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Technological use of green banana and birdseed flour in preparing cookies

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ABSTRACT. Cookies made up of flour containing unripe banana and birdseed were developed and characterized by centesimal composition, microbiological quality, color by CIE L^*, a^* and b^* system and sensory acceptance. Two formulations of cookies (F1 and F2) with different amounts of mixed flour (≅ 6.0 and 8.0 g 100 g^{-1}, respectively) were designed. All formulations exhibited attractive nutritional properties, mainly due to the levels of protein (F1: 11.6 and F2: 10.7 g 100 g^{-1}) and dietary fiber (F1: 22.6 and F2: 31.03 g 100 g^{-1}). There was no significant difference ($p < 0.05$) in color parameters between the upper surfaces of F1 and F2, and between the undersides of cookies. Both compositions showed high acceptability in color, texture, odor and taste, with a predominance of scores of the category 8 (like very much) and no statistical difference ($p < 0.05$) in the perception of these attributes by the tasters between formulations. The results of the purchase intention test suggest a good commercial prospect for the cookies developed. Our findings represent a new proposal for the use of flour with unripe banana and birdseed in the development of a food product with high added value.

Keywords: baking, grain, sensory, centesimal composition.

Aproveitamento tecnológico de farinha de banana verde e de alpiste na preparação de cookies

RESUMO. Cookies contendo farinha mista composta por farinhas de banana verde e alpiste foram desenvolvidos e caracterizados quanto à composição centesimal, qualidade microbiológica, cor pelo sistema CIE L^*, a^* e b^* e aceitação sensorial. Foram elaboradas duas formulações contendo diferentes quantidades de farinha mista (≅ 6,0 e 8,0 g 100 g^{-1}). As formulações desenvolvidas apresentaram propriedades nutricionais atrativas, especialmente pelos teores de proteínas (11,6 e 10,7 g 100 g^{-1}) e fibra alimentar (22,6 e 31,03 g 100 g^{-1}). Não houve diferenças significativas ($p < 0.05$) quanto aos parâmetros de cor L^*, a^* e b^* entre as superfícies superiores dos cookies, bem como entre as superfícies inferiores. Ambas as formulações apresentaram boa aceitação sensorial quanto aos atributos cor, textura, odor, sabor e impressão global, com predominância de notas na categoria 8 (gostei muito) e sem diferença estatística ($p < 0.05$) em relação à percepção de tais atributos entre as formulações pelos provadores. As informações obtidas pelo teste de intenção de compra sugerem boa perspectiva comercial para os cookies desenvolvidos. Os resultados do trabalho contribuem como uma nova proposta de aproveitamento da farinha de banana verde associada à farinha de alpiste no desenvolvimento de produto alimentício com elevado valor agregado.

Palavras-chave: panificação, grãos, sensorial, composição centesimal.

Introduction

Banana (*Musa spp.*) is one of the most appreciated fruit worldwide because of its good taste and low cost, particularly in tropical countries. This fruit has become the focus of several scientific studies due to its good nutritional value and popularity, being accessible to all social strata, including the underprivileged classes.

Banana can be used in its totality. The most common use is the consumption of its pulp after maturity, but the green fruit may be fully used in the form of flour or it may also be consumed after cooked. Green banana flour has a high fiber, carbohydrate and mineral content, showing, therefore, a high potential as an ingredient in the formulation of several foodstuffs (ALKARKHI et al., 2011; ALVARENGA et al., 2011; BEZERRA et al., 2013).

Several studies have recently shown the potential use of green banana flour in the production of food products such as pasta (SAIFULLA et al., 2009,

ALVARENGA et al.; 2011), gluten-free pasta (ZANDONADI et al., 2012), *snacks* (WANG et al., 2012), pre-mixture ingredient for flan (CUNHA et al., 2014) and food bars (BRIZOLA; BAMPI, 2014). Another application of the green banana flour is its use as a prebiotic vegetal fiber for *Lactobacillus casei* adherence (GUERGOLETTO et al., 2010).

Another plant product that may be used as a food ingredient in the form of flour is the birdseed (*Phalaris canariensis L.*). Birdseed is a cereal with a high content of starch, fibers, protein with high levels of the amino acids cysteine, tryptophan and phenylalanine, minerals and essential fatty acids, such as oleic, linoleic, palmitic and linolenic acids (ABDEL-AAL et al., 2011, WENDE; BETA, 2012).

Magnuson et al. (2014) affirm that birdseed is a highly nutritious cereal, however, it has not been used for human subsistence, partially due to the concerns regarding the safety of its consumption. The authors report that the *glabro* birdseed, or hairless, can be used in human feeding because of the absence of trichomes. Besides, studies on birdseed reported that the grain consumption has been associated with a lower incidence of liver steatosis.

Comino et al. (2013) describes the birdseed as an alternative grain with potential use by celiac patients. Wende and Beta (2012) evaluated 19 varieties of *glabro* birdseed and mentioned high contents of carotenoids, especially β-carotene, and considered it a potential ingredient for functional foods enriched with carotenoids.

Green banana and birdseed flours can be used in the formulation of cookies. According to Fasolin et al. (2007), cookies have an extended shelf life, good acceptance and a large consumer market. Although they are not part of the basic human diet, people from different age groups and social classes consume them. They have been formulated with specific ingredients, rich in fibers, vitamins or proteins intended to make them fortified, seeking to respond to a consumer market demanding high quality.

With the purpose of constantly increasing the nutritional value of cookies, there has been a substantial increase in the number of researches aiming at this goal with the use of mixed flour (FEDDERN et al., 2011). In this sense, the main purpose of the present study was the development of a cookie formulation containing green banana and birdseed flours that contribute to the formulation of a foodstuff with relevant nutritional properties.

Material and methods

Raw material

In order to produce banana flour, we used the pulp and the peel of raw fruit that have not been subjected to the climatization process, purchased from a company specializing in the commercial distribution of the product. Birdseed was purchased in a grain store at the local market in the city of Pato Branco, Paraná State. The remaining ingredients used in the cookies formulations are oat flour, brown sugar, eggs, wheat flour, butter, starch, peanuts and lyophilized yeast.

Flours of green banana, birdseed and mixed

The first step was to wash the fruit (green banana) with running water and to sanitize them through the immersion in Sodium hypochlorite solution (20 ppm) for 10 min. Then, fruit were sliced transversely and subjected to chemical bleaching with citric acid solution at 0.5% (m v^{-1}) (10 min. immersion). Sanitized fruit were dehydrated in a commercial dehydrator at 60°C to moisture content between 7 and 10% (about 12 hours). The dehydrated biomass was ground in a blender for 5 min. (maximum speed) to produce the flour.

Birdseed flour was obtained by grinding the seeds in a blender for 5 min. (maximum speed). For the production of the mixed flour, the green banana and birdseed flours were mixed at the same ratio (1:1, w w^{-1}).

Cookies formulation

The mixed flour partially replaced wheat flour in the formulation of the cookies, according to Table 1.

Table 1. Formulations of the cookies.

Ingredients	Formulations (g)		Ingredients	Formulations (g)	
	F1	F2		F1	F2
Brown sugar	45	45	Mixed flour	20	30
Refined sugar	80	80	Corn starch	40	40
Butter	50	50	Baking soda	4	4
Egg	50	50	Bread yeast	4	4
Oat flour	80	80	Toasted and	40	40
Wheat flour	110	100	milled peanut		

For the preparation of the cookies, first, the corn starch was mixed with the baking soda, bread yeast, flours and peanut, and, separately, sugar, eggs and butter. After that, the contents were manually homogenized to uniform dough. This uniform dough was opened with the aid of a Rolling pin and divided (cut) into equivalent parts (disks) of approximately 5 g, which were placed in pans greased with vegetal oil and floured with wheat flour. The cookies were baked in an oven at 180 C for 10 min. and, after cooling, were stored in glass

pots until characterization and sensory analysis (about 7 days).

Physical-chemical and microbiological characterization

In order to characterize the cookies, physical-chemical analyses of moisture, ash (mineral residue), lipid, protein, dietary fiber and water activity were performed. The moisture content was determined through the kiln-drying method at 105°C to constant weight (AOAC, 2007), the amount of ash (mineral residue) was gravimetrically determined after the incineration of samples in muffle furnace at 550ºC (AOAC, 2007). The amount of raw protein was determined through the *Kjeldahl* method (nitrogen-protein conversion factor of 6.25) (AOAC, 2007), the total amount of lipids (ether extract) was determined by the *Soxhlet* extraction method (AOAC, 2007). The content of dietary fiber was determined by Prosky-AOAC method (AOAC, 2000) using total dietary fiber assay kit (Sigma–Aldrich Co., USA). The water activity was determined with the use of a water activity analyzer of Novasina (Labmaster Standard, USA).

The Student's t-test was applied to evaluate the data on the centesimal composition, at a 5% probability, after checking the assumptions of normal data distribution and the homoscedasticity of variances by the Shapiro-Wilk and Levene tests.

For evaluating the microbiological quality of the cookies, coliform analysis at 35 and at 45ºC, *Salmonella* spp. and *Staphylococcus coagulase positiva* was performed (SILVA et al., 2007). The microbiological quality of the cookies was assessed before the sensory acceptance tests.

Color analysis

The color analysis used a digital colorimeter CR-410 (Konica Minolta, Japan), using the CIE L^*, a^* and b^* color system, where the luminosity value (L^*) varies between zero (black) and 100 (white), the values of the chromaticity coordinates a^* and b^*, vary from $-a^*$ (green) to $+a^*$ (red), and from $-b^*$ (blue) to $+b^*$ (yellow). The following equation (1) determines the color variation among the samples (F1 and F2):

$$\Delta E = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2} \quad (1)$$

where:
ΔE = difference in color;
ΔL^* = Lp (luminosity of the cookie F1) – Lt (luminosity of the cookie F2);
Δa^* = ap (value of a^* of cookie F1) – at (value of a^* of cookie F2); and
Δb^* = bp (value of b^* of cookie F1) – bt (value of b^* of cookie F2). Color parameters were analyzed by the non-parametric Kruskal-Wallis ANOVA test ($p < 0.05$).

Sensory analysis and purchase intent

To evaluate the sensory acceptance of the cookies, the acceptance test by hedonic scale, structured with 9 points [varying from dislike extremely (1) to like extremely (9)], was performed (DUTCOSKY, 2007). The attributes analyzed were taste, smell, texture, color and overall quality.

A 5-point scale with scores varying from (1) would certainly not buy it, (2) would probably not buy it, (3) maybe would buy it, maybe not, (4) would probably buy it and (5) would certainly buy it, was used to assess the purchase intent of the product (LEITE et al., 2013).

For the sensory evaluation and the purchase intent assessment, 100 consumers were recruited as untrained tasters, with ages from 16 to 60 years old. The Wilcoxon Matched-Pairs T test was applied to evaluate the difference in acceptance of the different attributes for both formulations (GONZÁLEZ et al., 2011). The box-plot graph was used to illustrate the acceptance behavior of the two different formulations for the individual sensory attributes (NAES et al., 2010) through the median values.

All statistical analysis of the data was run with the support of the software STATISTICA 8.0.

Results and discussion

Characterization of the cookies produced

The formulations of cookies (F1 and F2) presented low moisture contents (5.31 and 3.58 g 100 g^{-1}, respectively) and low levels of water activity (0.526 and 0.425), which contributes to a greater chemical and microbiological stability, and an improved crispness. The moisture contents of samples F1 and F2 are consistent with the Brazilian legislation (RDC 263 of September 22nd, 2005 of the National Health Surveillance Agency), which establishes a maximum limit of moisture at 15% (m m^{-1}) (BRASIL, 2005), and are consistent with baked food products (Table 2).

Both samples presented relatively similar quantities of mineral residue (1.85 and 1.64 g 100 g^{-1}), with values in accordance with the RDC 263 of September 22nd, 2005 of the National Health Surveillance Agency (BRASIL, 2005).

The amount of lipids varied from 15.69 (F1) to 20.32 g 100 g^{-1} (F2), similar to the ones presented in the label of the type of cookies available in the Brazilian market, which present mean values varying from 14 to 23 g 100 g^{-1} (CUNHA el at., 2015). The highest content of lipids observed in formulation F2

in relation to formulation F1 is possibly associated with the higher amount of mixed flour used and, consequently, the larger amount of birdseed, which is rich in fats (PAIANO et al., 2011).

Table 2. Centesimal composition of the cookies.

Parameter	Results**		Anvisa*** Parameters
	F1	F2	(g 100 g^{-1})
Moisture (g 100 g^{-1})	5.31^{a} ± 0.08	3.58^{b} ± 0,04	≤ 14
Mineral residue (g 100 g^{-1})	1.85^{a} ± 0.01	1.64^{b} ± 0,02	≤ 3
Lipid (g 100 g^{-1})	15.69^{b} ± 0.54	20.32^{a} ± 0,61	-
Protein (g 100 g^{-1})	11.58^{a} ± 0.30	10.68^{b} ± 0,15	20
Carbohydrate** (g 100 g^{-1})	42.97^{a} ± 0.97	32.75^{b} ± 0,67	-
Dietary Fiber (g 100 g^{-1})	22.60^{b} ± 0.67	31.03^{a} ± 0,49	-
Water activity	0.526^{a} ± 0.003	0.425^{a} ± 0,001	-
Energy (Kcal 100 g^{-1})	359.41^{a} ± 1.5	356.60^{a} ± 1.2	-

**Calculated by difference; ***RDC 263 of September 22nd, 2005; ^{a,b}Means (two repetitions) followed by different letters, in the same row, are significantly different to each other ($p < 0.05$).

The F1 and F2 samples presented total protein contents of 11.58 and 10.68 g 100 g^{-1}, respectively. Fasolin et al. (2007) reported lower protein contents (amounts between 6.77 and 7.80 g 100 g^{-1}) in cookies formulated with green banana flour as a substitute for approximately 10 to 30% of the total flour content.

The use of mixed and oat flours increased the fiber content (22.6 and 31.03 g 100 g^{-1}) of the cookies, qualifying the cookies as fiber-rich products according to the RDC 54 of November 12nd, 2012 (BRASIL, 2012). The total estimated energetic value for the formulations F1 (359.41 Kcal) and F2 (356.6 Kcal 100 g^{-1}) was similar, with no statistical differences ($p < 0.05$).

According to Zucco et al. (2011) the surface color of baked products, such as cookies, associated with texture and taste, is an important parameter for the initial acceptance of the product by consumers. In the present work, the color parameters L*, a*, b* were evaluated, as well as the total color difference (ΔE) between the upper side and the underside (Table 3) of both formulations developed (F1 and F2). According to the CIE L*, a*, b* system, the upper surface color of the F1 cookie was L* = 59.75 ± 1.5, a* = 8.62 ± 0.45 and b* = 26.53 ± 1.13, with no significant difference ($p < 0.05$) from the color verified in the upper side of the F2 cookie (L* = 60.15 ±1.40, a* = 8.69 ±0.65 and b* = 27.27 ±0.95). Likewise, there was no significant difference for L*, a*, b* color coordinates for the underside between the F1 cookies (L* = 52.64 ±1.64, a* 12.54 ±0.88 and b* = 24.97 ±1.24) and F2 cookies (L* = 52.04 ±1.27, a* = 12.13 ±0.58 e b* = 24.38 ±1.02). On the other hand, the F1 cookie presented a higher luminosity (L*) and a higher b* chromaticity level (tendency to yellow) in the upper surface in comparison with the underside of the F2 cookie. The color of the underside of the F2 cookie showed a higher intensity of red (a*) when compared with the upper surface of the F1 cookie.

Table 3. Results of the color analysis through the CIE L*, a* e b* system.

Formulation		Color			
		L*	a*	b*	ΔE
F1	Upper side	59.75^{a} ± 1.5	8.62^{b} ± 0.45	26.53^{a} ± 1.13	$\Delta E_{US}^{\#} = 0.84$
	Underside	52.64^{b} ± 1.64	12.54^{a} ± 0.88	24.97^{b} ± 1.24	
F2	Upper Surface	60.15^{a} ± 1.40	8.69^{b} ± 0.65	27.27^{a} ± 0.95	$\Delta E_{UD}^{\#\#} = 0.94$
	Underside	52.04^{b} ± 1.27	12.13^{a} ± 0.58	24.38^{b} ± 1.02	

L* (luminosity or brightness, variation from 0 to 100), a* (variation from green to red, from -60 to +60) and b* (variation from blue to yellow, -60 to +60); ΔE: color difference. $^{\#}$ΔE Upper side (F1 and F2); $^{\#\#}$ΔE Underside (F1 and F2); ^{a,b}Means (two repetitions) followed by different letters, in the same column, are significantly different to each other ($p < 0.05$).

Arun et al. (2015) described L* values between 46.2 and 52.8 in cookies containing flour obtained from a by-product derived from banana chips processing (Nedran type), as a partial substitute for wheat flour. These authors verified a* values varying from 5.4 to 9.4 and b* values between 18.3 and 25.97.

With regard to the perceptible color differences (ΔE), samples F1 and F2 may be classified as slightly different according to the analytical classification proposed by Tiwari et al. (2008). These authors classify the perceptible color differences in very different, when ΔE > 3.0, different, when 1.5 < ΔE < 3.0, and slightly different, when ΔE < 1.5.

Microbiological quality parameters

Both formulations presented microbiological quality consistent with the RDC 12, of January 2nd, 2001, as described in Table 4. Importantly, besides the nutritional quality, the microbiological quality is essential for the consumer's safety and health (APPELT et al., 2015). The results indicated that the formulation processes followed the appropriate hygiene and cleanliness protocols.

Table 4. Microbiological parameters.

Microbiological parameters	Results		Brazilian Legislation (tolerance for the representative sample)
	F1	F2	Anvisa$^{\#}$
Salmonella spp.	Absent	Absent	Absent
Staphylococcus aureus	<1 x 10^{1} CFU*	<1 x 10^{1} CFU*	10^{2} CFU*
Coliforms at 35ºC	<2.9 MPN**	<2.9 MPN**	10 MPN**
Coliforms at 45ºC	<2.9 MPN**	<2.9 MPN**	-

$^{\#}$RDC 12 of January 2nd, 2001 (BRASIL, 2001); *CFU - Colony-Forming Unit (g mL^{-1}); **MPN - Most Probable Number.

Sensory acceptability and purchase intent

The developed cookies presented an attractive visual aspect with a brownish color, typical of cookies. There was a significant hedonic difference at a 95% level, between the samples for all evaluated sensory attributes, including for the overall impression (Table 5), with an advantage for cookie F2. Such result indicates that the increase in the mixed flour content from 3.8 (F1) to 5.7% (F2), contributed for the differences in perception of the sensory attributes evaluated by the tasters. Although the tasters had observed sensory differences between the samples, they accepted well both formulations in regards to their sensory attributes. The box plot (Figure 1) clearly indicates the predominance of the score 8, when considering the median values, with the exception of the attribute smell for cookies F1. Score 8 corresponds to an acceptance index of 88.8%, which is considered an excellent result (QUEIROZ; TREPTOW, 2006).

Table 5. Average score given by the tasters to the sensory parameters evaluated.

Samples	Attributes				
	Color	Texture	Smell	Taste	Overall Impression
F1	7.34[b]	7.66[b]	7.12[b]	7.48[b]	7.45[b]
F2	7.51[a]	7.79[a]	7.34[a]	7.75[a]	7.68[a]

[a,b]Different letters in the same column indicate significant differences ($p < 0.05$); n = 100.

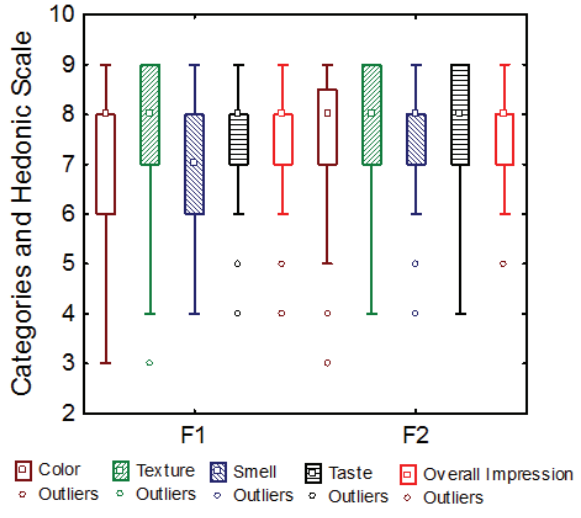

Figure 1. Box plot of the acceptance of formulations F1 and F2. Median: □; 25% -75% of observations: ; Non-Outlier Range: ⌶; Outlier: ○; (1) disliked very much; (2) disliked a lot; (3) regularly disliked; (4) slightly disliked; (5) neither liked nor disliked; (6) slightly liked; (7) regularly liked; (8) liked a lot and (9) liked very much.

It is also important to note that the attributes taste and texture are important parameters of sensory quality in cookies (LAGUNA et al., 2013; TARANCÓN et al., 2015). Besides showing the median value in the category 8, they report an interquartile range with a maximum value of 9 and a minimum value of 7, that is, 50% of the tasters showed acceptance indices between 77.7 and 100%. Interestingly, several tasters have reported they recognized and appreciated the tastes of two other ingredients used in the formulation: oat and peanut.

The histogram on Figure 2 describes the purchase intent for cookie formulations F1 and F2. Sixty-five percent of tasters indicated that they would certainly (43%) or probably (22%) buy the cookie formulation F1. As for cookie formulation F2, 78% of the tasters indicated that they would buy the product (44% of tasters would probably buy it, and 34% would certainly buy it).

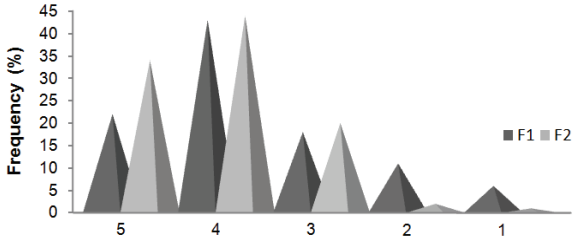

Figure 2. Histogram of purchase intent of tasters regarding formulations F1 and F2 - (1) would certainly not buy it; (2) would probably not buy it; (3) maybe yes, maybe not; (4) would probably buy it and (5) would certainly buy it.

The results of the purchase intent test confirm the sensory acceptance hedonic evaluation, indicating that both formulations present good sensory quality, as well as a good market potential. The formulation with the largest amount of mixed flour would be probably the most interesting for potential customers.

Conclusion

The green banana flour associated with the birdseed flour can represent a good alternative ingredient for the development of healthy and nutritious food products, considering that the first can stimulate intestinal microbiota (green banana) and the later contains significant levels of minerals (birdseed). The use of green banana and birdseed flours in cookies contributes to the application of these biomasses to products with a higher value.

The cookies developed present interesting nutritional properties, especially in regards to high contents of fiber and satisfactory levels of protein content, as well as microbiological quality consistent with the quality standards recommended by the Brazilian legislation. The sensory acceptance and purchase intent tests indicated that both cookie

formulations have market potential and can compete for market space with existing similar products.

Our findings demonstrate a new possibility for the application of green banana flour in association with birdseed, a nutritious cereal not commonly used in human feeding.

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