Comunicata Scientiae
Horticultural Journal

ORIGINAL ARTICLE
published: 10 May 2022
https://doi.org/10.14295/CS.v13.3561

Quality of cookies with partial substitution of wheat flour for okra flour

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Abstract

Okra is a vegetable of high nutritional value, but highly perishable when stored *in natura*. Biscuits are products of great popular acceptance and allow the use of alternative flours. The objective was to evaluate cookies made with partial substitution of wheat flour for okra. Okra fruits were dried to obtain the flour. This was applied in biscuit formulations in the concentrations of 0 (A), 5 (B), 10 (C) and 15% (D). The cookies were evaluated for the difference in mass, thermal factor, yield, humidity, ash, fibers, proteins, lipids, carbohydrates, caloric value, presence of coliforms at 45 °C, positive coagulase *Staphylococcus* and *Samonella* sp., In addition to the sensory evaluation acceptance and purchase intention. The dough, ash, fiber and protein content of the cookies enriched with okra flour were higher. The carbohydrates and caloric value content was higher in formulation A. All cookies are within the microbiological standards required by law. Sensory acceptance and purchase intention were superior in formulations A and B. The differences between the cookies are due to the okra differentiated composition and vary according to the concentration in which it is added. Formulation B obtained better nutritional quality without interfering with its good sensory acceptance.

Keywords: *Abelmoschus esculentus*, nutritional quality, drying

Introduction

Cookies or biscuits are products obtained by mixing flour (s), starch (s) and/or starch(s) with other ingredients, submitted to kneading and cooking processes, fermented or not (Brasil, 2005). Cookies or crackers are products with a long shelf life and great commercial acceptance, with nutritional and sensory characteristics that can be improved through the incorporation of nutritious and functional foods (Oliveira et al., 2020).

Wheat flour is a basic ingredient for the various foods production, such as breads, cakes, pasta and cookies. However, most of the wheat nutrients are lost during the refined flour production, leaving only starch (Narwal et al., 2017). The wheat flour mixture with flours produced from tubers, vegetables, cereals and fruits can add benefits to the functional, physical-chemical and nutritional properties of the final product (Noorfarahzilah et al., 2014).

Okra (*Abelmoschus esculentus*) has a reasonable vitamin content, especially vitamin C and B complex; proteins; minerals, mainly calcium; and carbohydrates, such as soluble sugars, fibers, celluloses, hemicelluloses and lignin (Santos et al., 2013; Ashour et al., 2020). Studies have also demonstrated the great anti-diabetic and anti-hyperlipidemic potential (Sabitha et al., 2011), it helps in feeling full, reducing cholesterol, blood glucose and postprandial insulin levels, increasing fecal mass, in addition to acting in the fight against gastritis and neurodegenerative diseases, such as Alzheimer's (Mairuae et al., 2015)

The nutritional value of dehydrated fruit flours is higher than fresh fruit, due to the nutrients concentration resulting from the drying process (Alasalvar et al., 2020). Flours can be used as ingredients in several products, such as yoghurt, baby food and bakery products in general,

Received: 12 August 2020
Accepted: 21 February 2022

such as breakfast cereals and cookies (Aktağ & Gökmen, 2020).

The objective was to evaluate cookies made with partial replacement of wheat flour with okra flour, in order to obtain a new product, with high nutritional value and well accepted by the senses.

Material and Methods

The study was carried out in accordance with the Ethics Committee of the Instituto Federal de Educação, Ciência e Tecnologia do Ceará, under registration number 41102815.2.0000.5589, as required by Resolution No. 466 of 2012, of the Conselho Nacional de Saúde (Brazil, 2012).

Obtaining okra flour

Albemochus esculentus fruits were obtained at the local market in Limoeiro do Norte, Ceará, Brazil, selected, sanitized, removed the peduncles and dehydrated in a drying oven with air circulation (Ishimoto, 2007). The dehydrated fruits were crushed and the resulting flour was sieved, packed in plastic bags and stored at room temperature (average annual temperature of 30 °C) until the production of the cookies.

Cookies Preparation

Four biscuit formulations with partial substitution of wheat flour for okra flour were elaborated (Table 1).

Table 1. Cookies formulations made with and without okra flour.

Ingredients (%)	Formulations			
	A	B	C	D
Flour	100	95	90	85
Okra flour	0	5	10	15
Margarine	50	50	50	50
Egg	10	10	10	10
Dehydrated onion	5	5	5	5
Garlic	3.5	3.5	3.5	3.5
Salt	1.5	1.5	1.5	1.5
Oregano	0.3	0.3	0.3	0.3

A: standard biscuit, B: 5% okra flour, C: 10% okra flour, D: 15% okra flour.

The wheat and okra flours were mixed, added of the other ingredients, separately, and homogenized until a doughy and cohesive mass was formed. The dough was rolled and cut with the aid of plastic molds 3.5 cm in diameter and 0.6 cm thick to obtain the cookies. The cookies were then baked in a domestic oven at 200 °C for 20 minutes, cooled to room temperature and packed in plastic packaging. Three batches of each formulation were produced.

Physical and physical-chemical analysis

The biscuit formulations were submitted, in triplicate, to the analysis of:

Difference in mass- determined by the difference between the masses before and after the baking of three cookies of each formulation (Ornelas, 2001);

Thermal factor- determined by the ratio between the finished cookie dough and the dough before baking (Ornelas, 2001);

Yield- Obtained by the product of the thermal factor per 100 (Ornelas, 2001);

Humidity- determined using the drying method in an oven at 105 ° C until constant weight (IAL, 2008);

Ashes- by means of a muffle incineration at 550°C until constant weight (IAL, 2008);

Crude fiber- determined through Weende's method, by hot hydrolysis with diluted acids and alkalis (AOCS, 2005);

Proteins- determined by the classic micro Kjeldahl method, in which the total nitrogen content was measured and the result was converted into protein content by means of the product with the conversion factor 6.25 (IAL, 2008);

Lipids- determined by direct extraction in Soxhlet with hot solvents (IAL, 2008);

Carbohydrates- determined by the difference between 100 g of the sample and the contents of proteins, lipids, ash and fibers, according to resolution RDC n ° 360 (Brazil, 2003);

Caloric value- determined according to the guidelines of RDC nº 360, adopting a 100 g portion of biscuit. The levels of macronutrients obtained were multiplied by their respective caloric value coefficients, in which 1 g of carbohydrate has four kcal, 1 g of protein has four kcal and 1 g of lipid has nine kcal. Finally, the values were added to obtain the total caloric value of the portion (Brasil, 2003).

Microbiological analysis

The biscuit formulations were submitted, in

triplicate, to the microbiological analyzes required by RDC nº 12, of January 2, 2001, of the National Health Surveillance Agency (ANVISA), for biscuits and cookies, without filling, with or without coverage, including honey bread, cookies and the like, ready for use or consumption, stable at room temperature. Were evaluated:

Coliforms at 45 ° C- determined using the Most Likely Number (MLN g^{-1}) technique (Silva et al., 2017);

Salmonella sp.- determined through the method in stages of pre-enrichment, selective enrichment and isolation in specific media (Silva et al., 2017);

Coagulase positive staphylococci- determined using the direct plate counting method (Silva et al., 2017).

Sensory analysis

Acceptance and purchase intention tests were applied to 112 untrained voluntary evaluators, including men and women aged 18 to 40 years, students and employees of the institution, who agreed to participate in the study by signing the Informed Consent Form (IC).

The evaluators tested the cookies in individual booths, at room temperature and under blue light, in order to avoid that the color difference between the samples interfered in the evaluation. The formulations were presented in a balanced and random way (Dutcoski, 2007), disposed in disposable plastic cups of 80 mL coded with random numbers of three digits. The evaluators analyzed the acceptance as to the appearance, texture, flavor and overall impression of each sample through a Structured Hedonic Scale of nine points, with ends called "I disliked extremely" (1) to "I liked it extremely" (9). The Acceptability Index (AI) was calculated (1). The purchase intention was assessed using a five-point scale, varying between "I would not buy" (1) and "I would buy with certainty" (5) (Dutcoski, 2013).

$$AI\ (\%) = \frac{A \times 100}{B} \qquad (1)$$

Where: A = average of attributes, B = highest score obtained.

Statistical analysis

The data obtained were tabulated and analyzed using analysis of variance (ANOVA) and the means compared by the Tukey test at the level of 5% significance, using the software Assistat version 7.7 (Silva, 2016).

Results and Discussion

The mass of the cookies enriched with okra flour was greater in relation to the biscuit without the okra flour. The thermal factor and yield did not differ significantly (Table 2).

Table 2. Averages of the physical evaluations of the elaborated cookies.

Determinations	Formulations			
	A	B	C	D
Mass difference (g)	0.96±0.09b	1.20±0.078a	1.26±0.076a	1.26±0.03a
Thermal factor	0.84±0.02a	0.79±0.05a	0.79±0.03a	0.81±0.06a
Performance (%)	84.1 a	79.2a	78.8a	81.0a

Means followed by equal letters on the same line do not differ significantly by Tukey's test (p <0.05). Results expressed as mean ± standard deviation.

High values of mass difference before and after cooking indicate great losses in cooking, caused by the lower water retention capacity (CRA) of the cookie components dough after the wheat flour partial substitution for okra flour (Fasolin et al., 2007; Silveira et al., 2017). The lower CRA may be due to the low sugar okra flour content compared to wheat flour, since sugars have high hygroscopicity, which increase the cookies CRA (Fasolin et al., 2007). The thermal factor and yield are also indicative of changes from cooking, differing only that the yield is expressed as a percentage. The changes caused by cooking are mainly due to water loss, hygroscopicity, heat applied intensity, utensil type or equipment used, cooking time and labor used qualification (Amorim & Jokl, 2016).The ash contents, fiber and protein were higher in cookies enriched with okra flour, differing significantly from cookies without okra flour. The carbohydrate content and caloric value were higher in the standard formulation, without okra flour. There was no significant difference in the lipid content between cookies (Table 3).

The cookies presented moisture and ash contents within the identity standards and quality of the current legislation, which requires maximum levels of 14 and 3%, respectively (Brasil, 1978). Humidity is an essential parameter that directly affects the product's useful life, considering that high moisture levels favor microbial development (Holanda et al., 2020). The food ash content expresses the inorganic residue that remains after the burning of organic matter (Vieira et al., 2018) and varies significantly according to the species of fruits and vegetables used. The formulated cookies ash content increased proportionally to the okra flour amount added, showing that the wheat flour partial substitution for that okra enriched the mineral contents.

Table 3. Average results of the physical-chemical characterization and caloric value of the cookies.

Determinations	Formulations			
	A	B	C	D
Moisture (%)	5.32±0.1b	6.23±0.1a	3.52±0.1c	5.25±0.1b
Ashes (%)	3.48±0.1c	3.66±0.1b	4.05±0.1a	4.10±0.1a
Fibers (%)	3.70±0.9b	5.89±1.9ab	7.44±0.6ab	8.34±3.5a
Proteins (%)	9.48±0.2b	9.48±0.2b	10.02±0.3ab	10.24±0.4a
Lipids (%)	22.60±0.8a	23.17±1.0a	23.26±0.2a	22.75±1.3a
Carbohydrates (%)	55.42±1.7a	51.89±1.2ab	51.06±0,2ab	51.38±4.0b
CV (kcal/100g)	463.00	454.06	453.64	451.23

Means followed by equal letters on the same line do not differ significantly by Tukey's test ($p < 0.05$). Results expressed as mean ± standard deviation.

The consumption of fibers beneficially helps in the modulation of processes related to satiety and in the prevention of chronic pathologies, such as cardiovascular diseases, diabetes, obesity and colon cancer (Oliveira et al., 2020).

The fiber content increased proportionally to the amount of okra flour added because okra is a vegetable with a high fiber content (Costa et al., 2020). Formulations C and D, with the addition of 10 and 15% of okra flour, obtained fiber contents above 6%, being able to use the claim of "high content" in fibers, as allowed by the current legislation (Brasil, 2012).

Proteins are macromolecules that constitute one of the three main nutrients ingested in the human diet (Hammond et al., 2013). They are essential for the functioning of energy metabolism, the perception of sweetness and the responses of blood glucose levels, etc. (San-Cristobal et al., 2020). Protein contents were higher in formulations C and D, made with higher amounts of okra flour, because okra is a vegetable with a high protein content, especially in the content of essential amino acids (Oliveira et al., 2020).

Lipids are important macromolecules due to their function of delaying gastric emptying and reducing the immediate postprandial hyperglycemic peak (Santos et al., 2017). However, high-fat diets often cause comorbidities related to systemic inflammation that can cause cardiovascular problems, induce insulin resistance in muscle tissues, liver and adipose tissue, etc. (Alcântara et al., 2020). In addition, foods with a high lipid content have a reduced shelf life due to rapid degradation by oxidative reactions, in which strange flavors and aromas are formed (Ganiari et al., 2017). There was no significant difference in the lipid content of formulations containing okra flour compared to the standard formulation since the okra pulp is poor in this macronutrient (Bueno, 1980).

Carbohydrates are macromolecules that occupy the main place in human nutrition, constituting the largest source of energy readily available and satisfying the instinctive desire for sweetness (Lykke & Padonou, 2019). Carbohydrates with a high glycemic index, such as those in breads and doughs, generate free radicals that stimulate key chronic transcriptionals that intensify the expression of inflammatory proteins, facilitating the appearance of joint inflammation and chronic fatigue (Shelton & Miller, 2010). The carbohydrate content was lower in formulations containing okra flour because it contains less carbohydrates than wheat flour. While wheat contains around 60 g 100 g^{-1}, okra has 6.4 g of carbohydrates per 100 g of pulp (Souza et al., 2019).

Obesity is a public health problem that affects more than 650 million people worldwide (Al-Nbaheen, 2020). The imbalance in energy input and output is the basic reason for weight gain (Schmidt et al., 2017). This is because exposure to high-calorie foods stimulates subsequent intake (Coelho et al., 2012), causing individuals to consume more and more calories, reducing energy balance and favoring weight gain (Schmidt et al. , 2017). The caloric content of cookies made with okra flour was lower than the standard formulation, mainly due to the higher carbohydrate content of wheat flour compared to okra flour. Cookies using okra flour are a healthy alternative for consumers with a predisposition to obesity.

The cookies prepared are in accordance with the microbiological standards required by current legislation, as shown below (Table 4).

Table 4. Average results of the microbiological evaluation of the cookies.

Assay	Formulations				Brasil (2001)
	A	B	C	D	
Coliformes at 45°C (*NMP)	<3.0	<3.0	<3.0	<3.0	10/g
Estafilococus coagulase positiva (**UFC)	<10	<10	<10	<10	$5x10^2$/g
Samonella sp.	Ausência	Ausência	Ausência	Ausência	Ausência/25g

*MPN/g: Most Likely Number per gram of the sample analyzed.

**UFC/g: Colony Forming Unit per gram of the analyzed sample.

Coliforms are pathogenic bacteria that develop even at refrigerated temperatures, causing diarrhea and other diseases when associated with other microorganisms (Sedki et al., 2017). Enterotoxigenic Staphylococcus, such as those of the positive coagulase type, represent a great risk to public health due to the synthesis of enterotoxins that cause food poisoning (Andrade et al. 2011). Salmonella is a pathogen associated with animal reservoirs and transmitted by food, being one of the main causes of systemic typhoid fever and diarrhea (Al-Rifai et al., 2020). The absence of adequate hygienic-sanitary control is the biggest cause of the development of pathogenic microorganisms (Soon, 2019). The results indicate that the handling during the production and storage processes took place under adequate hygienic-sanitary control and that, therefore, the cookies can be considered suitable for consumption.

The cookies presented acceptance equivalent to "I liked it extremely" and "I liked it moderately". Cookies made with 0 (standard) and 5% okra flour were the most accepted by the evaluators, as shown below (Table 5).

Table 5. Average results of the sensory evaluation of the cookies.

Attributes	Formulations			
	A	B	C	D
Appearance	7.53±1.4a	7.08±1.5a	6.53±1.5b	6.33±1.9b
Flavor	7.14±1.9a	6.76±1.8a	5.83±1.8b	5.01±2.2b
Texture	7.09±1.6a	6.83±1.7ab	6.38±1.7bc	5.88±1.8c
Global impression	7.24±1.5a	6.90±1.5a	6.07±1.6b	5.60±1.9b

Means followed by equal letters on the same line do not differ significantly by Tukey's test (p <0.05). Results expressed as mean ± standard deviation.

Appearance is an attribute directly related to the consumer's purchase decision (Viana et al., 2018). The greater acceptance of the appearance of formulations with 0 and 5% okra flour refers to the difficulty that the consumer finds in accepting products with different aspects of the common, since food neophobia is one of the main barriers in the acceptance of differentiated foods (Torri et al., 2020). Flavor is seen as the main attribute considered in food acceptance (Andersen et al., 2019). The lower acceptance of formulations C and D demonstrates a certain rejection of the outstanding residual flavor of okra in these formulations. However, acceptance of the flavor of formulation B demonstrates that the addition of 5% okra flour does not significantly alter the flavor of the cookies compared to the standard formulation. Texture is another attribute that directly influences the perception of taste and the commercialization of food products (Kortei et al., 2020). Formulations C and D obtained less acceptance in texture, probably due to the presence of dehydrated okra mucilage, which promoted an unwanted aspect seen by the evaluators (Oliveira et al., 2020), in addition to the high fiber content that forms a sticky mass. and with little extensibility (Kaur et al., 2019). The global impression, referring to the general acceptance of the product (Silva et al., 2017), shows that formulations A and B were equally accepted, demonstrating that the addition of concentrations of okra flour at levels of 5% adds nutritional value without interfering negatively on the sensory acceptance of cookies.

Cookies made with 0 (standard) and 5% okra flour had the highest Acceptability index (Table 6).

Table 6. Acceptability index for cookies.

Attributes	Formulations			
	A	B	C	D
Appearance (%)	83.67	78.67	72.56	70.33
Flavor (%)	79.33	75.11	64.78	55.67
Texture (%)	78.78	75.89	70.89	65.33
Global impression (%)	80.44	76.67	67.44	62.22

A: standard biscuit, B: 5% okra flour, C: 10% okra flour, D: 15% okra flour.

The evaluation of the acceptability index (AI) of new products is essential to predict their behavior in relation to the consumer market (Bastos et al., 2014). Products considered sensorially well accepted must obtain averages of acceptability index (AI) ≥ 70% (Dutcosky, 2008). All attributes of formulations A and B obtained AI greater than 70%, demonstrating that there is no negative interference in the acceptance of cookies added with okra flour in concentrations of up to 5%. The flavor, texture and global impression attributes of the other formulations obtained little acceptance by the evaluators, suggesting possible commercial rejection.

Cookies made with 0 (standard) and 5% okra flour showed the highest frequency of positive purchase intention, as shown below (Table 7).

Table 7. Percentage of purchase intention values for cookies.

Buy intention	A	B	C	D
1 (%)	29.46	27.68	7.14	8.93
2 (%)	28.57	23.21	11.61	10.71
3 (%)	22.32	25.89	34.82	20.54
3 (%)	11.61	14.29	28.57	33.04
5 (%)	8.04	8.93	17.86	26.79

1: would certainly buy, 2: would probably buy, 3: indifference, 4: probably would not buy, 5: certainly would not buy.

Formulations A and B had the highest frequencies of positive purchase intent ("certainly would buy" and "probably buy"), while C and D had the highest frequency of negative purchase intent ("probably would not buy" and "certainly would not buy"). The purchase intention corroborates with the sensory evaluation on a hedonic scale and AI of the attributes by demonstrating the preference of the evaluators for formulations A and B, with a lower concentration of okra flour.

This behavior is the result of the strong residual flavor that okra gives to the final product.

Conclusions

Cookies made with partial substitution of wheat flour for okra flour obtained better nutritional quality without interfering with their good sensory acceptance when used in concentrations of up to 5%.

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.