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# Evaluation of Color *Tenebrio molitor* Larvae by Different Methods of Dehydration

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## Abstract

The use of insects, as food presents two important technological challenges: how to transform insects in safe, healthy and tasty food and how to produce insect efficient and sustainable way to meet the growing market demand. The assessment of quality of dehydrated food must be analyzed to ensure the quality of the final product. Thus the color analysis, the first attribute judged by the consumer becomes an important tool to cause, measure, analyze and interpret reactions produced directly the characteristics of the product and how they are perceived. Dehydrated insects as well as more nutritious than other types of meat, take up less space and have a high shelf life. Given this fact, the objective was to make a comparative assessment of the *Tenebrio molitor* larvae color dehydrated in conventional microwave oven and tray dryer with forced ventilation. The results obtained, it was observed that dehydration done in conventional microwave provided a minor change from the original coloration of the *Tenebrio molitor* larvae, where as the dehydration in tray drier with forced ventilation presented undesirable browning.

**Keywords:** Edible insects; Dehydration; Evaluation of color; Entomophagy; Microwave

## Introduction

Insects are a renewable natural resource and food are consumed as a food supplement or as main constituent of the diet of people in many different regions of the world [1]. The edible insects have in their protein and amino acid composition, especially essential amino acids, especially the large amounts of leucine, lysine and valine, and these extremely important due to the need of the daily intake for humans [2].

The *Tenebrio molitor* larvae, representative of the Coleoptera order, undergoes a complete metamorphosis, going through the stages of egg, larvae, pupa and adult insect-able to play. The reproductive cycle is completed within 6 months, being, however, very subject to temperature, humidity, lighting and nutrition. Table 1 shows their nutritional composition.

In food processing the main goal is to convert perishable foods in stable products that can be stored for long periods, reducing losses and making them available in times of scarcity, out of season and in places far from the production site. Various process technologies on an industrial scale were used to preserve food, the main ones are the bottling, freezing and dehydration. Among the above, dehydration is probably the oldest and most practical method of preserving food for mankind. With drying, to reduce the amount of water, in addition to weight reduction, it creates unfavorable conditions for microbial growth in the product [3].

The dehydration or drying involves the simultaneous occurrence of heat and mass transfer in which the heat is transferred to the product and the moisture is removed in the form of water vapor for a gas phase unsaturated [4]. Strumilo and Kudra [5] state that on drying, the moist material comes into contact with unsaturated air resulting in a decreased humidity of the material and air humidification.

Color is a very important attribute for any food to be the initiating factor in choosing the product by the consumer. When applying a technological process on a food, you should take care to impart a desirable appearance to the final product. In the case of drying should use a time/temperature combination that is effective in water removal, to increase the shelf life of food, but not too dim the product [6]. Given this fact, the objective was to make a comparative assessment of the *Tenebrio molitor* larvae color dehydrated in conventional microwave oven and tray dryer with forced ventilation.

## Materials and Methods

### Raw material

*Tenebrio molitor* larvae were produced by Zootechnician Fabricio Gomes de Oliveira, the owner of Kaissara Insects Biofactory that produces mass rearing system in the species: *Tenebrio molitor*, *Zophobas morio*, *Gryllus assimilis* and *Nauphoeta cinerea*.

### Methods

**Obtaining the *Tenebrio molitor* larvae dehydrated:** When complete 100 days of the life cycle, the *Tenebrio molitor* larvae remained fasting for 24 hours in visceral purge and was subsequently slaughtered in boiling water (100°C). After slaughter dehydration was carried out in oven with forced ventilation for 18 hours at 65°C and conventional microwave oven for 2 min at 2450 MHz frequency.

**Color evaluation:** To determine the instrumental color parameters *Tenebrio molitor* larvae dehydrated were captured digital images of samples and application "Microsoft Office Picture Manager" aid was selected for each sample, three areas of approximately 5 cm × 5 cm each.

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Since the samples had not uniform staining, the mean is calculated of three readings in each of three areas.

The images were converted to RGB values average, using the program "Average color RGB converter to BMP images" [7]. Later, the data were converted to the CIELAB system by the "Munsell Conversion" [8], obtaining $L^*$ (lightness), $a^*$ (red-green component) and $b^*$ (yellow-blue component).

From the data obtained, we calculated the values of Hue ($H^*$) (Equation 1).

$$H^* = tan^{-1}\left(\frac{b^*}{a^*}\right) \quad (1)$$

**Data processing:** Data were compared by analysis of variance (ANOVA) and the means were compared by Tukey's test at 95% significance ($p<0.05$). Statistical using the Statistica 7.0 software. All analyzes were performed in triplicate.

## Results and Discussion

Through Figure 1, it is possible to observe the *Tenebrio molitor* larvae alive (control), and Figures 2 and 3 show the color difference obtained for the different types of drying.

The instrumental color parameters $L^*$ (lightness), $a^*$ and $b^*$ (chromaticity) and the parameter $H^*$ (hue) calculated by Equation 1 can be seen on Table 2.

The CIE $L^*a^*b^*$ (Figure 4) allows you to record the brightness $L^*$ that has scale from zero (black) to 100 (white), that is, the closer to 100, more white is the product . The chromaticity coordinates $a^*$ ($a^*$ +, red, -$a^*$, green) and $b^*$ ($b^*$ +, yellow, -$b^*$, blue) enable to calculate the Hue angle ($H^*$). When the values of Hue angle is close to 0°, the color is brown-red, near 90° yellow, or blue-green (180°) or blue (270°).

Regarding the lightness ($L^*$) was no statistical difference among all samples, but the sample showed DB lower value DM and SD representing the most darkness.

When the results observed for hue ($H^*$), DB sample showed lower value indicating darker shade between the samples. Although no statistical difference between the MD and SD samples, the results showed a tendency to yellow tint in the sample MD representing a closer control of staining the sample (SD).

The dryer trays is a very versatile equipment for drying food. The product is arranged in trays and subjected to a stream of heated air. The control parameters may vary according to the process, but overall

Source: Kaissara Insects [8].

**Figure 1:** *Tenebrio molitor* larvae alive.

Source: Kaissara Insects [8].

**Figure 2:** *Tenebrio molitor* larvae dried in tray drier with forced ventilation.

| Component | *Tenebrio molitor* larvae |
|---|---|
| Moisture (%) | 4.0 |
| Protein (%) | 47.0 |
| Lipids (%) | 35.0 |
| Fibers (%) | 6.5 |
| Ash (%) | 7.5 |

**Table 1:** Nutritional composition *Tenebrio molitor* larvae dehydrated.

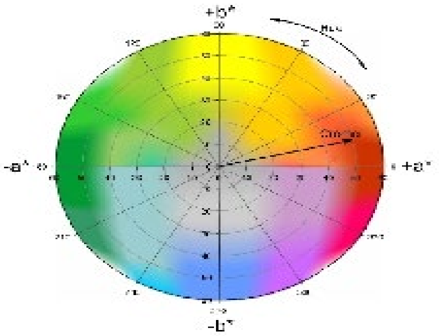
| Parameter | DB | DM | SD control |
|---|---|---|---|
| **$L^*$** | $3.52^a \pm 0.64$ | $23.44^b \pm 0.42$ b | $20.16^c \pm 0.11$ |
| **$a^*$** | $6.45^a \pm 1.46$ | $5.43^b \pm 0.96$ | $28.96^c \pm 0.93$ |
| **$b^*$** | $4.30^a \pm 1.01$ | $29.34^b \pm 3.55$ b | $30.02^b \pm 0.01$ |
| **$H^*$** | $0.59^a \pm 0.81$ | $1.39^b \pm 0.64$ | $0.80^c \pm 0.45$ |
| (*) Equal letters on the lines do not show statistical difference (p<0.05). | | | |

**Table 2:** Mean values of the color instrumental parameters the *Tenebrio molitor* larvae dehydrated in a conventional microwave oven. dried in tray drier with forced ventilation (DB), *Tenebrio molitor* larvae dehydrated in a conventional microwave oven (MD) and *Tenebrio molitor* larvae alive (SD).

Source: Kaissara Insects [8].

**Figure 3:** *Tenebrio molitor* larvae dehydrated in a conventional microwave oven.

the temperature, drying time and size of the food are influential in any drying process because exert effects on the rate of drying, the final moisture content and shrinkage product, these characteristics relating to the preservation and quality of food [9]. Drying by forced circulation, an important variable to control is the drying air velocity related to the drying rate. The food size can decrease when the temperature rises or the air speed and high drying rates are achieved because there is an increase in moisture diffusion coefficient, and the desired degree of humidity is achieved more quickly. However, during the drying




**Source: Minolta [9].**

**Figure 4:** *Color coordinate System CIEL*a*b*.*

process, one can observe a decrease in product dimensions due to a change in the fresh tissue microstructure, in which there is an increase of cavities elongated cells, among other modifications the heat estres and especially by moisture removal, and varies according to the type of food and its studied geometry [10].

Already, in food heated by microwave irradiation occurs an interaction of the electromagnetic wave with the electric dipole of the molecule, and does not cause changes in the molecular structure. An important attribute of heating by microwave is the direct absorption of energy by the material to be heated, unlike what occurs when heating is carried out by convection, in which energy is transferred from the reaction vessel slowly to the solution. Thus, the microwave heating is selective and will depend mainly on the dielectric constant and the relaxation frequency of the material [11].

To understand the simplified heating of a substance in a microwave oven, you can make an analogy to what happens when the molecules are subjected to the action of an electric field. When this is applied, the molecules have electric dipole moment or can be induced dipole moments tend to align themselves with the field and when the electric field is removed, there will be a dielectric relaxation, that is, tend molecules return to their unaligned state, dissipating the absorbed energy as heat [11].

A striking feature of the dielectric heating is its selectivity to certain types of materials. In the particular case of mixtures, the preferential heating of certain components may result in the formation of hot spots within the sample, that is, regions whose temperature is considerably higher than the average temperature of the sample. It is believed that this particular form of heating is responsible for a number of effects observed in processes conducted via microwave [12].

At first, the larger the electric dipole, more intense should be the molecular orientation under the action of the electric field. If a material has a larger dielectric constant value, more energy can be stored. In a field alternating phase, such as an electromagnetic wave, the molecular orientation varies cyclically, and that for a microwave oven with a frequency of 2450 MHz which is the frequency adopted in domestic and laboratory furnaces, there are 109 guidelines [13].

Domestic microwave ovens have no ventilation and rotor system, so we do not have a uniform distribution of microwave radiation. They produce interference between the microwaves and, thus, some parts of the oven are given higher incidence of waves others [11].

The penetration and heating food in a microwave field are virtually instantaneous, in contrast to the conventional heating methods, where the surface heat transfer to the center takes 10 to 20 times slower [14]. Theoretically, the heating effects of microwave energy on the components of various foods may differ significantly from those produced by heating in a conventional oven. The microwave energy is a unique energy source because it produces heat within the processed material. This property results in faster processing times, higher yield of final product, and usually in a superior quality product as compared to that obtained with conventional processing techniques [15,16].

Proteins and lipids are components that are present in higher quantities in the composition of *Tenebrio molitor* larvae (Table 1). Another factor that can contribute to change in its color in the dehydration forced air dryer, was the formation of protein-lipid complexes time caused by excessive heat exposure.

Proteins are known to form complexes with a variety of substances, including lipids and phospholipids. The formation of protein-lipid complexes can result in agglomeration of amino group of L-lysine, oxidation of the sulfide group of L-methionine or changes to other amino acids, especially tryptophan. The protein-lipid complexes cause changes in digestibility. They are the result of a decrease in lipolysis rate of lipids by pancreatic lipase, as well as a reduction of the rate and extent of proteolysis by digestive enzymes. The presence of the protein-lipid complex can affect the taste of flavor compounds without binding or the formation of new flavor compounds. They affect the color as a result of browning reactions (Taha, Mohamed).

## Conclusion

The results showed change in the color of the *Tenebrio molitor* larvae when compared to both methods of dehydration. Dehydration by the conventional microwave oven showed less change in color as compared to the control sample (SD), a result of higher instantaneous temperature inside the product, different from dehydration by forced ventilation drier which had undesirable blackening caused by the transfer slow surface energy, thermal constants with long and slow heat penetration.

As a continuation of this study, it is intended to make a nutritional evaluation of the *Tenebrio molitor* larvae, in order to compare the possible proximal causes caused by different methods of dehydration.

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