CHEMICAL ENGINEERING TRANSACTIONS
VOL. 93, 2022
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.cetjournal.it
Guest Editors: Marco Bravi, Alberto Brucato, Antonio Marzocchella

ISBN 978-88-95608-91-4; **ISSN** 2283-9216
DOI: 10.3303/CET2293035

Physico-Chemical and Sensory Characteristics of Barbecue Sauce as Influenced by Cricket Flour (*Gryllus Assimilis*)

Sergio E. Fernández[a], Jhunior A. Marcía*[b], Roy D. Menjívar[a], Ricardo J. Santos[c], Ana G. Pinto[d], Ismael Montero-Fernandez[e], Jose T. Reyes[d]

[a] Faculty of Agrarian Sciences, Universidad Nacional de Agricultura, Catacamas, Olancho, Honduras
[b] Faculty of Technological Sciences, Universidad Nacional de Agricultura, Catacamas, Olancho, Honduras
[c] Department of Food Science, Louisiana State University, USA
[d] Faculty of Earth Sciences and Conservation, Universidad Nacional de Agricultura, Catacamas, Olancho, Honduras
[e] Department of Organic and Inorganic Chemistry, University of Extremadura, Cáceres, Spain.
jmarcia@unag.edu.hn

The addition of cricket flour into foods has been extensively examined giving its great economic, nutritional, and environmental advantages. Even though entomophagy presents great economic, nutritional, and environmental benefits, there is yet a notable reluctance to insects as foods. Consequently, the use of edible-cricket flour (ECF) in foods is quite challenging. For this reason, the aim of this study was to evaluate the physicochemical and sensory properties of barbecue sauce (BS) as affected by cricket flour. Barbecue sauce formulations without (Control) and with 5% (T1), 10% (T2) & 15% (T3) w/w were evaluated by 100 panelists (color, aroma, texture, flavor, overall liking, and purchase intent) under the following informed condition: without ECF (ECF−) and with ECF + benefits (ECF+). In addition, the pH, brix, viscosity, color (L*, a*, b*, browning index), and texture (firmness & adhesiveness) were analyzed. The crickets were farmed and the ECF was made by, baking, grounding, and drying processes. The addition of ECF into BS did not drive to a significant ($P < 0.05$) difference in the pH while ECF affected color, brix, texture, and viscosity. When compared to control, the color, aroma, texture, flavor, and overall liking did not differ significantly ($P < 0.05$) only among samples containing 5% of ECF (T1). Furthermore, purchase intent and overall liking were significantly ($P < 0.05$) increased with the beneficiary statement only among T1 samples. To sum up, 5% of ECF can be added when improving the nutritional profile of barbecue sauce.
Keywords: Gryllus assimilis, barbecue sauce, cricket flour, physico-chemical, sensory characteristics.

1. Introduction

In developing countries, food insecurity is a matter of great concern given the predicted rise in the global population. To overcome food insecurity worldwide, it's crucial to develop sustainable and nutrient-dense foods from alternative economic sources. The inclusion of insect diets or ingredients has been extensively examined giving its great economic, nutritional, and environmental advantages. The insect-based food production systems are more eco-friendlier and economically viable than the animal-based food production systems (Glover & Sexton, 2015; Alfaro et al., 2019). Furthermore, edible insects are rich in nutrients such as protein, minerals, essential amino acids, and B-complex vitamins to name a few (de Castro et al., 2018). ECF in foods has become a trend in recent years since it has been recommended to be utilized in food products such as snacks, cereal bars, protein shakes, bread, and tortillas (Ardoin & Prinyawiwatkul, 2020). Even though entomophagy presents great economic, nutritional, and environmental benefits, there is yet a notable reluctance to insects as foods. Largely in the Western world, food neophobia could cause badly perceived sensory quality and negative emotions (Huis, Dicke, & Loon, 2015). Therefore, it's noteworthy to examine the influence of CS on BS regarding physicochemical and sensory characteristics. Furthermore, this study is the first to analyze these effects.

Paper Received: 12 February 2022; Revised: 17 March 2022; Accepted: 30 April 2022
Please cite this article as: Fernandez S.E., Marcia J.A., Menjivar R.D., Santos R.J., Pinto A.G., Montero-Fernandez I., Reyes J.T., 2022, Physico-Chemical and Sensory Characteristics of Barbecue Sauce as Influenced by Cricket Flour (Gryllus Assimilis), Chemical Engineering Transactions, 93, 205-210 DOI:10.3303/CET2293035

2. Materials and method

2.1 Cricket farming and cricket flour preparation

Cricket farming took place in the National University of Agriculture (UNAG) cricket farm, Olancho, Honduras. Crickets (*Gryllus assimilis*) were obtained from the entomology laboratory at UNAG. In three months, crickets were fed with grounded corn, palm kernel, wheat flour, and fresh cabbage and there were held in a fragill cricket cage bucket 1280 (Fragill, WI, USA) at 35 ˚C. To obtain ECF, crickets (after three months) were dehydrated in a convection oven (Digitronic TFT- Selecta, J.P. SELECTA, Barcelona, Spain) at 50 °C/48 h and were grounded in a knife mill Retsch SM 100 (Retsch GmbH, Germany) (501-700 mm).

2.2. Barbecue formulation & preparation

The BS was made with margarine (12.2%) (Mazola, San Pedro, Honduras), mustard (12.2%) (Heinz, PA, USA), brown sugar (21.3%) (Doña Matilde, San Pedro, Honduras), tomato paste (15.2%) (Naturas, San Pedro, Honduras), soy sauce (3.8%) (Don Julio, San Pedro, Honduras), liquid smoke Colgin (0.5%) (Colgin, TX, USA), ketchup (4.6%) (Heinz, PA, USA), and water (30.4%) (Agua Azul, San Pedro, Honduras). The ingredients were purchased in Walmart (Catacamas, Olancho, Honduras). Cricket flour was incorporated with the ingredients at 0%, 5%, 10%, and 15%. BS was produced in UNAG dining hall. The ingredients were added to the water and the mix was stirred vigorously and 10 L of BS were baked in Cleveland KET-3-T 3 Gallon Tilting 2/3 Steam Jacketed Electric Tabletop Kettle (Katom restaurant supply, TN, USA) at 85˚C for 30 min.

2.3. Physicochemical analysis

The proximal analysis of CF and BS was performed by standard methods of AOAC (2000) to analyze proteins (920.152), fat (963.15), ash (940.26), and moisture (925.09) content. In addition, total carbohydrates (21CFR101.92) and calories (21CFR101.92) were estimated. For BS, the pH, brix, viscosity, color (L*, a*, b*, & browning index), and texture (firmness & adhesiveness) were analyzed. The pH analyses were carried out by using a Thermo Orion 3 Star pH Benchtop Meter (Fisher Scientific, Instruments, Pittsburgh, PA). The apparent viscosity was determined by using a PCE-RVI-1 rotational viscometer (PCE Instruments, Southampton, UK). Samples were measured with an L4 spindle at 30 rpm. The soluble solids of the sauces were analyzed using a BOECO hand refractometer (BOECO, Hamburg, Germany). The L* (lightness-darkness), a* (red-green axis) b* (yellow- blue axis) values were analyzed by using a Colorflex HunterLab® colorimeter (Hunter Lab, VA, USA) and browning index (BI) values were estimated as Palou et al., (1999). Measurements were determined with D 65 illumination and a 10° observer angle. The texture parameters firmness and adhesiveness were analyzed in BS in a Brookfield CT3 texture meter (Brookfield Engineering Lab Inc., Stoughton, MA) by using the Hai-Yan Yu (2016) method.

2.4 Sensory study

The sensory evaluation was carried out at UNAG Sensory Analysis Laboratory. BS was evaluated the same day it was made. One hundred untrained panelists were recruited among professors, staff, and students from UNAG, and all four treatments were given to each customer. About 1 tablespoon of BS with oven-baked chicken thigh (about half a pound) was served and, for palate cleanse, a cup of water (Agua Azul, San Pedro, Honduras) and unsalted crackers (Nabisco, Northfield, IL) were given. The panelists analyzed color, aroma, flavor, texture, and overall linking (OL) on a 9-point hedonic scale, and purchase intent (PI) was evaluated on a “yes/no” scale with tasting. After tasting, panelists were illustrated with the following ingredient benefit claims (IBC): “As cricket, cricket flour is a great source of protein, vitamins, minerals, fiber, and fatty acids.” After receiving IBC, consumers rated OL, and PI once more. The sensory analysis was carried out according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee in Biomedical Research at Universidad Autónoma de Honduras (UNAH).

2.5. Statistical analysis

All statistical analyses were performed using SPSS 16 software (SPSS Inc., Chicago, IL USA). A one-way analysis of variance (ANOVA) and Post-Hoc Tukey's test (α=0.5) was used to analyze hedonic responses and physicochemical measurements. The 2-related sample-dependent t-test was used to compare differences in

OL before and after consumers received IBC. McNemar's test was used to identify significant increases in PI after IBC. An independent t-test was used for proximal analysis of barbecue sauce.

3. Results and discussion

3.1 Proximate analysis of cricket flour and ECF-enriched barbecue sauces

The chemical composition of ECF and BS is shown in Table 1. For ECF, a high protein (48.72 g/100 g) and fat (33.04 g/100 g) content were found, and low carbohydrate content (7.24 g/100 g) and a considerable amount of minerals (3.90 g/100 g) were observed. Gonzalez et al., (2019) & Khatun Gonzalez et al., (2021) have reported a similar trend regarding Acheta demesticus and Gryllus assimilis species. Depending on the insect species, protein content can range between 7-91% (Huis, Dicke, & Loon, 2015). In addition, the type of diet can have a critical role on growth performance leading to influencing the nutrient profile of cricket powder (Bawa et al., 2020). For BS, T2 (BS-CF 5%) had a significantly ($P < 0.05$) higher protein, fat, and mineral content than control samples. Not surprisingly, the fortification of cricket powder (5%) can increase the protein and mineral content of BS improving the nutritional profile. The addition of edible insects into food systems could provide desired nutrients such as protein, minerals, essential amino acids, chitin, and B-complex vitamins (de Castro et al., 2018). Even though cricket flour fortification can increase the fat content, edible insects have a low omega 6: omega 3 ratio (Sosa et al., 2014; Marcía-Fuentes et al., 2021).

Table 1. Chemical composition of CF and BS

Sample	Moisture (g/100 g)	Ash (g/100 g)	Protein (g/100 g)	Fat (g/100 g)	Carbohydrates (g/100 g)	Total energy (kcal/kg)
CF[N/A]	7.1±1.26	3.90±0.05	48.72±3.28	33.04±3.83	7.24±0.67	4922±48.78
BS-CF 0%	57.9±3.93a	2.39±0.11b	1.69±0.32b	15.88±1.34b	22.13±1.33a	2382±27.05b
BS-CF 5%	53.5±2.05b	2.63±0.08a	4.23±0.46a	19.15±1.05a	20.48±1.89a	2711±20.45a

Means followed by different letters in the column differ by the t-test ($p < 0.05$). * The 0 and 5% BS-CF treatments correspond to the CF addition of 0% and 5% respectively. **CF=cricket flour, BS= barbecue sauce
N/A= Means comparison does not apply.

3.2 Physico-chemical properties of ECF-enriched barbecue sauces

In Table 2, the soluble solids, pH, viscosity, firmness, and adhesiveness are shown. The addition of ECF in BS modified the soluble solids content, texture, and viscosity while ECF did not significantly ($P < 0.05$) affected the pH. The pH values were within the recommended levels (<4.6) (Codex Alimentarius, 2013). For viscosity, it increased (from 12,246 to 19,104 cP) with the addition of ECS into BS among sauces. As ECF increases the protein content in BS (Table 1), Gelation of proteins could occur when BS was thermally treated and the gel matrix captured water leading to a viscosity increment (Thakur, Singh & Handa, 1996). On the other hand, a significant ($P < 0.05$) decrease was observed for the soluble solids content (from 42.2 to 38.1 °Brix) with the incorporation of ECF. Firstly, this reduction could occur because the ECF decreases the carbohydrate content in BS (Table 1). Secondly, a higher moisture content (Table 1) from the ECF-enriched barbecue sauce was reported when compared to the control sample. The evaporation rate of the BS could be less with the addition of ECF as it had high lipid content, which could decrease the water diffusion. Similarly, water diffusion could also decrease due to the formation of gel matrixes caused by the protein content in ECF. For texture, the increase in the ECF concentration led to a higher firmness and adhesiveness. The BS formulation containing 15% ECF was firmer, more adhesive when compared with the other treatments. As anticipated, viscosity tends to be directly related to firmness and adhesiveness (Ahouagi et al., 2020) in this type of food system.

Table 2. Soluble solids, pH, viscosity, firmness and adhesiveness of the CF-enriched barbecue sauces

Formulation	pH	Soluble solids (°Brix)	Viscosity (cP)	Firmness (N)	Adhesiveness (mJ)
BS-CF 0%	4.21 ±0.05a	42.2 ±0.84a	12,246±417d	0.89 ±0.17d	8.90 ±1.24d
BS-CF 5%	4.20 ±0.08a	40.7 ±0.73b	13,360±572c	1.65 ±0.47c	20.67 ±2.57c
BS-CF 10%	4.22 ±0.08a	39.5 ±0.94c	15,953±462b	4.87 ±0.78b	54.80 ±7.79d
BS-CF 15%	4.18 ±0.06a	38.2 ±0.87d	19,104±1365a	7.21 ±1.23a	105.30 ±18.97a

Means followed by different letters in the column differ by the Tukey test ($p < 0.05$). ** The 0, 5, 10 and 15% BS-CF treatments correspond to the CF inclusion of 0%, 5%, 10% and 15%, respectively.

3.3 Color characteristics of ECF-enriched barbecue sauces

The impact of the addition of ECF in BS was notable (Table 3 & Figure 1). The addition of ECF in BS decreased significantly ($P < 0.05$) the L*, a*, b*, C*, and BI while the H* values increased. These results are because of the presence of protein in the cricket flour that coincidentally with the carbohydrates present in the BS formulation during the heat treatment could cause the Maillard reaction to happen, responsible for the darker colors. Lertsir et al., (2001) and Chao, Hsu & Yin, 2009 also supported that sauces' dark browning could be affected by the protein and carbohydrate content present in sauce formulation. In addition, BI is strongly related to a* values (Zambrano-Zaragoza et al., 2014). Similarly, control samples had higher H* values than the other treatments indicating a less reddish color (Ahouagi et al., 2021). Chromaticity is described as saturation and shows the color intensity. The addition in the ECF pointed to a more intense color when compared with control samples (Table 3). Generally, the perception of intense red colors in barbecue sauce could appeal to consumers liking.

Table 3. Color of the CF-enriched barbecue sauces

Formulation	L*	a*	b*	Chroma	Hue	Browning Index (BI)
BS-CF 0%	35.79±0.38a	23.84±0.65a	45.84±0.72a	51.66±0.54a	62.52±0.53b	396.95±7.67a
BS-CF 5%	32.78±0.42b	19.41±0.51b	38.68±0.39b	43.27±0.36b	63.35±.0.41b	331.14±9.84b
BS-CF 10%	31.21±0.46c	17.30±0.43c	35.70±0.27c	39.67±0.47c	64.14±0.47a	309.83±5.72c
BS-CF 15%	30.75±0.31c	14.42±0.36d	31.42±0.47d	34.57±0.38d	65.34±0.42a	247.53±6.55d

Means followed by different letters in the column differ by the Tukey test ($p < 0.05$). ** The 0, 5, 10 and 15% BS-CF treatments correspond to the CF inclusion of 0%, 5%, 10% and 15%, respectively.

3.4. Sensory properties of ECF-enriched barbecue sauces

The mean scores of liking (before & after), flavor, aroma, color, consistency, and purchase intent (before & after) are shown in Table 4. Before the IBC, control samples and T1 (BS-CF 5%) presented the highest mean values towards color (mean value=7.17 & 6.75 respectively), flavor (mean value= 7.54 & 7.32 respectively), aroma (mean value= 6.90 & 6.83 respectively), consistency (mean value= 7.35 & 6.94 respectively) and overall liking (mean value= 7.63 & 7.31 respectively). Commonly, the perception of brown-red colors, desired mouthfeel, and acidity flavor could affect consumers' acceptability (Alonso, 2019). Claybon & Barringer (2002) reported that BS acceptability lowers down when the product is too red or too brown. Not surprisingly, BS-CF 5% did not distantly modify physicochemical properties (Table 2) when compared with the other treatments. It is also likely that the panelists' familiarity with BS influenced their perception. The other studies suggested that a sense of familiarity with a given product could impact the appeal of customers (Choi et al., 2015). After IBC, BS-CF 5% reported a significant ($P < 0.05$) increase in OL and PI mean values. A positive impact could be produced in the OL and PI scores when a proper IBC is given (Padhi et al., 2015). When using edible insect ingredients, other studies have reported good acceptability in snacks, meat, bakery, pasta, and protein bars (Hirunyophat et al., 2018; Megido et al., 2016; Osimani et al., 2018; Duda et al., 2019; Adámek et al., 2018).

Table 4. Mean consumer color, aroma, flavor, consistency, liking and purchase intent of CF-enriched barbecue sauces

Formulation	Color	Aroma	Consistency	Flavor
BS-CF 0%	7.17±1.36a	6.90±1.42a	7.35±1.32a	7.54±1.38a
BS-CF 5%	6.75±1.62b	6.83±1.55a	6.94±1.40a	7.32±1.42a
BS-CF 10%	5.63±1.68c	5.88±1.86b	5.78±1.75b	6.67±1.75b
BS-CF 15%	5.25±1.88c	5.76±1.73b	5.51±1.70b	6.49±1.78b

Formulation	Overall liking (Before)	Overall liking (After)	Purchase intent (%) (Before)	Purchase intent (%) (After)
BS-CF 0%	7.63±1.35a	7.47±1.36a	80.00	78.50
BS-CF 5%	7.31±1.41a*	7.69±1.11a*	68.50*	75.75*
BS-CF 10%	6.47±1.72b	6.23±1.34b	52.50	54.25
BS-CF 15%	6.28±1.71b	6.10±1.94b	41.25	40.25

Means followed by different letters in the column differ by the Tukey test ($p < 0.05$). ** The 0, 5, 10 and 15% BS-CF treatments correspond to the CF inclusion of 0%, 5%, 10% and 15%, respectively. *Indicates significant differences of overall liking based on the dependent sample t-test, and of purchase intent based on the McNemar's test ($P<0.05$), comparing before and after consumers had been given information about free and low sodium health benefits.

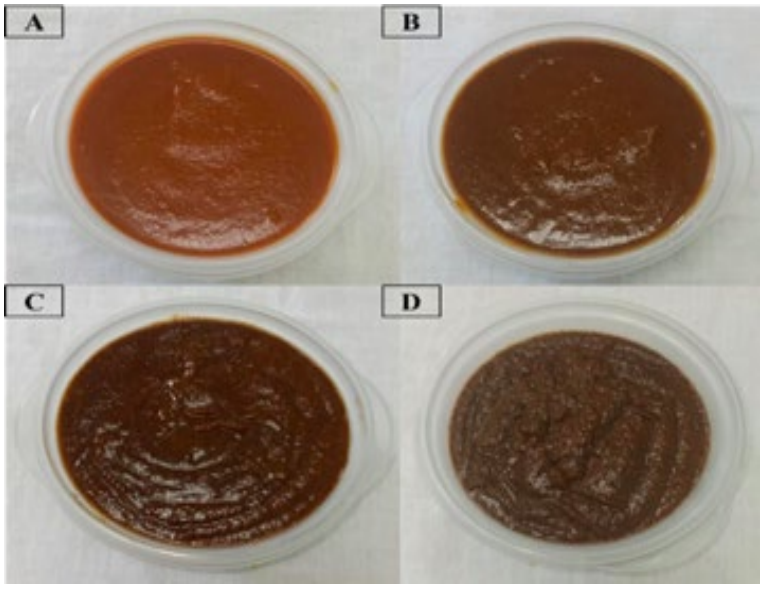

Figure 1. Color of the BS-CF 0% (A), BS-CF 5% (B), BS-CF 10% (C), an BS-CF 15% (D).

4. Conclusions

The impact of adding ECF that is rich in essential nutrients such as protein, minerals, and fatty acids on the physicochemical and sensory characteristics of BS was studied. The incorporation of CF into BS did not lead to a significant ($P < 0.05$) difference in the pH, but it affected color, brix, texture, and viscosity. For sensory properties, only BS-CF 5% samples did not differ from control sauces, and the OL and PI scores were increased when IBC was received by the consumers. Overall, 5% of ECF can be used in BS when consumers are looking for improving nutritional profile of barbecue sauce and food insecurity.

References

Adámek, M., Adámková, A., Mlček, J., Borkovcová, M., Bednářová, M., 2018, Acceptability and sensory evaluation of energy bars and protein bars enriched with edible insect, *Potr. Slovak J. Food Sci*., 12, 431–437.

Ahouagi, V., Mequelino, D., Tavano, O., Garcia, J., Nachtigall, A., & Vilas Boas, B., 2021, Physicochemical characteristics, antioxidant activity, and acceptability of strawberry-enriched ketchup sauces, *Food Chemistry,* 340, 127925.

Alfaro, AO., Núñez, WL., Marcia, J., Fernández, IM., 2019, The Cricket (*Gryllus assimilis*) as an alternative food versus commercial concentrate for tilapia (*Oreochromis* sp.) in the nursery stage, *J Agric Sci* 11(6): 97-104.

Alonso Marenco, J.R., 2019, Sodium Reduction Through Salt Substitute Mixtures, Visual Cues, and Salt Level Statements, and Its Effects on Consumer Perception: A Case of Barbecue Sauce, LSU Doctoral Dissertations, 4962.

AOAC., 2000, Official methods of analysis of AOAC international, vol. 1, 17th edition. AOAC International, Gaithersburg A. International, Ed.

Ardoin, R., & Prinyawiwatkul, W., 2020, Product appropriateness, willingness to try and perceived risks of foods containing insect protein powder: A survey of U.S. consumers, *International Journal of Food Science & Technology*, 55(9), 3215-3226.

Bawa, M., Songsermpong, S., Kaewtapee, C., & Chanput, W., 2020, Effect of Diet on the Growth Performance, Feed Conversion, and Nutrient Content of the House Cricket, *Journal of Insect Science*, 20(2).

Chao, P., Hsu, C., & Yin, M., 2009, Analysis of glycative products in sauces and sauce-treated foods, *Food Chemistry*, 113(1), 262-266.

Choi, J. H., Gwak, M. J., Chung, S. J., Kim, K. O., O'Mahony, M., Ishii, R., & Bae, Y. W., 2015, Identifying the drivers of liking by investigating the reasons for (dis)liking using CATA in cross-cultural context: A case study on barbecue sauce, *Journal of the Science of Food and Agriculture*, 95(8), 1613–1625.

Claybon, K., Barringer, S. A., 2002, Aceptabilidad del consumidor del color en productos de tomate procesados por consumidores afroamericanos, latinos y prototípicos, *Journal of Food Quality*, 25 (6): 487–498.

Comision del Codex Alimentarius., 2013, Norma para el concentrado de tomate elaborado, Codex stan 57-1981, Adoptada en 1981, Revisada en 2007, Enmendada en 2013, 6 p.

de Castro, R.J.S., Ohara, A., dos Santos Aguilar, J.G., Domingues, M.A.F., 2018, Nutritional, functional and biological properties of insect proteins: Processes for obtaining, consumption and future challenges, *Trends Food Sci. Technol*., 76, 82–89.

Duda, A., Adamczak, J., Chełmińska, P., Juszkiewicz, J., Kowalczewski, P., 2019, Quality and Nutritional/Textural Properties of Durum Wheat Pasta Enriched with Cricket Powder, Foods, 8, 46.

Glover, D., Sexton, A., 2015, Edible Insects and the Future of Food: A Foresight Scenario Exercise on Entomophagy and Global Food Security; IDS: Sussex, UK.

Hirunyophat, P., Chalermchaiwat, P., On-nom, N., Prinyawiwatkul, W., 2021. Selected nutritional quality and physicochemical properties of silkworm pupae (frozen or powdered) from two species, Int. *J. Food Sci. Technol.*, 56, 3578–3587.

Khatun, H., Claes, J., Smets, R. et al., 2021, Characterization of freeze-dried, oven-dried and blanched house crickets (*Acheta domesticus*) and Jamaican field crickets (*Gryllus assimilis*) by means of their physicochemical properties and volatile compounds, *Eur Food Res Technol,* 247, 1291–1305.

Lertsiri, S., Maungma, R., Assavanig, A., & Bhumiratana, A., 2001, Roles of the maillard reaction in browning during moromi process of thai soy sauce, *Journal of Food Processing And Preservation*, 25(2), 149-162.

Lucas-González, R., Fernández-López, J., Pérez-Álvarez, J.A. et al., 2019, Effect of drying processes in the chemical, physico-chemical, techno-functional and antioxidant properties of flours obtained from house cricket (*Acheta domesticus*), *Eur Food Res Technol,* 245, 1451–1458.

Marcía-Fuentes, J., Santos-Alemán, R., Montero-Fernandez, I., et al*.,* 2021, Effect of cricket meal (*Gryllus assimilis*) as a potential supplement on egg quality and performance of laying hen, Atena editor, Alimentos, Nutrição e Saúde, Cap. 25; 239-249.

Megido, R.C., Gierts, C., Blecker, C., Brostaux, Y., Haubruge, É., Alabi, T., Francis, F., 2016, Consumer acceptance of insect-based alternative meat products in Western countries, *Food Qual. Prefer*., 52, 237–243.

Osimani, A., Milanović, V., Cardinali, F., Roncolini, A., Garofalo, C., Clementi, F., et al., 2018, Bread enriched with cricket powder (*Acheta domesticus*): A technological, microbiological and nutritional evaluation, *Innov*. *Food Sci. Emerg. Technol*., 48, 150–163.

Padhi, E., Dan Ramdath, D., Carson, S., et al., 2015, Liking of soy flour muffins over time and the impact of a health claim on willingness to consume, *Food Research International.,* 77:491-497.

Palou, E. A., López-Malo, G.V., Barbosa-Cánovas, J., Welti-Chanes, B.G., 1999, Swanson Polyphenoloxidase activity and color of blanched and high hydrostatic pressure treated banana puree, *Journal of Food Science*, 64, 42-45.

Thakur, B., Singh, R., & Handa, A., 1996, Effect of added soy protein on the quality of tomato sauce, *Journal Of Food Processing And Preservation*, 20 (2), 169-176.

Tzompa-Sosa, D. A., Yi, L., van Valenberg, H. J. F., van Boekel, M. A. J. S., Lakemond, C. M. M, 2014, Insect lipid profile: aqueous versus organic solvent-based extraction methods, *Food Research International,* 62(), 1087–1094.

Van Huis, A., Dicke, M., van Loon, J. J., 2015, Insects to feed the world, *J. Insects Food Feed*, 1, 3–5.

Zambrano-Zaragoza, M. L., Mercado-Silva, E., Del, A., Gutiérrez-Cortez, E., Cornejo-Villegas, M. A., & Quintanar-Guerrero, D., 2014, The effect of nano-coatings with α-tocopherol and xanthan gum on shelf-life and browning index of fresh-cut & quot; Red Delicious & quot; apples.