PHYSICAL-CHEMICAL INFLUENCE OF *ACHETA DOMESTICUS* FLOUR AS A PARTIAL REPLACEMENT FOR BEEF IN BURGERS

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I. INTRODUCTION

Insect farming demonstrates good prospects for food and animal feed due to high fertility and growth rates, efficient feed conversion, ability to thrive in reduced spaces, resistance to drought, lower risk of transmitting zoonotic diseases, and more eco-friendly footprints compared to conventional livestock [1]. Nutritionally, insects are sources of high-quality proteins, unsaturated and essential fatty acids, fiber, vitamins, and minerals [2]. In this sense, consuming edible insects (entomophagy) is pointed out as a contributor to addressing global food supply shortages, combating food insecurity, while also presenting beneficial environmental, nutritional, and subsistence appeals [3]. Consumers, especially in Western countries, are still hesitant to include insects in their diet mainly due to food neophobia, and spreading reliable information about the benefits of entomophagy can help overcome this challenge [4]. Therefore, this study aimed to develop burgers containing cricket (*Acheta domesticus*) flour (ADF) as a partial replacement for beef and evaluate the influence on some of the main limitations of their quality, lipid oxidation and color of the raw and cooked burgers (ready-to-eat).

II. MATERIALS AND METHODS

ADF was imported from a local market in Italy. Three different treatments were made to achieve isoprotein formulations considering that the meat forequarter contained 20.5% protein, while ADF presented 64.0% (as determined previously): control treatment with 75.0% beef (CON), treatment with a 10% reduction in the amount of beef (T10: 67.5% beef + 2.4% ADF), and treatment with a 20% beef reduction (T20: 60% beef + 4.8% ADF). All treatments had pork backfat (20.0 g/100.0 g) and 3% hamburger seasoning, and formulations were completed with ice-cold water. The meat and pork backfat were ground on a 4 mm disc (Picador 22, Beccaro). The ingredients were mixed until they formed a homogeneous mass. The burgers were shaped into approximately 100-gram units using a manual formatting machine (HP112, Picelli). The samples were stored frozen (-18ºC) and thawed at 4ºC for 24 hours before analysis. To assess the cooked burger samples, they were cooked at 180ºC on an electric heating plate until the geometric center reached 75ºC. Objective color (L: brightness; a*: green-red; b*: blue-yellow) was evaluated using a portable colorimeter (MiniScan XE Plus, HunterLab) with the D65 standard illuminant and observation angle of 10°. Cooked burgers (CB) were cut longitudinally to assess their internal color. Raw burgers (RB) and CB were evaluated for lipid oxidation using the thiobarbituric acid reactive substances (TBARS) method [5]. Statistical analysis was performed by Analysis of Variance (ANOVA) and Tukey's test within the significance level of 5%, using SAS© software version 9.4 (SAS Institute Inc., North Carolina, USA). The experiment followed a completely randomized design with three treatments and two replications at the processing level.

III. RESULTS AND DISCUSSION

Table 1 presents the results of lipid oxidation and color parameters. Adding a greater amount of cricket flour led to an increase in lipid oxidation in both RB and CB, while T10 did not differ from CON. Some authors establish 2.0 mg MDA/kg as the limit for the perception of rancidity by consumers, therefore, all ready-to-eat burgers are tolerable [6].

When ADF was added as a replacement for meat, it caused an increase in luminosity and a reduction in the red index in RB samples. This could be due to the color characteristics of ADF (L = 57.54±0.99;

a* = 5.46±0.14; b* = 18.06±0.67) compared to ground beef (L = 46.40±0.96; a* = 16.55±0.95; b* = 14.49±1.03). After cooking, the difference in both L and a* parameters decreased between the three treatments, and T10 showed similar luminosity to CON, but slightly lower a*, also noticeable concerning T20 ($P<0.05$). Regarding yellowness (b*), there was no difference between all treatments before or after cooking ($P>0.05$). The RB and CB samples are shown in Figure 1.

Table 1 – Parameters of objective color and lipid oxidation of burgers with and without the addition of FAD.

Parameters	Cooking	Treatment		
		CON	T10	T20
TBARs (mg MDA/kg sample)	Raw	0.62 ± 0.13^{b}	0.68 ± 0.07^{b}	0.95 ± 0.27^{a}
	Cooked	1.23 ± 0.07^{b}	1.32 ± 0.09^{b}	1.66 ± 0.21^{a}
L	Raw	52.13 ± 1.24^{c}	53.58 ± 0.36^{b}	54.94 ± 0.50^{a}
	Cooked	48.27 ± 1.26^{a}	48.77 ± 0.38^{ab}	46.94 ± 0.60^{b}
a*	Raw	15.82 ± 0.72^{a}	11.96 ± 0.61^{b}	8.01 ± 0.32^{c}
	Cooked	6.11 ± 0.40^{a}	5.48 ± 0.19^{b}	5.20 ± 0.27^{b}
b*	Raw	13.33 ± 0.80	13.93 ± 0.63	12.86 ± 0.40
	Cooked	12.13 ± 1.69	13.08 ± 0.68	12.47 ± 0.98

Means ± standard deviation. $^{a-c}$ different lowercase letters on the same line (different treatments): values differ statistically from each other ($P<0.05$); no superscript letters: no significant difference ($P>0.05$). Treatments: CON: without adding insect flour; T10: 10% beef reduction; T20: 20% beef reduction.

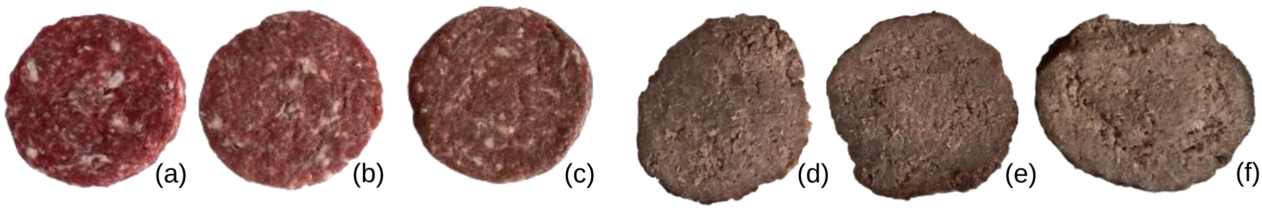

Figure 1. Typical appearance of samples. RB: (a) CON; (b) T10; (c) T20; Internal CB: (d) CON; (e) T10; (f) T20.

IV. CONCLUSION

The study showed that using *Acheta domesticus* as a substitute for beef in burgers can be a feasible option with minimal or no alteration in the investigated physical-chemical properties, particularly when 10% of the meat content was replaced (T10). This finding can be considered promising for offering more ecologically sustainable protein alternatives to address the combat of food insecurity.

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REFERENCES

1. Van Huis, A. (2013) Potential of Insects as Food and Feed in Assuring Food Security. Annual Review of Entomology, 58: 563–583.
2. Bukkens, S. G. F (1997) The Nutritional Value of Edible Insects. Ecology of Food Nutrition, 36: 287–319.
3. FAO, IFAD, UNICEF, WFP, WHO (2023) The State of Food Security and Nutrition in the World 2023. Urbanization, agrifood systems transformation and healthy diets across the rural–urban continuum: Rome, FAO, 316p.
4. Mina, G., Peira, G., Bonadonna, A. (2023) The Potential Future of Insects in the European Food System: A Systematic Review Based on the Consumer Point of View. Foods, 12 (3): 646.
5. Vyncke, W. (1975) Evaluation of the Direct Thiobarbituric Acid Extraction Method for Determining Oxidative Rancidity in Mackerel (Scomber Scombrus L.). Fette, Seifen, Anstrichmittel, 77: 239–240.
6. Campo, M.M., Nute, G.R., Hughes, S.I., Enser, M., Wood, J.D., Richardson, R.I. (2006) Flavour Perception of Oxidation in Beef. Meat Science, 72: 303–311.