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Bread enriched with flour from cinereous cockroach (*Nauphoeta cinerea*)

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ABSTRACT

Animals and insects are the main sources of protein. The objective of the present study was to produce a flour from *cinereous cockroach* (*Nauphoeta cinerea*) for protein enrichment of wheat bread. To prepare the flour, the dehydrated insects were crushed and sieved to reduce the granulometry to a particle size of 1.18 mm. The flour was analyzed microbiologically and then added in amounts of 5, 10, and 15% (based on wheat flour) in a bread formulation that was analyzed for chemical composition and color, firmness, and specific volume and compared to white wheat bread and whole wheat bread. Sensorial evaluation was carried out on bread enriched with 10% roasted flour as the one that presented the best nutritional characteristics, differing little from the white and whole wheat bread. It is concluded that the use of *cinereous cockroach* (*Nauphoeta cinerea*) flour is an efficient way to enrich wheat bread without alterations in sensorial quality.

1. Introduction

A report released by the United Nations (UN) discloses that the world population is expected to reach > 9.2 billion by 2050. This represents a great challenge to the availability of resources to meet the needs of this enormous population. Increased productivity, new and more efficient and sustainable technical proposals to combat crop pests, and more appropriate product handling to minimize losses to marketing, among other factors, will be needed so that the world food production meets the growing demand for decades to come (Zuben, 2012).

Wild animals and insects are often the main sources of protein in forest areas, while leaves, seeds, mushrooms, honey, and fruits provide minerals and vitamins that ensure a nutritious diet. The forecast of the UN Food and Agriculture Organization (FAO) says that the land area intended for breeding will have to grow by 70% to feed the planet's population by 2050, which is expected to reach 9 billion people, and even with the small amount of insects that can be consumed by humans (only 1600 edible types in 1.5 million species cataloged), the frenetic pace at which insects reproduce makes their “meat” an abundant source of food. They are rich in protein, vitamins (especially vitamin B), and minerals, such as iron and calcium. In addition, they are rich in lipids and essential fatty acids (Dicke, 2012; Heymans & Evrard, 1970; Landry, De Foliart, & Sundae, 1986; MacEvilly, 2000; Phelps, Struters, & Moyo, 1975).

According to Lynn Kimsey (2014), entomology professor at the University of California in the United States, besides being more nutritious than other types of meat, it is cheaper to raise insects than cattle. Since insects are cold-blooded, have more complex metabolisms than warm-blooded animals, and can adapt to different temperature levels, they need less food and a simpler and cheaper feed. In addition, insects take up less space and reproduce faster than other animals commonly seen in pastures. And at the end of the process, they are better leveraged by the fact that many parts of cattle, for example, are not used for human consumption, such as the hooves, teeth, bones, and skin, which are commonly used in the manufacture of animal feed.

The FAO lists the benefits of large-scale insect production: 2 kg of feed is required to produce 1 kg of insects, whereas cattle require 8 kg of feed to produce 1 kg of meat. The insect feed is simple because it can be made from agricultural residues. Insects are extremely ecological; they use much less water and produce less greenhouse gases than cattle (Durst, Johnson, Leslie, & Shono, 2006).

Several groups of insects can be found in abundance in different environments; one can therefore infer that a large amount of biomass is not utilized as a food source for humans. And since in the future the greatest challenge for humanity will be growing food in increasingly greater quantity, insects are likely to be an important food source (MacEvilly, 2000; Zuben, 2012).

Worldwide, the base of the food pyramid is made up of carbohydrates. Because of this, bread has high consumption because it is high in this energy source, and it is not an expensive food. It can be consumed by all social classes, from a food supplement, as seen in families with

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greater purchasing power, or even as one of the few sources of food, as seen in low-income families. Bread can be purchased in high-end establishments or produced at home in a more artisanal way. Therefore, aiming at the protein enrichment of bread, this study set out to modify a product very popular in Brazil using a type of insect, the *cinereous cockroach* (*Nauphoeta cinerea*).

2. Materials and methods

2.1. Raw materials

Wheat flour was purchased in the local market of Rio Grande, RS, and flour based on the cinereous cockroach (*Nauphoeta cinerea*) was provided by Nutrinsecta, a company that develops ingredients for animal feed that is certified by the Ministry of Agriculture, Livestock and Supply. Insects were reared obeying strict environmental and health standards. They were fed with fruit and vegetable remains, slaughtered in boiling water, and dried in an oven and packaged. The ingredients used for the production of bread, such as hydrogenated vegetable oil (Primor), sodium chloride (Synth), and sucrose (União), were purchased from the local shops. Additives such as ascorbic acid PA (Synth), manufacturing aids, and fresh yeast (Fleischmann) were also used.

2.2. Methods

2.2.1. Obtaining the insect flour

To obtain the flour, cinereous cockroaches, received dehydrated, were ground in a ball mill for 3 h. Subsequently, the flour obtained was sieved through a 14 mesh and then packaged in glass jars and kept refrigerated at 4 °C until testing.

2.2.2. Assessment of cinereous cockroach flour

2.2.2.1. Chemical composition of the insect flour. The following chemical analysis was conducted on the cockroach flour:

a) Humidity: determined according to AACC (2000), Method No. 44-15[a];
b) Ash: determined according to AACC (2000), Method No. 08-01;
c) Protein: determined according to the Kjeldahl method, AACC (2000), Method No. 46-13;
d) Total lipids: the fat content was determined by the Soxhlet method, AACC (2000), Method No. 30-20;
e) Fibers: determined by the Adolfo Lutz Institute (Zenebon & Pascuet, 2008);
f) Amino acid profile: determined by high-performance liquid chromatography (HPLC) in CBO laboratory, Campinas São Paulo/Brazil;
g) Fatty acids: determined by gas chromatography in CBO laboratory, Campinas São Paulo/Brazil.

2.2.2.2. Microbiological evaluation of cockroach flour. In the microbiological evaluation, analyses were carried out to determine thermo-tolerant coliforms at 45 °C and mold and yeast counts. These analyses were performed following the procedures described by the American Public Health Association (APHA, 2001). To verify the sanitary conditions, the sample was subjected to *Salmonella* analysis according to NBR 12124 - MB 3465/1991 (*Salmonella* - Determination in Food) and positive *Staphylococcus* coagulase following the procedures described by the APHA (2001).

2.2.3. Formulation of standard and insect flour-added breads

The straight dough method was used for the preparation of the bread. Three formulations (Table 1) with different quantities (5%, 10%, and 15% of cockroach flour in wheat flour basis) were evaluated and compared to the standard bread to verify the influence on the specific volume (SV), hardness, color, protein content, and sensory quality.

Table 1
Formulations of the bread used in the study.

Ingredients	Standard bread	Bread enriched with cockroach flour		
		5%	10%	15%
Wheat flour (g)	300	285	270	255
Insects flour (g)	–	15	30	45
Sodium chloride (g)	6	6	6	6
Sucrose (g)	15	15	15	15
Fresh yeast (g)	9	9	9	9
Ascorbic acid (g)	0.027	0.027	0.027	0.027
Hydrogenated vegetable fat (g)	6	5.47[a]	1.94[a]	0[a]
Water (mL)	180	160	160	158

[a] Fat content present in the insect flour was deducted from the formulation.

2.2.3.1. Elaboration of standard and cockroach flour-enriched bread. First, the dry ingredients were blended into a planetary mixer (Kitchen-Aid) followed by the addition of vegetable fat, water, and dissolved yeast. The mixture was done at full speed for 10 min until the gluten was developed. The dough was weighed, divided into 80-g pieces, rounded in a spherical shape by hand, modeled with a roll of pasta and placed with roll and put into greased individual metal pans (3 × 5 × 11.5 cm). The fermentation step was carried out in an oven (Q317M-Quimis) at 30 °C for 95 min, with controlled temperature and relative humidity. Baking occurred at 200 °C for 20 min in an electric oven (Diplomata-Fischer). The resulting breads were cooled to ambient temperature and examined after 1 h of rest.

2.2.4. Evaluation of bread quality

The evaluation of bread quality was performed by determining the external and internal characteristics, aroma, and taste according to El Dash, Diaz, and Camargo (1982) spreadsheet. The parameters analyzed as external characteristics were crust color, breaking, symmetry, and SV (mL/g), which was obtained by the ratio between the apparent volume (mL) carried by millet seed displacement according to Pizzinatto, Magno, Campagnollli, Vitti, and Leitao (1993) and the mass (g). Crust characteristics, crumb color, crumb cell structure, and crumb texture were analyzed as internal characteristics. Subsequently, the aroma and taste were analyzed.

2.2.4.1. Crumb hardness. The hardness of the bread crumb was measured on fresh bread after 1 h of baking and held in a texturometer TA-XT2 (Stable Micro Systems, UK). The test was performed according to AACC method 2000 (74-09.01), which consists of compressing two slices of 25 mm thickness in the texturometer platform center with a cylindrical probe of 36 mm diameter under the following working conditions: pre-test speed of 1.0 mm/s, test speed of 1.7 mm/s, post-test speed of 10.0 mm/s, 40% compression, and trigger force of 5 g.

2.2.4.2. Crumb color. The analysis of the bread crumb and crust was done in a Minolta® CR400 colorimeter (Minolta, 1993). The experiment followed the color system in the L* a* b* (or CIE L*a*b*) space defined by the CIE (International Commission on Illumination) in 1976, evaluating the L* values (brightness) and a* and b * (chromaticity coordinates). The value of chroma or C* and hue angle or h_{ab} was also calculated, referred to as the CIELCh color system according to Minolta (1993) (Eqs. (1) and (2)).

$$\mathbf{C}^* = (a*^2 + b*^2)^{\frac{1}{2}} \tag{1}$$

$$h_{ab} = \tan^{-1} \cdot \frac{b^*}{a^*} \tag{2}$$