Cricket Powder (*Gryllus assimilis*) as a New Alternative Protein Source for Gluten-free Breads

Carolina da Rosa Machado*, Roberta Cruz Silveira Thys

Institute of Food Science and Technology, Federal University of Rio Grande do Sul, Porto Alegre, RS, Brazil

* Corresponding author: carolinarmachado@live.com

INTRODUCTION

Considering that world population is projected to reach 8.6 billion of people in 2030 (United Nations, 2017) and that land and water resources are becoming ever more scarce (van Huis et al., 2013), it seems necessary to find alternative and sustainable ways of growing food.

The major environmental advantages of insect farming compared to livestock production are: less land and water is required; lower greenhouse gas emissions; insects have high feed conversion efficiencies; insects can transform low-value organic by-products into high quality food or feed; and certain species can be used as animal feed or aqua feed (van Huis and Oonincx, 2017).

The main components of insects are protein (reaching 77% in some species) and fat, followed by fibre and ash in no particular order (Rumpold & Schlüter, 2013).

The addition of the right protein sources in ideal amounts in gluten-free products is essential to form protein structures similar to gluten, which can partially mask changes caused by starch retrogradation (Moore, Schober, Dockery, & Arendt, 2004) and also play an important role on the carbon dioxide holding capacity of the dough (Ziobro, Witczak, Juszczak, & Korus, 2013). Furthermore, the addition of non-gluten proteins has important nutritional and sensorial roles, as it reduces amino acid deficits and improves the colour and sensory properties of gluten-free bread (Wang, Lu, Li, Zhao, & Han, 2017).

The purpose of this study was characterise cricket powder (*Gryllus assimilis*) and evaluate its effects on technological properties of gluten-free bread, in comparison with widely used protein sources in gluten-free formulations: legume (lentil) and pseudo cereal (buckwheat) flours.

METHODS

Characterisation of cricket powder:

- Proximate chemical composition: moisture, protein, lipids and ash (AACC International, 2012), total dietary fibres (AOAC International, 1995)
- Non-protein nitrogen: TCA (Trichloroacetic acid) precipitation method (DeVries et al., 2017)
- Water and oil holding capacities (WHC & OHC) (Kabirullah and Wills, 1982)
- Microbiological analyses: yeasts and moulds, thermotolerant coliforms at 45 °C and *Staphylococcus aureus* (APHA, 2001), Salmonella spp. (AOAC International, 1995)

All analyses were carried out in triplicate.

Bread formulations:

Table 1. Control and enriched breads formulations

Ingredients (% flour basis)	Control	Enriched breads	
		10%	20%
Rice flour	30	30	30
Cornstarch	70	70	70
Protein source	-	10	20
Sugar	2	2	2
Canola oil	4	4*	4*
Salt	2	2	2
Yeast	2.5	2.5	2.5
Mono- and diglycerides of fatty acids	0.5	0.5	0.5
Xanthan gum	1	1	1
Carboxymethyl cellulose	1	1	1
Water	150	150	150

* Due to the high lipid content in the cricket powder, further loaves were prepared using the same formulations but with no addition of canola oil.

Bread quality evaluation:

- Moisture, protein and total lipids contents (AACC International, 2012)
- Non-protein nitrogen: TCA precipitation method (DeVries et al., 2017)
- Crust and crumb colour: Chroma meter (Minolta®, CR400, Japan)
- Texture profile analysis (TPA): hardness, cohesiveness, springiness and chewiness (Texture Technologies Corp. and Stable Micro Systems, 2018).
- Loaf volume: rapeseed displacement method (AACC International, 2012)
- Internal structure of the loaves: porosity, cell density, and percentage of pores bigger than 5 mm (Ziobro, Juszczak, Witczak, & Korus, 2016) were analysed by ImageJ software v. 1.52 (National Institutes of Health, US)

All analyses were carried out in triplicate. Differences between the formulations were evaluated by one-factor analysis of variance and Tukey's test (significance level of $p < 0.05$) using Minitab software v. 18.1 (Minitab Inc., State College, US).

RESULTS

Characterisation of cricket powder:

Proximate chemical composition (g/100g) in dry basis: protein - 62.76 ± 1.12 (non-protein nitrogen - 0,75 ± 0,01); lipids - 20.96 ± 0.28; dietary fibres - 8.42 ± 0.75; ash - 3.19 ± 0.04 and moisture - 9.70 ± 0.06.

WHC and OHC: 2.87 ± 0.04 g_{water}/g_{powder} and 3.22 ± 0.26 g_{oil}/g_{powder}.

Microbiological evaluation: moulds and yeasts – 4 x 10^2 CFU/g; thermotolerant coliforms at 45°C – 4.3 x 10^1 MPN/g; Salmonella spp. – absence in 25g; *Staphylococcus aureus* - <1.0 CFU/g.

Bread quality evaluation:

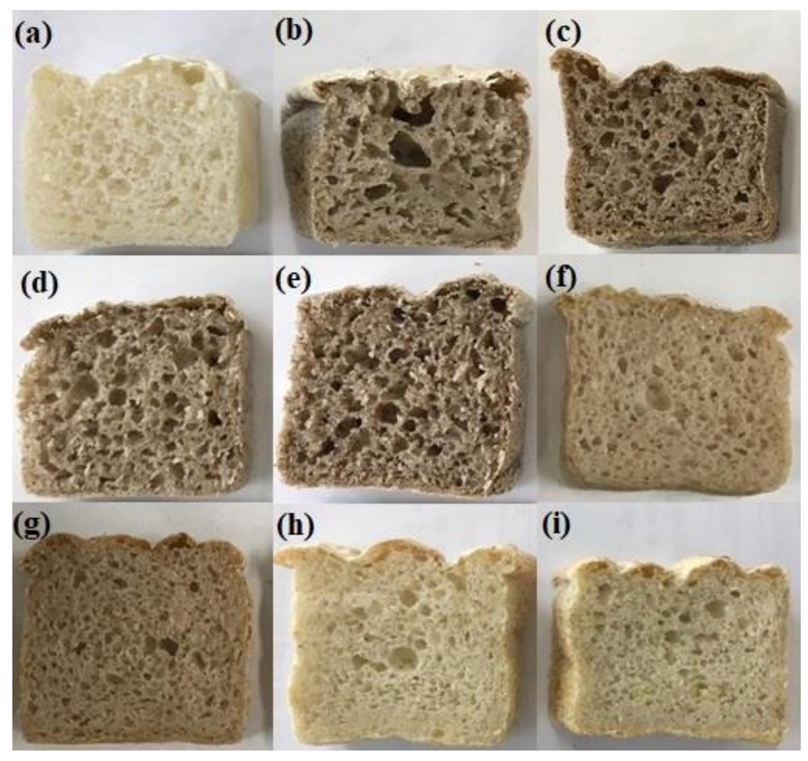

Fig. 1. Internal structure of bread slices: (a) control, (b) cricket 10%, (c) cricket 20%, (d) cricket 10% no oil, (e) cricket 20% no oil, (f) buckwheat 10%, (g) buckwheat 20%, (h) lentil 10%, (i) lentil 20%.

Table 2. Moisture, protein and lipids contents of the breads (dry matter)

	Moisture (g/100 g)	Protein (g/100 g)	Lipids (g/100 g)
Control	61.77 ± 0.27^{a}	6.07 ± 0.12^{de}	1.20 ± 0.11^{d}
Cricket 10%	60.49 ± 0.08^{a}	8.53 ± 0.08^{b}*	3.23 ± 0.18^{b}
Cricket 20%	58.45 ± 0.16^{a}	12.52 ± 0.07^{a}*	4.49 ± 0.29^{a}
Buckwheat 10%	61.52 ± 0.03^{a}	5.24 ± 0.61^{e}	1.19 ± 0.09^{d}
Buckwheat 20%	60.03 ± 0.08^{a}	6.25 ± 0.16^{cde}	2.40 ± 0.29^{c}
Lentil 10%	61.97 ± 1.62^{a}	6.63 ± 0.12^{cd}	1.27 ± 0.08^{d}
Lentil 20%	59.93 ± 0.14^{a}	7.13 ± 0.11^{c}	1.43 ± 0.02^{d}

Values labeled with different letters in the same column are significantly different (p<0 .05)

* Non-protein nitrogen (g/100g): cricket 10% - 0.11 ± 0.00; cricket 20% - 0.17 ± 0.00

Table 3. Results from Texture Profile Analysis of control and enriched breads crumbs

	Hardness (g)	Cohesiveness	Springiness	Chewiness (g)
Control	557.8 ± 21.2^{e}	0.75 ± 0.01^{ab}	1.038 ± 0.007^{abc}	435.7 ± 21.4^{d}
Cricket 10%	1209.6 ± 10.6^{b}	0.64 ± 0.03^{cd}	1.060 ± 0.008^{a}	819.5 ± 33.6a^{bc}
Cricket 20%	1524.5 ± 151.9^{a}	0.63 ± 0.01^{d}	1.056 ± 0.005^{ab}	1020.4 ± 108.5^{a}
Cricket 10% (no oil)	768.7 ± 54.7^{de}	0.81 ± 0.03^{a}	1.040 ± 0.006^{abc}	651.0 ± 43.9^{c}
Cricket 20% (no oil)	1062.1 ±101.6^{bc}	0.73 ± 0.00^{b}	1.052 ± 0.006^{ab}	818.7 ± 88.1^{abc}
Buckwheat 10%	804.0 ± 80.7^{d}	0.76 ± 0.03^{ab}	1.028 ± 0.004^{c}	631.0 ± 43.9^{cd}
Buckwheat 20%	1075.6 ±121.2^{bc}	0.70 ± 0.02^{bcd}	1.033 ± 0.007^{bc}	728.2 ± 30.6b^{c}
Lentil 10%	962.2 ± 57.3^{cd}	0.73 ± 0.04^{b}	1.045 ± 0.017^{abc}	733.6 ± 76.0^{c}
Lentil 20%	1296.6 ± 69.2^{ab}	0.71 ± 0.04^{bc}	1.037 ± 0.004^{abc}	954.5 ± 100.2^{ab}

Values labeled with different letters in the same column are significantly different (p<0 .05)

CONCLUSIONS

Analyses carried out in the cricket powder confirmed its good sanitary attributes for human consumption, in addition to its high protein and lipids contents. Moreover, the high WHC of the insect powder indicates that bakery products enriched with it can maintain good technological properties during storage.

All of the enriched breads presented crumbs with higher hardness and chewiness than the control bread. However, for the ones enriched with cricket powder, those parameters improved after canola oil was removed from the formulations, resulting in products with similar characteristics to the control sample. The addition of cricket powder led to nutritional improvements of the loaves in relation to protein values. The use of insect powder also resulted in significant increases in lipid contents; therefore, the use of defatted cricket powder or oil-free formulations is recommended in order to obtain nutritionally richer products.

The results found in this study indicate that it is possible to produce good quality gluten-free bread by its enrichment with cricket powder. Further sensory analysis is advisable to verify the acceptance of this product by potential consumers.

REFERENCES

AACC International. (2012). *Approved Methods of Analysis* (11th ed.). St. Paul, MN: American Association of Cereal Chemists (AACC).

AOAC International. (1995). Official Methods of Analysis of AOAC International (16th ed.). Arlington: Association of Official Agricultural Chemists (AOAC).

APHA. (2001). Compendium of Methods for the Microbiological Examination of Foods. In I. F. P., Downes; K. (Ed.) (4th ed.). Washington: American Public Health Association (APHA).

DeVries, J. W., Greene, G. W., Payne, A., Zbylut, S., Scholl, P. F., Wehling, P., … Moore, J. C. (2017). Non-protein nitrogen determination: A screening tool for nitrogenous compound adulteration of milk powder. *International Dairy Journal*, *68*, 46–51.

Kabirullah, M., & Wills, R. B. H. (1982). Functional properties of acetylated and succinylated sunflower protein isolate. *International Journal of Food Science & Technology*, *17*(2), 235–249. Rumpold, B. A., & Schlüter, O. K. (2013). Nutritional composition and safety aspects of edible insects. *Molecular Nutrition and Food Research*, *57*(5), 802–823.

Texture Technologies Corp. and Stable Micro Systems, L. (2018). Chapter IV - What does TPA measure? Retrieved October 21, 2018, from https://texturetechnologies.com/resources/texture-profile-analysis

United Nations, Department of Economic and Social Affairs, Population Division (2017). World Population Prospects: The 2017 Revision, Key Findings and Advance Tables. ESA/P/WP/248.

van Huis, A., & Oonincx, D. G. A. B. (2017). The environmental sustainability of insects as food and feed. A review. *Agronomy for Sustainable Development*.

Van Huis, A., Van Itterbeeck, J., Klunder, H., Mertens, E., Halloran, A., Muir, G., & Vantomme, P. (2013). Edible Insects: Future prospects for food and feed security. Rome: Food and Agriculture Organization of the United Nations.

Wang, K., Lu, F., Li, Z., Zhao, L., & Han, C. (2017). Recent developments in gluten-free bread baking approaches: a review. *Food Science and Technology*, *37*(suppl 1), 1–9.

Ziobro, R., Juszczak, L., Witczak, M., & Korus, J. (2016). Non-gluten proteins as structure forming agents in gluten free bread. *Journal of Food Science and Technology*, *53*(1), 571–580.

Ziobro, R., Witczak, T., Juszczak, L., & Korus, J. (2013). Supplementation of gluten-free bread with non-gluten proteins. Effect on dough rheological properties and bread characteristic. *Food Hydrocolloids*, *32*(2), 213–220.