



FORMULATION OF NATURAL FOOD COLORING BASED ON CEMPASÚCHIL (TAGETES ERECTA) IN TRADITIONAL MEXICAN DAY OF THE DEAD BREAD

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ABSTRACT

Objective: To develop a natural colorant from the marigold flower through 7 extraction methods, to substitute the use of artificial colorants in the elaboration of traditional Mexican Day of the Dead bread.

Theoretical framework: Flowers have been used as food, decoration, medicine and pigment due to their attributes; in Mexico there is the marigold flower known for its use in the Day of the Dead celebration. Several studies have shown negative consequences of the consumption of artificial foods on human health, an example is the artificial colorants that can be substituted by the natural ones contained in flowers.

Methods: In this descriptive, cross-sectional and mixed article, 7 methods of extraction of dye from cempasúchil flowers for use in pan de muerto were developed by students and researchers of the Benemérita Universidad Autónoma de Puebla.

Results and discussion: The tones obtained in the bread were green (undesirable for consumption), derived from the extraction method used, being also important factors the use of inputs of animal or vegetable origin and the preparation techniques.

Practical implications: linked to the stabilization and fixation of the color in the bread due to the fact that the cempasúchil enzymes reacted when in contact with the pH of the dough, friction, oxygen and temperature, resulting in the green color.

Originality: The present study contributes to promote the creation of natural colorant alternatives based on edible flowers through natural methods to obtain them.

Keywords: Natural colorant, Pan de muerto, Cempasúchil, Carotenoids.

FORMULAÇÃO DE UM CORANTE ALIMENTAR NATURAL À BASE DE CEMPASÚCHIL (TAGETES ERECTA) NO PÃO TRADICIONAL MEXICANO DO DIA DOS MORTOS

RESUMO

Objetivo: Desenvolver um corante natural a partir da flor de calêndula usando sete métodos de extração para substituir o uso de corantes artificiais na preparação do tradicional pão mexicano do Dia dos Mortos.

Quadro teórico: As flores têm sido usadas como alimento, decoração, medicamento e pigmento devido a seus atributos. No México, a flor de calêndula é conhecida por seu uso na celebração do Dia dos Mortos. Vários estudos

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demonstraram as consequências negativas do consumo de alimentos artificiais para a saúde humana, um exemplo disso são os corantes artificiais que podem ser substituídos pelos naturais contidos nas flores.

Método: Neste artigo descritivo, transversal e misto, sete métodos de extração de corantes das flores de cempasúchil para uso no pan de muerto foram desenvolvidos por alunos e pesquisadores da Benemérita Universidad Autónoma de Puebla.

Resultados e discussão: os tons obtidos no pão foram verdes (indesejáveis para consumo), derivados do método de extração utilizado, sendo que o uso de insumos de origem animal ou vegetal e as técnicas de preparação também foram fatores importantes.

Implicações práticas: ligadas à estabilização e à fixação da cor no pão, pois as enzimas da calêndula reagiram em contato com o pH da massa, o atrito, o oxigênio e a temperatura, resultando na cor verde.

Originalidade: O presente estudo contribui para promover a criação de alternativas de corantes naturais com base em flores comestíveis usando métodos naturais para obtê-los.

Palavras-chave: Corante natural, Pan de muerto, Cempasúchil, Carotenoides.

FORMULACIÓN DE COLORANTE ALIMENTICIO NATURAL A BASE DE CEMPASÚCHIL (TAGETES ERECTA) EN EL PAN TRADICIONAL MEXICANO DE DÍA DE MUERTOS

RESUMEN

Objetivo: desarrollar un colorante natural de la flor de cempasúchil mediante 7 métodos de extracción, para sustituir el uso de colorantes artificiales en la elaboración del pan tradicional mexicano de día de muertos.

Marco teórico: Las flores se han utilizado como alimento, decoración, medicina y pigmento debido a sus atributos, en México existe la flor de cempasúchil conocida por su uso en la celebración del Día de Muertos. Diversos estudios han demostrado consecuencias negativas del consumo de alimentos artificiales sobre la salud humana, un ejemplo son los colorantes artificiales que pueden ser sustituidos por los naturales contenidos en las flores.

Método: En este artículo descriptivo, transversal y mixto se desarrollaron 7 métodos de extracción de colorante de la flor de cempasúchil para su uso en el pan de muerto, a cargo de estudiantes e investigadoras de la Benemérita Universidad Autónoma de Puebla.

Resultados y discusión: Los tonos obtenidos en el pan fueron verdes (indeseables para el consumo), derivado del método de extracción utilizado, siendo también factores importantes la utilización de insumos de origen animal o vegetal y las técnicas de preparación.

Implicaciones prácticas: ligadas a la estabilización y fijación del color en el pan debido a que las enzimas del cempasúchil reaccionaron al entrar en contacto con el pH de la masa, fricción, oxígeno y temperatura, dando como resultado el color verde.

Originalidad: El presente estudio contribuye a promover la creación de alternativas de colorantes naturales a base de flores comestibles mediante métodos naturales para su obtención.

Palabras clave: Colorante natural, Pan de muerto, Cempasúchil, Carotenoides

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1 INTRODUCTION

The use of dyes in food dates back more than a hundred years, Sánchez (2013) states that:

In the early 19th century, with the increasing evolution of chemistry, foods were colored with lead chromate, mercury sulfite, copper arsenate, or coal pitch. Many of these were banned in 1887 with the first law of dyes, having proven its toxic effects. (p. 236).

Contreras (1996) states that the main shades that were obtained were red, yellow and green since they were extracted from stems, leaves or flowers of some vegetables that existed, as resources in New Spain. During pre-Hispanic times in America, natives used them to dye cotton, thread, clothing, vessels, codices, houses, temples and even for religious ceremonies.

A clear example of the use of resources was the grana cochinilla, an insect native to Mexico (Contreras, 1996), with which the indigenous people made a buns called *nocheztlaxcalli* or grana breads that they traded in markets of their village (Dahlgren, 1990). During the 19th century, luminous dyes were used, mainly for the textile industry and later in food, with the aim of making them more attractive for sale (Sánchez, 2013). Today dyes continue to be present in different types of industry and for different uses.

Synthetic dyes are used in the bakery industry, due to the intensity of color they provide, as well as their high stability (Ngamwonglumlert *et al.* 2017). Dyes are a group of substances consumed daily in human life, so it should be followed with regulations since some have been related to possible adverse health effects (Kraser and Hernández, 2020).

At present, when consumers choose a product, they are mainly looking for an attractive appearance, so the color is one of the first characteristics they perceive (Badui, 2006), that is why dyes have been used in a wide variety of products, thus, this research aims to formulate a natural food dye based on cempasúchil through 7 different methods for its integration and incorporation in the traditional bread of the day of the dead in Mexico, which would allow avoiding the use of artificial dyes that cause adverse effects on the health of consumers.

2 THEORETICAL FRAMEWORK

Arias, Ballesteros, Martínez and Poveda (2018) mention that for a substance to be considered as a dye it must meet the following characteristics: have enough pigment to use only what is necessary, possess stability to light and heat, do not present an unpleasant aroma and



taste, be economic, compatible and safe. It is important to mention that each country has an agency in charge of regulating the way of use and acceptance of different types of dyes, in the case of Mexico, there is the Federal Commission for Protection against Health Risks (COFEPRIS), which controls the additives allowed in food in the country. In Mexico, within the food industry, the Federal Consumer Prosecutor's Office (PROFECO, 2020) mentions that there are studies that determine that artificial dyes produce reactions such as hyperactivity, insomnia and allergies, even points out that some should not be consumed by humans.

Galarza (2013) mentions that the amount of relatively natural dyes that are accepted worldwide is minimal, of which is low the percentage of those that are commercially important, such as cochineal and coal. Marín and Mejía (2012) explain that due to the new trend of consumption of natural foods, there are little explored alternatives for obtaining natural dyes based on plant species such as flowers. In nature there is a diversity of carotenoids of different plant species, which provide different shades to the flowers. Much of the carotenoids in the flower petals are yellow xanthophylls, whose range of colors ranging from light yellow, dark yellow to orange, all depending on the amount of carotenoids present in each petal. (Lara, 2013)

According to Agama et al. (2021) in Mexico there are 61 species of edible flowers such as pumpkin, maguey, cactus pear, tule, colorín and cempasúchil, it should be mentioned that the latter due to the lack of knowledge about its use as a dye and food, is not part of the diet or consumption of Mexicans.

The Cempasúchil flower (*Tagetes erecta* L.) is native to Mexico, it is an inflorescence and its shades range from weak yellows to intense orange, this is due to the presence of carotenoids. (Del Villa del Mar, et al. 2007).

Cempasúchil pigments are currently used as additives in the preparation of food for fish, birds and crustaceans and thus improve the appearance of these species and are more attractive to the consumer (Del Villa del Mar, et al. 2007).

For this reason, cempasúchil can be an alternative to avoid the consumption of chemical additives such as artificial dyes within the Mexican bakery, in addition to taking advantage of the properties of this flower, specifically in the preparation of dead bread.

Dey (2018) explains that artificial dyes are the most used in the food industry mainly in cereals, beverages, desserts, breads and sweets, due to their low microbiological contamination and low production costs.

There are various classifications of Mexican bread, according to Mesas y Alegre (2002), are: sweet bread (made with sugar or some other sweetener), salt (without sugar) and party



(used for special celebrations and Mexican holidays, of which dead bread is representative in this classification for its cultural importance) (Ramírez, 2022).

López (2012) mentions that the bakery industry is one of the areas in which the variety of the use of dyes is most perceived to obtain a more attractive color for the consumer.

The tendency to consume the natural is increasingly strong and the use of them is considered an attribute of product quality (Carmona, 2012), although it should be noted that natural resources are finite, and the world population grows exponentially, which demands innovative products (Severo and De Guimarães, 2022), in this way, the bakery industry has sought new alternatives for the replacement of chemical pigments by options extracted from natural inputs, without affecting the physicochemical and sensory characteristics of the products. (Sánchez, 2013).

Food quality and safety are essential pillars in public health, so it is the responsibility of companies to ensure products with the lowest probability of health risks (Santiago *et al.* 2024). According to Córdoba (2014) there is currently a preference for natural dyes due to their low or no toxicity when consumed, so it is of interest to investigate and develop various techniques that allow the obtaining of the pigment of the cempasúchil that replaces the synthetics safely.

3 METHODOLOGY

This study is descriptive, cross-sectional and mixed.

MATERIALS: Cempasúchil flower (*Tagetes erecta*) was collected from the community of San José Tzuzapan in the municipality of Quecholac, Puebla, Méx.

The ingredients used to make the dead bread were: a leavening compound (Tradipan yeast, Mexico), butter (Loma linda, Mexico), salt (La fina, Mexico), milk (Alpura entera, Mexico), eggs (Bachoco, Puebla), sugar (Zulka, Mexico), wheat flour (San Blas, Mexico) and vanilla essence (Molina, Mexico).

The ingredients used to make the dead bread were: a leavening compound (Tradipan yeast, Mexico), margarine (Iberia, Mexico), salt (La fina, Mexico), purified water (Ciel, Mexico), Chia (Valle Verde, Mexico), sugar (Zulka, Mexico), wheat flour (San Blas, Mexico) and vanilla essence (Molina, Mexico).

METHOD. Making of dead bread. The original recipe proposed by Quiroz (2014) was adapted and modified, so the preparation of the dead bread was made as follows: In a pedestal mixer (Kitchenaid model KSM150PSSC, United States) flour (500 g), sugar (200 g), salt (7 g), yeast (11 g) were added and integrated. Vanilla essence (5 ml) and milk (100 ml) were added



and mixed until a homogeneous mass was obtained. Then the butter (175 g) was incorporated until a glossy dough was obtained that did not stick. Then, the dough was allowed to rest (30 minutes) in a stainless steel bowl at room temperature (23°C) until doubled in size. Once the dough was fermented, portions of 55 grams were taken out, bolearón and given the format of Mexican dead bread, placing two crossed canillas and a ball in the center of the bread. It was then allowed to ferment (23°C) for a second time until it doubled in size. They were then butter-lacquered and baked for 20 minutes at 180°C in an electric oven (Rational Combimaster Plus XS Electric, Germany).

PRODUCTION OF MEXICAN DEAD BREAD WITHOUT ANIMAL PRODUCTS. The preparation of the dead bread was done as follows: In a pedestal mixer (Kitchenaid model KSM150PSSC) flour (500 g), sugar (200 g), salt (7 g), yeast (11 g) were added and integrated. Vanilla essence (5 ml) and water (100 ml) were then added and chia soaked for 12 hours in purified water (30 tbsp), mixed to obtain a homogeneous mass.

Then margarine (175 g) was incorporated until a glossy mass was obtained and it did not stick to the surface. The dough was allowed to rest (30 minutes) in a stainless steel bowl at room temperature covered with a cotton cloth until doubled in size. Once the dough was fermented, portions of 55 grams were taken out, bolearón and given the format of Mexican dead bread, placing two crossed canillas and a ball in the center of the bread. It was then allowed to ferment for a second time until it doubled in size. After that time they were baked about 20 minutes at 180°C in an electric oven (Rational Combimaster Plus XS Electric model).

OBTAINING THE DYE. Method 1: The petals were rinsed with drinking water, the excess moisture was removed with a cotton cloth and 100 grams of these were placed in an aluminum tray to dry in an electric oven (Chefman, Mexico) for 1 hour with 40 minutes at 95 °C stirring in intervals of 20 minutes. In the end they were ground in a blender (Oster, United States) for 2 minutes at a power of 1000 W (Watts) and passed through a sieve (3 mm) to obtain a weight of 10 g of dehydrated petals.

Method 2: 100 g of petals were obtained and rinsed with drinking water, then dried in a cotton cloth and placed in two ceramic dishes in a microwave (Daewoo model kor-6L5B, South Korea), at two intervals of two minutes. Then the plate was removed from the top and two intervals more than two minutes were made, to finish with two intervals of three minutes, stirring between each session. In the end the petals were ground in a wooden mortar and passed through a 3 mm sieve, to obtain 12 g of petal powder.

Method 3: 100 grams of petals were obtained, rinsed with drinking water and dried in a cotton cloth. Subsequently they were treated with the bleaching technique, submerging in



water at 120°C for 5 minutes, they were taken out and a shock ended up adding cold water (22°C). The petals were ground in a blender (Oster, United States) removing the excess water and obtaining a total weight of 120 grams of flower paste.

Method 4: Following the bleaching and grinding process of the sample 3 as a final step the paste was passed through a sky blanket made with cotton to obtain 50 ml of residual water with a yellowish tone with green flashes.

Method 5: 100 grams of petals were obtained and rinsed and dried with a cotton cloth to be subsequently ground in a blender (Oster, United States) along with 50 ml of purified water. Obtaining 150 ml of a deep orange liquid product. This mixture was added when incorporating the egg into the dough.

Method 6: 100 grams of petals were obtained, rinsed and dried with a cotton cloth and ground in a blender (Oster, United States) along with 50 ml of purified water. Obtaining 150 ml of a deep orange liquid product.

Method 7: 50 grams of petals were obtained, rinsed with purified water, dried with a cotton cloth, in a sterilized glass jar the petals were added along with 50 ml of vodka (Zaverich) and left in maceration for 15 days, obtaining 55 ml of macerated.

PERFORMANCE CALCULATION. The yield was calculated by weighing the fresh petals and petals at the end of each method of obtaining, using the following equation:

$$\% \text{ yield} = \frac{\text{mass of product obtained (g)}}{\text{Total product mass (g)}} \times 100 \quad (1)$$

COLORIMETRIC DETERMINATION. Color determination was performed as reflectance analysis using a colorimeter (Minolta Chroma meter CR-300, Osaka, Japan) and based on the CIE L*a*b* color system. The finishing was done in triplicate using different points of each slice of bread.

STATISTICAL ANALYSIS. The data obtained from the performance and colorimetric determination were analyzed using one-way Variance Analysis using Minitab software (Minitab Inc, USA). Similarly, a comparison of means with the Tukey test was made with a significance level of 0.05.



4 RESULTS AND DISCUSSION

OBTAINING DYE AND PERFORMANCE. The pigment produced by dehydration technique 1 was a soft yellow color that when added to the bread and when continued kneading changes to a soft green color whose intensity decreases after baking. The pigment obtained by the technique 2 was yellow color which when added to the dough and after a kneading of 5 minutes, the dough changed to a green color, at the end of baking, the color decreased. The pigment obtained by technique 3, was of intense yellow color, which when added to the dough, changed to an intense green color which did not decrease with baking. The pigment obtained with technique 4 was of intense yellow color that when added to the bread did not change color and that even intensified with the baking. With respect to the pigment with technique 5, orange tones were obtained at the beginning, whose color changed when added to the bread to a green with yellow tones, this tonality being more stable when not changing color with baking.

The performance results for each methodology used to obtain pigments are found in Table 1.

Table 1

Performance of pigment production processes

Method	Performance (%)
1	10:20+10:45 a
2	12.03+12.20 b
3	120:20+125:30 c
4	50.20+53.45 d
5	150.34+160.30 and
6	150.43+155.39e
7	55.28+63.56 F

Source: Own elaboration

Once the methods mentioned in the methodology were executed, the characteristics of the dyes used in the production of dead bread were obtained, as shown in Table 2.

Table 2

Color of pigments obtained before and after baking

Method	Color					
	Before			Then		
	L	to	b	L	to	b
1	72.59+0.05a	21.05+0.03a	74.479+0.08a	60.45+0.03b	-8.6+0.03b	67.68+0.08b
2	71.12+0.06a	31.59+0.04a	73.98+0.03a	52.07+0.02b	-9.23+0.04b	39.47+0.06b
3	83.35+0.07a	3.46+0.09a	75.82+0.05a	52.07+0.01b	-9.23+0.03b	39.47+0.03b



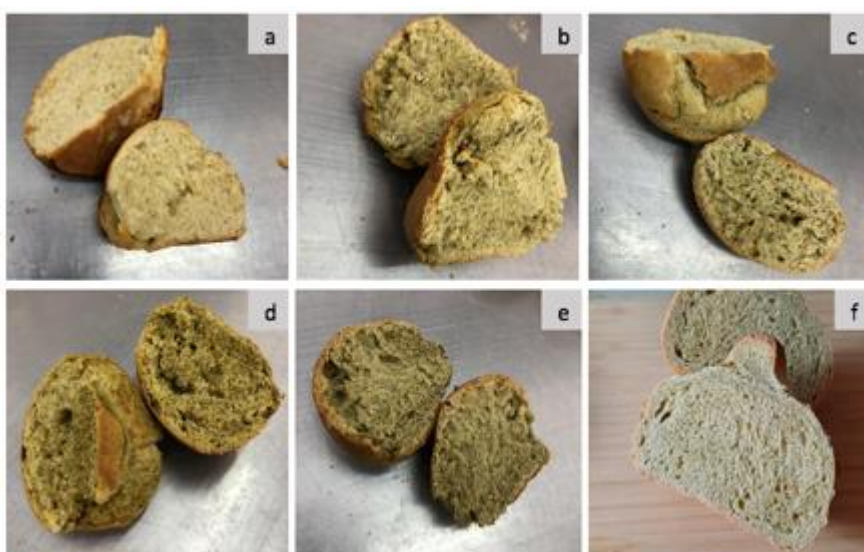
4	75.18±0.08a	20.63±0.08a	55.58±0.07a	73.56±0.04a	-10.38±0.05b	85.44±0.04b
5	87.29±0.09a	-9.28±0.08a	76.69±0.0a8	53.59±0.06b	-17.38±0.02bb	50.05±0.02b
6	75.18±0.06a	20.63±0.09a	55.58±0.09a	60.45±0.02b	-8.6±0.02b	67.68±0.05b
7	77.82±0.03a	10.66±0.07a	94.6±0.06a	60.45±0.02b	-8.6±0.03b	67.68±0.04b

Source: Own elaboration

With regard to the colors obtained, Figure 1 shows the breads with the addition of the different dyes:

Figure 1

Breads with dyes



Note: a) Control, b) Addition of pigment with technique 1, c) Addition of pigment with technique 2, d) Addition of pigment with technique 3, e) Addition of pigment with technique 4 and f) Addition of pigment with technique 5.

Source: Own elaboration

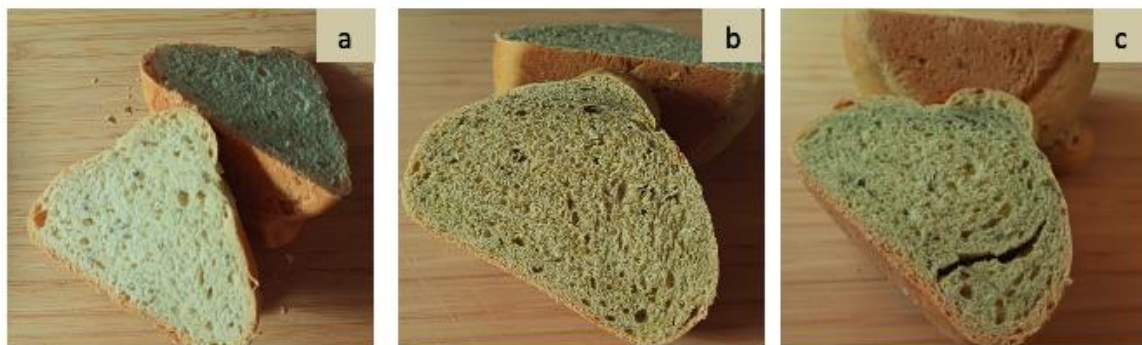
After obtaining 5 samples that resulted in a crumb with green tones in different shades and not obtaining the desired yellow color, Santos (2020) mentions that the viscosity of the egg white at a pH of 9 begins to change between 56.6 and 57.2 ° C which causes a faster oxidation, so to minimize the oxidation of the carotenoids present in the petals of the cempasúchil flower (*Tagetes erecta*), tests were carried out with a recipe for dead bread without animal products.

Of this bread, the control bread had a uniform color and relative to a dead bread without pigment. The pigment made with technique 6 presented soft yellow colors, but after five minutes, this hue was oxidized resulting in a green color with greater tone in parts near the surface of the bread. The pigment generated with technique 7, was yellow color that oxidized to give a bright green hue. For both techniques there was no significant change at baking time (See Figure 2).



Figure 2

Breads made without animal products



Note: a) Pan control, b) Addition of technical pigment 6, c) Addition of technical pigment 7

Source: Own elaboration

The bakery industry uses different food artificial dyes to present a striking product for the consumer, the constant consumption of artificial dyes brings adverse health effects, as an alternative for the replacement of these dyes, methods have been sought for the extraction of flower dyes such as cempasúchil flower (*Tagetes erecta*).

When experimenting with the cempasúchil flower (*Tagetes erecta*) to extract its yellowish pigment and use it in a bakery product, specifically the Mexican dead bread, different results were obtained from the desired one, since it was intended to obtain a yellow and pleasant tone to consume, otherwise greenish shades with oxidation appearance and not pleasant to be consumed were obtained, according to Arellano (2011) due to the composition of the flower there is a high instability that causes negative reactions to oxygen, light and high temperatures, so it explains that in the manipulation of the dough and the *baking these coloring were obtained*. As mentioned above, cempasúchil is made up of carotenoids and according to Mélenhez, *et al.*(2011) the pigments responsible for producing yellow, orange and red colors, with a chain composition of double conjugate bonds, are stable in their natural environment, but when subjected to heat temperatures they undergo an oxidation process as they lose cellular integrity and cause discoloration and loss of organoleptic characteristics.

Del Villar *et al.* (2007) They mention that when extracting the pigment from the flower by means of dehydration and grinding it must be with the help of solvents since an oleoresin composed mostly of esterified carotenoids with a xanthophyll content is produced, Restrepo (2006) explains that oleoresin is acquired from spices or different plants, with the function of producing color, flavor and spicy perception. Espinosa and García (2017) state that to obtain a correct extraction of the pigment without any adverse response, the use of microencapsulation technology must be carried out, which according to Parra (2011) consists of a polymer cover



with an active substance that protects a food or compound. Therefore, it is agreed with these authors that by modifying different factors such as ingredients and methods in the preparation of the samples, the same result was obtained, that is, the same greenish hue, so more advanced laboratory technologies are required that add chemicals to obtain a stable pigment.

Within the limitations of the present study, the green shades obtained were presented, instead of the yellow characteristics of the traditional Mexican bread of Día de Muertos, the above linked to the stabilization and fixation of the color in the bread due to the fact that the enzymes of the cempasúchil reacted when coming into contact with the pH of the mass, friction, oxygen and temperature, resulting in the undesirable green color for consumption, so future lines of research may propose the use of the cempasúchil flower dye with stabilizers that allow its use in various varieties of breads without modifying the characteristic yellow color of the crumb.

5 CONCLUSION

The use of the petals of the cempasúchil flower (*Tagetes erecta*) as a natural food coloring in Mexican dead bread, by means of different methods of integration to the dough (dehydration, bleaching, grinding) results in dry green tones and moss, due to the oxidation of the xanthophylls and carotenoids when they come into contact with the pH of the dough, the friction of the kneading and the oxygen to which the dough is exposed during its fermentation.

After seven samples made it is concluded that with the methods presented in this article can not obtain a natural yellow dye of the petals of the cempasúchil flower (*Tagetes erecta*), for its use it is necessary the addition of antioxidants and laboratory techniques that allow the carotenoids and xanthophylls of the petals do not oxidize when they come into contact with the mass.

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