member semi-trained panelists made up of students of the Department of Biology, University of Kinshasa, DRC.

The samples were assessed for color, aroma, taste, crispiness, sweetness and external appearance. It should be noted that the semi-panelists were regular consumers of cookies and who were neither sick nor allergic to any of the raw materials used for the production of these cookies. The samples were coded and presented in identical containers. A questionnaire was used to assess the degree of likeness of the cookies using a 3-point hedonic scale ranging from 3= like extremely to 1= dislike extremely. Water was used for rinsing the mouth between each tasting to avoid after taste.

2.5. Statistical analysis

In order to compare different treatments, Friedman test was used considering our data where each semi-panelist constituted a repetition with a p-value <0.05 as being significant. The data were processed with XLSTAT 2011 software.

3. Results and Discussion

3.1. Evaluation of proximate analysis

After manual homogenization of the dough, we obtained a non-sticky, fairly homogeneous dough, easily crumbled and not forming a shiny greasy film covering the dough but a slightly greasy hand appearance.

Fig. 1 shows the cookies made during this experiment. The proximate analysis of different formulas is presented in the Table 1.

Fig. 1. Cookie made from a mixture of millet, cassava and caterpillars.

From the above table, it was observed that all three formulas are rich in proteins (40.69%, 23.85%, 28.22%) respectively. This variability of proteins is due to the nutritional composition of different ingredients used especially caterpillars. According to Bertenshaw et al. (2008), proteins are more effective than carbohydrates and lipids in inducing satiety and contribute to the development and regeneration of tissues, ensure good growth, and are important in the proper functioning of the immune system. Formula B is essentially made of local products, including cassava, a low-protein food, and has reached 23.03% of protein value due to the addition of caterpillars. We believe that this formula is mainly made up of animal proteins compared to other formulas as caterpillars and millet are rich in proteins. The findings of this study are similar to Bello et al. (2020), whom reported that the cookies made with composite flours could be used to address the protein-energy malnutrition prevalence in most of the local communities. Moreover, the frequent eating of snacks may serve to alleviate the problem of protein deficiencies in children, of which are the targets for production of this nutritionally improved product, and for adults who may want to snack on healthy food products (Agu et al., 2023).

Table 1. Proximate analysis of different formula prepared

Parameters	Formula A	Formula B	Formula C
Crude proteins	40.69%	23.85%	28.22%
Lipids	23.03%	27.57%	25.43%
Total sugar	9.54%	16.67%	18.43%
Crude fibers	21.49%	23%	20.39%
Total ash	0.25%	0.65%	0.40%
Moisture	5%	8.26%	7.13%
Energy (kcal)	408.15	410.21	415.47
Iron (mg)	10.2	12.5	14.0

Their fat contents are 23.03%, 27.57%, 25.45% respectively for formulas A, B and C. We note that formula B has the highest content of fats, which are the main determinants of the energy density of foods. Our findings are not similar to what was reported by Agu et al. (2023), who stated that 17.30% of fats for their fortified composite flour. This could be explained by the addition of vegetal oil to our different formulas while making the cookies. However, these findings are above the standards as recommended. Lipids increase the absorption of fat-soluble vitamins, offer vital fatty acids, and crucial volatile chemicals for flavor and sensory aspects, high-fat content in food, particularly baked goods, might facilitate rancidity during storage (Musa & Lawal, 2013).

As for the total carbohydrate content, we have 9.54%, 16.67%, and 18.43% for formulas A, B and C respectively. Although carbohydrates are the best sources of rapidly available energy, Rippe et al. (2017) recommends restricting the intake of added simple carbohydrates and delaying the introduction of added sugar and sweetened manufactured products in the young child's diet (their consumption is not recommended before the age of 12 months and it should be moderate between 1 and 3 years). In this research, we observed the decrease of carbohydrates in different formulas though formula C has the higher content of sugar. Oluwamukomi et al. (2011) observed that initially the carbohydrate content increased in biscuit produced from composite flours of wheat, cassava, and soy flour as the cassava flour ratio increased. Moreover, it was also observed that the carbohydrate content of the biscuit reduced again with substitution with 10% of soy flour (Sanni et al., 2020). Meanwhile, Eke-Ejiofor et al. (2023) reported a higher content of carbohydrates (54.91-64.47%), which was justified by the fact that the flour made from Bambara groundnut has a higher content of starch (82.5%) and its amylopectin content (79.8%). The decrease in carbohydrate content may be due to the increase in protein and lipid content of the cookies.

Regarding the crude fiber content, we have 21.49%, 23% and 20.39% for formulas A, B and C respectively. We note that formula B has the higher content in fibers. Fibers are type of carbohydrates that the body doesn't digest or assimilate. This is a reason why they do not provide energy like other carbohydrates. They found their importance in the proper functioning of the digestive system. They prevent constipation, reduce the risk of cancer of the large intestine and help maintain a functional intestinal flora (Holesh et al., 2022). In addition, the high fiber and the reduced carbohydrate content of cookies have several health implications (Oluwamukomi et al., 2011). As to Villemejane, et al, (2012), a food-rich in dietary fiber, as in the case of formula B, leads to a strengthening and prolongation of the feeling of satiety. Furthermore, some studies reported that the crude fiber content of composite biscuits increased with substitution of wheat with cassava flour. The fiber content increased in the composite flour due to the addition of cassava flour which is rich in fiber. This explains the high content of crude fiber in formula B, because cassava flour constitutes one of the raw materials used to make this formulation.

The total ash content is 0.25%, 0.65%, 0.45% respectively for formulas A, B and C. Total ash is the residue of mineral compounds that remain after incineration of a sample containing animal, vegetal and synthetic substances. They represent about 1 to 5% of the mass of a food, on wet basis and its analysis allows to determine the digestibility of a food (Rachid, 2011). Moreover, ash content is an indication of mineral content; hence samples with higher ash content are expected to have a relatively higher mineral content (Olapade & Adeyemo, 2014; Bello et al., 2020). However, the values of ash found in our samples are lower than Sanni et al. (2020), who reported the ash content between 1.40% and 1.99%. This may be explained by the type of ingredients used in the making of cookies. This was also reported by Atobatele and Afolabi (2016), who observed that there was an increase in the ash content of cookies with increasing level of soy-flour in the flour blends.

The moisture content is 5%, 8.26% and 7.13% for formulas A, B and C respectively. The moisture values found in our cookies are below 10%, which allows a long-term conservation (Zambrano et al., 2019). Besides, moisture content in excess of 14% facilitates the growth of microorganism, which in turn causes spoilage and low nutritional qualities of the food products, therefore the lower the moisture content of a sample, the more its storability. The moisture content of the samples was significantly low and would promote long storage ability of the product (Dabel et al., 2016, Bello et al., 2020, Eke-Ejiofor et al., 2023). Furthermore, it should be noted that the difference moisture content of a product can be caused by several factors such as water content of the initial material, the processing process (time and temperature) and the water holding capacity of raw materials (Hasrini et al., 2021).

As for the energy value, different formulas show 408.15 kcal, 410.21 kcal and 415.17 kcal respectively. For nutritional management of malnourished, WHO treatment recommendations for children with severe acute malnutrition are to provide 100-135 Kcal per kg/day of energy as the only food for the beneficiaries, until the child has reached an adequate weight, usually for a period of 4-8 weeks (Codex Alimentarius, 2015). The energy value of a portion (equivalent to a cookie) of formula B weighing 25mg contains 102 Kcal, this meets the WHO standards and can cover the daily energy requirement of a child aged between 0 and 3 years for example (650 to 1360 kcal) at a rate of 6 to 13 portions per day without resorting to other foods.

Knowing that dietary iron deficiency leading to nutritional anemia is due to the amount of assimilable dietary iron being insufficient to cover the body's needs, the use of caterpillars as the main source of iron has made it possible to obtain 10 mg, 12.5 mg, and 14 mg respectively for formulas A, B and C. The daily requirement of iron varies according to age, sex and physical activity. For example, for infants it is 1mg per day, for children it is 7mg per day, for teenagers it is 15mg per day and for pregnant women it is 20 to 22 mg per day. The results obtained can cover the daily iron needs of this category of individual. Following the Codex Alimentarius (2015), a therapeutic food can contain about 10 to 14mg of iron per 100g. Our findings in iron content are higher than what Oguntoyindo et al. (2019) reported. They found relatively (2.10- 3.19 mg/100g) values for iron content found in cookies from wheat, banana and avocado peel composite flour. However, Eke-Ejiofor et al. (2023) found higher content of iron in their flours (Cassava/Bambara groundnut composite flour blend) (9.43-20.73mg/100g). Though the iron content of caterpillars is high, there are other foods who contain more minerals like iron in huge quantity. The difference in the iron content may attributed to different ingredients used to form the composite flour.

3.2. Proximate analysis of Formula B

The proximate analysis of formula B made essentially of local foods (cassava, caterpillars and millet) compared to that of a "Lia®" cookie, a manufactured product of DICO-P from DRC (Diaming-Congo Products) composed of soybean, wheat, peanuts, milk, eggs, oil and sugar. The nutritional composition per 100g of our cookies compared to "Lia®" DICO-P is presented in Table 2.

Table 2. Nutritional composition per 100g of our cookies compared to « *Lia®* » DICO.

Parameters	Formula B	« *Lia®* »
Moisture	8.26%	6%
Crude proteins	23.85%	10%
Total fat	27.57%	30%
Crude fibers	23%	-
Ash	0.65%	4%
Carbogydrates	16.67%	47.5%
Energy (kcal)	410.21	500
Iron (mg)	12.5	-

It was observed that the moisture content of formula B (8.26%) is higher than that of "Lia®" 6%. Kowalska et al. (2022) reported that a food with a water content lower than 10% is preserved for a long time. As for the crude proteins, we notice that formula B is twice is richer in proteins (23.85%) than Lia cookie (10%). The advantage of formula B is that it is mainly made up of animal proteins associated with vegetable proteins brought from caterpillars and millet flours respectively while the proteins present in the "Lia®" cookie are essentially of vegetable origin. As to total carbohydrates are concerned, we notice that formula B (16.57%) is lower than that of "Lia®" (47.5%). We would like to think that with this low carbohydrate content, formula B would be more beneficial for diabetics than the Lia® cookies. The fat content of "Lia®" is higher in this cookie (30%) than our formula B (27.5%). This manufactured product has this higher content due to the presence of peanuts and vegetable oil in its composition. The energy value of formula B is 410 kcal while that of Lia is 500 kcal, nevertheless a portion (equivalent to a cookie) of formula B weighs 25 g, and contains 102 kcal of energy and meets the WHO standards for the nutritional management of malnourished people.

We need to note that there are several points, which differ between laboratory and commercial cookies. First, recipes of laboratory cookies are often much simpler than those of commercial ones i.e., laboratory made products contain less ingredients than commercial ones. It is also what was observed in this study (Holt et al., 2000, Pareyt et al., 2009, Drewnowski et al., 1998). Secondly, for technical reasons, some emulsifiers, bulking agents and fibers are sometimes added to reduced variants of commercial products. Indeed, it would not be possible to knead the pastry without these ingredients (Holt et al., 2000). Thirdly, subjects consumed laboratory biscuits one or two days after they were produced while commercial cookies are usually consumed when they are in the marketplace, after at least 1 month (Drewnowski et al., 1998, Holt et al., 2000). Fourthly, laboratory cookies have sensory characteristics of homemade cookies compared to commercial ones (Biguzzi et al., 2014).

3.3. Test of acceptability of different formulas

3.3.1. Evaluation of the color

Fig. 2 presents the evaluation of color by the semi-trained panelists. Fig. 2 shows that a significantly large proportion of tasters agree that the cookies from these three formulas have a slightly golden color (Chi² = 57.900 for formula A, Chi² = 20.100 for formula B and Chi² = 57.900 for formula C; df = 2 and p-value < 0.001 for the three formulas).

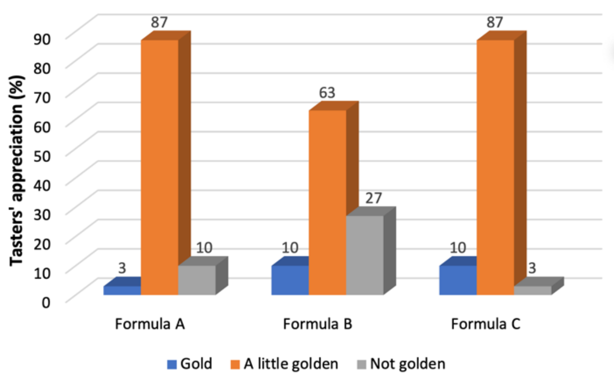

Fig. 2. Proportion of tasters' responses regarding color.

3.3.2. Aroma evaluation

The evaluation of aroma by the semi-trained panelist is displayed in Fig. 3. Fig. 3 shows that a significantly large proportion of panelists reported that the cookies made from these three formulas had a pleasant smell though there was no significant difference observed (Chi² = 17.067 for formula A, Chi² = 17.067 for formula B and Chi² = 38.400 for formula C; df = 1 and p-value < 0.001 for all three formulas). The Friedman test, for the comparison of these three formulas, indicates no significant difference in aroma (Q =2.133; df = 2; p-value = 0.344). Eke-Ejiofor et al. (2023) reported that the substitution of certain flours like cassava flour with Bambara groundnut flour may have imparted a pleasant aroma resulting in the higher mean scores of cookies produced from the flour blends. In this study, the smell was well scored by the semi-trained panelists, this may be due to different raw material used.

3.3.3. Taste evaluation

The taste evaluation is presented in the Fig. 4. Fig. 4 shows that a significantly large proportion of the semi-trained panelists report that the cookies from these three formulas taste good (with Chi² = 30.900 for formula A, Chi² = 39.900 for formula B and Chi² = 44.100 for formula C; df = 2 and p-value < 0.001 for the three formulas). However, the comparison of these three formulas considering the taste, the Friedman test, does not indicate a significant difference (Q = 1.444; df = 2; p-value = 0.486). It should be noticed that the taste in the three formulas was influenced by the ingredients (flours) used. The semi-panelists being the consumers of these different elements, they considered the taste to be good whatever the formula. Chopra et al. (2018) reported that the addition of other flours added to wheat which was the standard led to the deviation of taste from the expected one. The cookies had a bitter taste which might have been caused by the increased in polyphenol in the samples (Bello et al., 2020). Previous studies have reported increased likeness for taste of cookies produced from composite flours than single flours (Eke-Ejiofor et al., 2023).

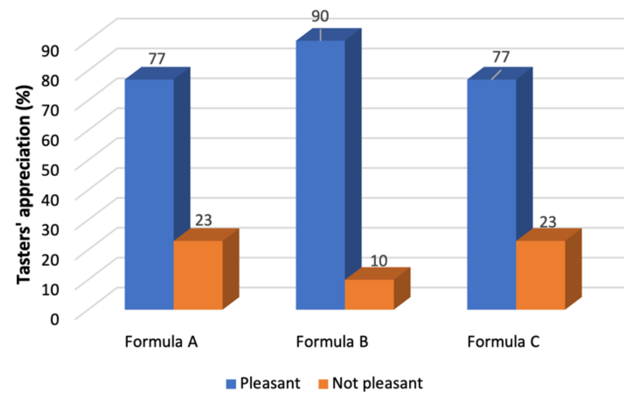

Fig. 3. Proportion of tasters' responses regarding aroma

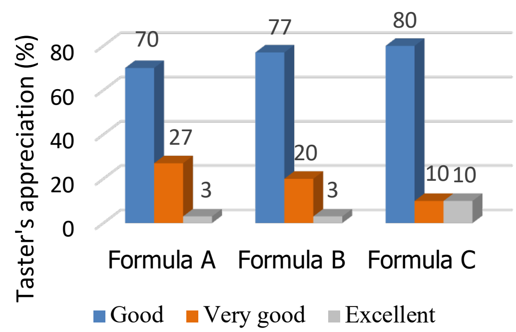

Fig. 4. Proportion of tasters' responses regarding taste.

3.3.4. Evaluation of sweetness

The evaluation of sweetness of our cookies is presented in the Fig. 5. Fig. 5 shows that a significantly large proportion of semi-trained panelists agree that the cookies produced from these three formulas are quite sweet (with Chi² = 72.900 for formula A and Chi² = 65.100 for formula B; df = 2 and p-value < 0.001 for both formulas). Considering the sweetness, the three formulas under study do not turn out to be significantly different (Q = 1.849; df = 2; p-value = 0.397). It should be noted that sweetness is mainly due to the sugar content but it also depends on the fat content and moisture (Biguzzi et al., 2014). The assessment of sweetness is linked to the fat content, which plays an important role in the texture, mouthfeel, flavor and aroma of food (Biguzzi et al., 2014). The sugar in the cookies reduces the viscosity of the dough, and during baking, the undissolved sugar gradually dissolves, contributing to the spread of the cookies. When the cookies cool, the sugar crystallizes and acts as a hardener (Maache-Rezzoug et al., 1998).

These findings are consistent with Jukic et al. (2022), who reported the lack of sweetness was readily apparent even in cookies with 66.6% added sucrose from the original recipe. While Biguzzi et al. (2014), applied a 16% reduction in sugar content affected the likability score of the cookies. This is the same observation that we made in this study, and it seems like people prefer more sweet food than less sweet food. The reduction of fat/sugar content in biscuits (cookies) can be a way to improve their nutritional composition (Goubgou et al., 2021). Furthermore, the reduction of sugar and fat content in cookies may result in consequences on the structure, texture, sensory and hedonic consequences (Biguzzi et al., 2014). However, too much sugar may lead to diseases and the occurrence of the Maillard reaction, which influences the color of the food (Tamanna & Mahmood, 2015).

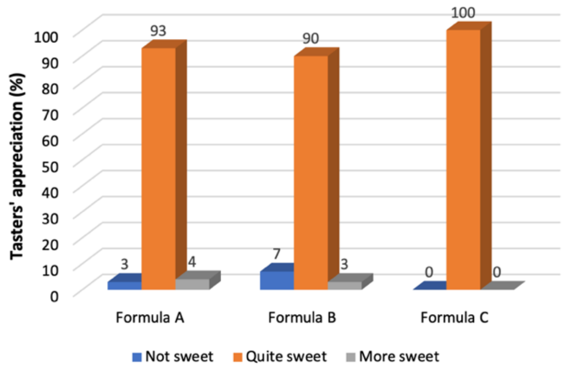

Fig. 5. Proportion of tasters' responses regarding sweetness.

3.3.5. Evaluation of crispiness

The evaluation of crispiness of the cookies is presented in Fig. 6. Fig. 6 shows that a significantly large proportion of semi-trained panelists indicated that the cookies produced from these three formulas were fairly hard (Chi-square = 27.900 for formula A, Chi-square = 6.300 for formula B and Chi-square = 17.100 for formula C; df = 2 and p-value < 0.001 for all three formulas). The Friedman test, for the comparison of these three formulas, does not indicate a significant difference in crispiness (Q = 0.110; df = 2; p-value = 0.947). Crispiness is perceived when food is chewed between molars, and is usually expressed in terms of hardness and fracturability (Nilugin et al., 2015). It should be noted that crispiness of cookies made from composite flour is associated with fats, which imparts on flavor and tenderness. In order to assess the texture of composite flour cookies there is a need to consider the snapping force and the breaking distance (Sanni et al., 2020). Unfortunately, it is not possible to accurately estimate the hardness of the cookies, since they do not all have the same thickness and their elasticity must be considered (Sanni et al., 2020). Therefore, the bending force index parameter is used as the main indicator of hardness, since it more accurately describes the overall texture (hardness) of the cookies (Jukic et al., 2022). In this study, this particular parameter was not taken into account to assess the hardness of the made cookies though the semi-trained panelists appreciated it.

3.3.6. Evaluation of the external aspect

The evaluation of the external aspect of our cookies is presented in Fig. 7. Regarding the external aspect, Fig. 7 shows that a significantly large proportion of the semi-panelists affirm that the cookies made on the basis of these three formulas are unattractive ($Chi^2 = 3.600$ for formula A, $Chi^2 = 8.400$ for formula B and $Chi^2 = 3.600$ also for formula C; df = 2 and p-value < 0.001 for the three formulas). When comparing the three formulas by the Friedman test, no significant difference is revealed regarding the external aspect (Q = 0.159; df = 2; p-value = 0.924). According to our semi-trained panelists, the score for the appearance was low for different formulas used. This may be due the raw material used notably caterpillars and millet.

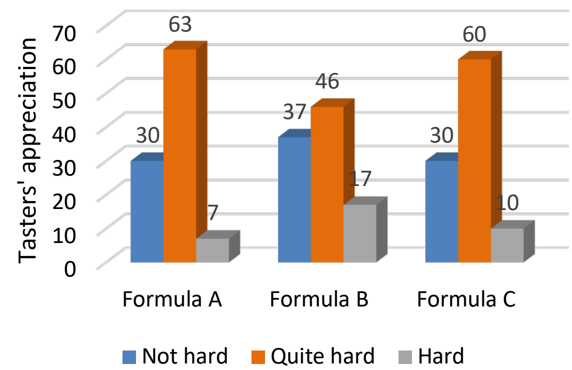

Fig. 6. Proportion of tasters' responses regarding crispiness.

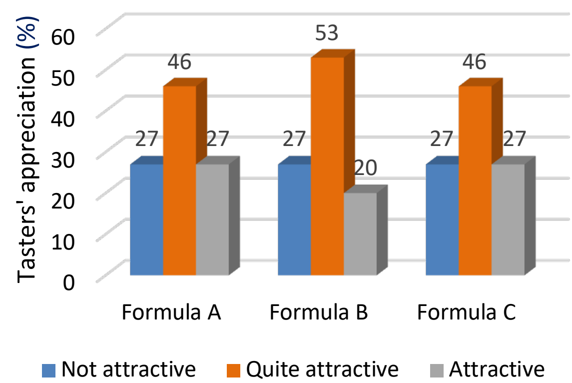

Fig. 7. Proportion of tasters' responses regarding external appearance.

4. Conclusion

Different cookie formulas were made for the determination of the nutritional value and submitted to the appreciation of the assessors for the acceptability test. The findings showed that the formulas A, B and C contain an important quantity of nutrients necessary for human health and a considerable energy density. The presence of iron as a trace element in these cookies is necessary for the production of hemoglobin in the body, of which its lack leads to anemia.

The acceptability test regarding color, aroma, taste, sweetness, crispiness, texture and its external appearance showed less interest from the semi-panelists. The majority think that the three formulas are slightly golden, have a pleasant smell, a good taste, are quite sweet, quite crispy, and are not very appealing (external appearance). The overall acceptability was moderately scored compared to the standards but the product was accepted. There is a need of improving the sensory attributes of these cookies for future studies The use of the composite flour for the development of other food products should also be considered and explored. Furthermore, the influence of socio-demographic characteristics of the semi-trained panel on the cookies produced would be considered as part of the results of the study, and means and standard deviations would be also added on different parameters evaluated.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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