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Natural conservation of guinea pig (*Cavia porcellus*) meat vacuum packed: Oregano essential oil effect on the physicochemical, microbiological and sensory characteristics

Yamaly Moreno[1]; Hubert. L. Arteaga-Miñano[2,*]

[1] *Cooperativa de Servicios Especiales - Redes de Productores de Cuyes del Crisnejas. Jr. Suarez 122, Cajamarca, Peru.*
[2] *Faculdade de Zootecnia e Engenharia de Alimentos. Universidade de São Paulo, Av. Duque de Caxias Norte 225, Campus Fernando Costa USP, CEP, 13635-900, Pirassununga, SP, Brasil.*

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Abstract

Guinea pig meat is high in protein and low in fat, representing an attractive option for human nutrition. In addition, its sensory characteristics are making this product more appreciated in both internal and external markets. However, it is a highly perishable product, for which it is important to look for products and technologies that allow it to preserve its quality. Oregano essential oil is a natural product that presents antimicrobial and antioxidant properties that can use on the preservation of meat. Thus, the objective of this work was to study the effect of the concentration of oregano essential oil (0.5% and 1%) and storage time (0, 35 and 70 days) at -10 °C, on physicochemical, microbiological and sensory characteristics of guinea pig meat vacuum packed. For this was used guinea pigs of Peru race with 3 months of age-old and weight range between 600 and 700 g. Oregano essential oil at 0.5 and 1% was dissolved in a saline solution at 2%, next add to surface internal and external of meat after this was packing vacuum in PE pouches and stored at -10 °C until 35 and 70 days. At each storing time was evaluated physicochemical, microbiological and sensory characteristics. The best results in the majority of the characteristics were obtained to 0.5% oregano essential oil concentration and 70 days of storage, in this condition the characteristics were pH = 6.11 ± 0.05; moisture (%) = 71.6 ± 0.36; ΔEi = 3.74 ± 0.77; ΔEe = 8.30 ± 0.55; PBC = 99 ± 4 cfu/g and; texture, odor, internal and external color and, appearance acceptable.

Keywords: essential oils; guinea pig meat; sensory properties; foods preservation.

1. Introduction

Guinea pig meat is traditionally consumed in the highlands of Peru and other countries of South America as a base diet of their population (Lammers *et al.*, 2009; Jurado-Gámez *et al.*, 2016). This meat has high protein content (20.3%), and low content fat (7.8%); compared with other meat products, like birds (18.2% protein and 10.2% fat), cattle (18.7% protein and 18.2% fat) and pigs (12.4% protein and 35.8% fat). So, it has high nutritional potential (Pascual, 2000; Rosenfeld, 2008). For nowaday, researchers have been studying this meat with approaches nutritional, productive and preservation (Ordoñez and Martos, 2004). As, the meat is a matrix rich in nutrients that provide an adequate environment for the proliferation of pathogenic and spoilage microorganisms (Guevara *et al.*, 2018), is important to find methods to preserve it. Added to this it is important to consider that, consumers demand safer food products, natural and healthy (Rivera *et al.*, 2015).

Oregano essential oil is one natural alternative that has antioxidant effects (Fasseas *et al.*, 2007; Goulas *et al.*, 2007; Scramlin *et al.*, 2010), and antimicrobial properties when it is added to meat (Burt, 2004; Gutierrez *et al.*,2008), these effects justifies its addition as preservative in processed foods. However, there are insufficient works in preservation of Guinea Pig meat using essential oils. Hernández *et al.* (2007) had reported that oregano essential oil at 0.15% on pig meat presented bacterial inhibition against *Escherichia coli* and *Staphylococcus aureus*. In both cases its antioxidant and antimicrobial effect was attributed at high content of polyphenols; carvacrol and

* Corresponding author
E-mail: harteaga@usp.br (H. Arteaga-Miñano).

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thymol, which are the main components of the essential oil of oregano (Kosar *et al.*, 2003; Capecka *et al.*, 2005; Al-Bandak, 2007). The other hand, oregano essential oil can contribute to improving the ones sensory characteristics of taste and odor in food in which they are applied (Burt, 2004; Cristani *et al.*, 2007; Fasseas *et al.*, 2007; Brewer *et al.*, 2011). Sullivan *et al.* (2004) indicated that the use of natural antioxidant into chicken nuggets decreases the total lipid oxidation and increases color stability. Oregano essential oil can add in emulsion, nanoemulsions encapsulated (Moraes-Lovison *et al.*, 2017), in pads absorbent (Oral *et al.*, 2009) or incorporated in edible films (Karagöz *et al.*, 2010; Iturriaga *et al.*, 2012). Its add can be combined with others compound natural or synthetics (Chouliara *et al.*, 2007; De Barros *et al.*, 2012; Hulankova *et al.*, 2013) in vacuum packing (Atrea *et al.*, 2009) or with modified atmospheres (Skandamis *et al.*, 2001; Giatrakou *et al.*, 2008) searching to improve their effectiveness.

Considering the importance that have guinea pig meat on feeding and the consumers preferences to value the safe, nutritious and natural products, the objecttive this work was to evaluate the effect of the concentration of oregano essential oil and storage time; on physicochemical, microbiological and, sensory characteristics of guinea pig meat (*Cavia porcellus*) vacuum packed.

2.Materials and methods

2.1 Preparation of samples

Was used 32 carcasses of fresh guinea pig, only males of race Peru, with 3 months of age-old, selected with an average weight of 600 - 700 g (Fernandez, 2010). The meat fresh was characterized by selecting 5 of the 32 samples randomly, determining the values of pH, moisture (%) and texture (N). The 27 remaining samples were used as follows: 9 samples immersed in a saline solution 2% with 0.5% oregano essential oil, 9 samples in saline solution 2% with 1% oregano essential oil; and 9 samples only in saline solution 2%. After this, with a brush was spread evenly over the surface of the carcass. Then these were packed, sealed vacuum in LDPE bags and stored to -10 °C (Ordóñez, 2004) at 35 and 70 days of storage. In each storing time, the meat samples were thawed in 6 hours at 4 °C and measured pH, moisture (%), ΔE (variation of internal and external color), PBC (psychrophilic bacteria count) and sensory characteristics.

2.2 Physicochemical Characteristics

The pH was analyzed for triplicate using potentiometer (Metrohm 827) following method 947.05 of the AOAC (2000). To determine the moisture (%) was used method 950.46 AOAC (2000). The variation of color (ΔE) was assessed using a colorimeter (JZ-300 Shenzhen Kingwell Instruments Co., China) with coordinates L*, a*, and b* that are values corresponding to luminosity, reddening and yellowness respectively: black (-L) or white (L), green (-a) or red (a), and blue (-b) or yellow (b) (Filgueras *et al.*, 2010; Holman *et al.*, 2017; Naves *et al.*, 2017). The variation of color was calculated using coordinates of sample fresh respect to sample stored by each storage time (Wei *et al.*, 2012).

$$\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

The hardness was determined according to Dalvi-Isfahan *et al.* (2016) using a texture analyzer model TA. HDPlus (Stable Micro System, Surrey, UK), with probe p/2 (2mm) with 5 N load cell, until the compressive strain reached 25% of the initial thickness.

2.3 Sensory Characteristics

Was used a non-parametric scale of 9 points; for evaluating the characteristics of texture, odor, internal color, external color and appearance for each sample. The survey was applied to 12 expert judges (Beriain *et al.*, 2001) members of the Association of breeders of Guinea pig in the province of Cajabamba (Peru), 11 men and 1 woman between the ages of 35 to 50 years.

2.3 Microbiological Characteristics

25 g of each sample was crushed and dissolved with 225 mL solution of peptone 0.1%, then stir for 1 minute. Moreover, dilutions from 10^{-1}, 10^{-2} and 10^{-3}, were made. Then two plates were prepared with each dilution by adding 1 ml on each Standard Plate Count Agar (PCA). Plates were incubated to 4 °C for 10 days (ICMSF, 1999; Hulankova *et al.*, 2013), after the incubation period was made count of psychrophilic bacteria, identifying the organism through a Gram staining; and the result was expressed as colony forming units (cfu/g).

2.4 Statistical analyses

For characteristic physicochemical and microbiological was performed an analysis of variance (ANOVA) and the Tukey test using a significance level of 0.05. While to sensory characteristic was applied Friedman and Wilcoxon test. The analyses were conducted using Statistica 10.0 (Statsoft®, USA).

Table 1
Physicochemical characteristics of guinea pig meat with oregano essential oil in storage

Treatment (Cxt)	pH	Moisture (%)	ΔEi	ΔEe
T1(0x0)	6.44±0.02^{a}	70.9±0.92^{a}	0.00±0.00^{a}	0.00±0.00^{a}
T2(0x35)	6.70±0.06^{b}	70.1±0.81^{a}	4.44±1.31^{b}	2.94±1.70^{b}
T3(0x70)	6.35±0.02^{a,d}	74.2±0.25^{b}	7.65±1.02^{c}	3.54±1.23^{b}
T4(0.5x0)	6.37±0.02^{a,d}	71.5±0.61^{a}	0.00±0.00^{a}	0.00±0.00^{a}
T5(0.5x35)	6.07±0.04^{c}	70.5±0.20^{a}	2.59±0.91^{b}	8.18±1.98^{c}
T6(0.5x70)	6.11±0.05^{c}	73.1±0.96^{b}	3.74±0.77^{b}	8.30±0.55^{c}
T7(1x0)	6.33±0.01^{d}	71.8±0.26^{a}	0.00±0.00^{a}	0.00±0.00^{a}
T8(1x35)	6.33±0.02^{d}	70.9±0.50^{a}	4.10±1.59^{b}	5.13±0.31^{b}
T9(1x70)	6.17±0.01^{c}	72.9±0.87^{b}	6.06±0.37^{b,c}	9.52±0.69^{c}

Mean ± SD. C: Oregano essential oil concentration, t: storage time. Values with superscripts different (a, b, c and d) in the same column are significantly different ($p < 0.05$) by Tukey test.

3. Results and discussion

3.1 Physicochemical characteristics

The samples fresh of guinea pig meat presented 6.3±0.03 of pH, 71.3±0.61 % of moisture and 33.25±3.66 N of hardness; these values are into range of the NTP 201.058 (2006) and others works (Mota-Rojas *et al.*,2012; Lucas *et al.*, 2018) in pH and, according to Hilvay (2015) for moisture with 70.6%, while texture values have been reported as shear strength of 983.89 and 1093.67 N for males insensitized by dislocating and the electrical method respectively (Mota-Rojas *et al.*, 2012) .

The results are presented in Table 1, the range of variation of pH and moisture were small, having a nonlinear behavior depending on the treatment conditions. However, the variation of color was greater, especially in the external part, increasing with oregano essential oil concentration and storage time.

pH

The figure 1 shows the behavior of pH in each treatment, in the beginning the differences were not significant. However, increasing the storage time, the behavior depended of the oregano essential oil concentration. Thus, with 0.5 % and 1% allows to maintain pH in values lowest to 6.37. The pH of meat depends on several factors among which are the race, gender, management, amount of muscle glycogen reserves, type of stunning and the hormones that circulate in the blood (Mota-Rojas *et al.*, 2012). The optimum pH for Guinea pig meat is between 5.99 to 6.37 according with NTP 201.058 (2006). Samples without oregano essential oil (0%) show an increment in pH until 35-day, exceeding the limit established by the norm. Similar behavior was found by Hulankova *et al.* (2013) in minced beef. Besides, Moore and Gill (1987) reported increasing of pH in lamb meat from 5.61 to 6.23 in 10 weeks of vacuum packed storage. They hypothesized that basic compounds can be formed by the rupture of muscle fibers at a higher speed than the formation of lactic acid.

The pH behavior of Guinea Pig meat with oregano essential oil can be explained by the high level of polyphenols containing the oil, since they are excellent hydrogen donors that could form strong hydrogen bonding with the protein through a hydroxyl group. This depends on the velocity which is transferred theses ions in the meat matrix and biochemical stage of glycogen transformation to lactate and ions hydrogen. Moreover, should be considered type of muscle used (Sánchez-Macías *et al.*, 2018).

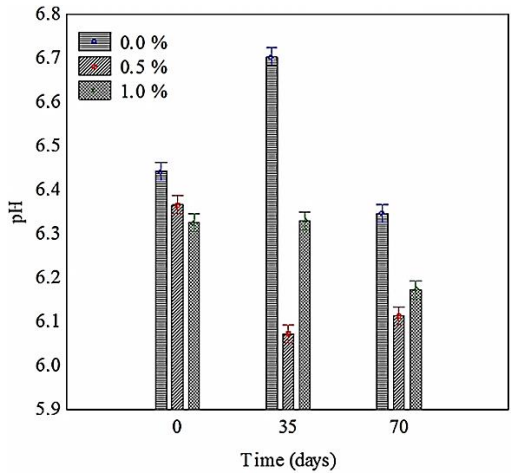

Figure 1. pH depending of oregano essential oil concentration (%) and storage time (days).

Moisture

In Figure 2 is showed that % moisture increases slowly while increases the oregano essential oil concentration as much to 0-day as to 35-day, nevertheless at 70-day behavior is inverse. The sample without oil (0%) presented a greater variation between 70.9 to 74.2, while samples with oil to 0.5% and 1% showed no significant variation with values between 70.5 to 72.9; the essential oil generated only a slight change in water-holding

capacity. However, storage time at 70 days present an increase significative.

This behavior is associated with the decline in pH of the samples of meat causing a shrinking of polypeptides network that leads to a decrease of meat capacity to retain water (Forrest, 1979). Elmasry *et al.* (2012) evaluated the % moisture in 81 samples of beef with Basil oil to concentrations of 0.15%, 0.5% and 1% reporting final values of 69.40, 72.92 and 76.30, respectively. Sánchez-Macías *et al.* (2018) reported for fresh carcass meat of guinea pig a range of 73 to 75.5% of moisture. Another factor to consider is the freezing temperature of storage on meat structure cells damage, making available water that could be partially bound.

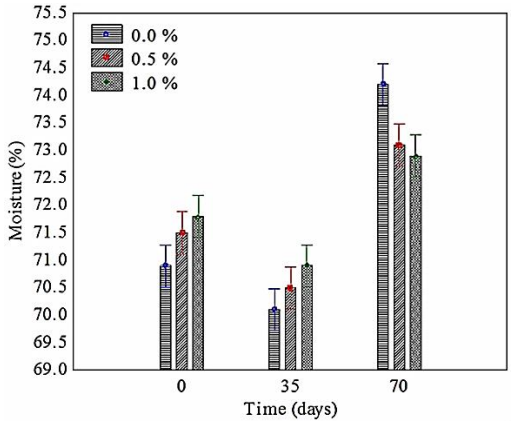

Figure 2. Moisture of guinea pig meat depending of oregano essential oil concentration (%) and storage time (days).

Variation of internal (ΔEi) and external (ΔEe) color

The position for measure internal and external color is shown in Figure 5. In figure 3a is showed a minor variation of internal color in the samples with 0.5%, this happens by the antioxidant action of carvacrol that reacts capturing free radicals and preventing oxidative, on muscular tissues. Besides, these compounds can be reducers, sensitive to oxygen and suppressors of pro-oxidant metals, help to maintain the color. Nevertheless, the variation of external color was greater in this condition, only being only being exceeded by the concentration of 1% to 70 days. It is worth noting that, skin tissue was more sensitive to change in color than muscular tissue.

At higher oregano essential oil concentration (1%) increases Myoglobin oxidation process generating greater variation of color (Gutierrez *et al.*, 2009), so it is not advisable to use percentages greater than 1%, since it could be acting as pro-oxidant. Naves *et al.* (2017) indicated that in meat refrigerated, part of the extracellular water may have reallocated in the intracellular medium and the effects of the pigments concentration may have been gradually overcome by the protein denaturation and lipid oxidation effects, promoting an increase in lightness, but contribute to the auto-oxidation of DMb (purplish-red deoxymyoglobin) to MMb (brown metmyoglobin) with aging. It has also been suggested that higher L* values observed with increased aging time are associated with the reduction of mitochondrial respiratory activity, which provides greater oxygenation of the myoglobin molecule, resulting in the greater formation of OMb (cherry-red oxymyoglobin).

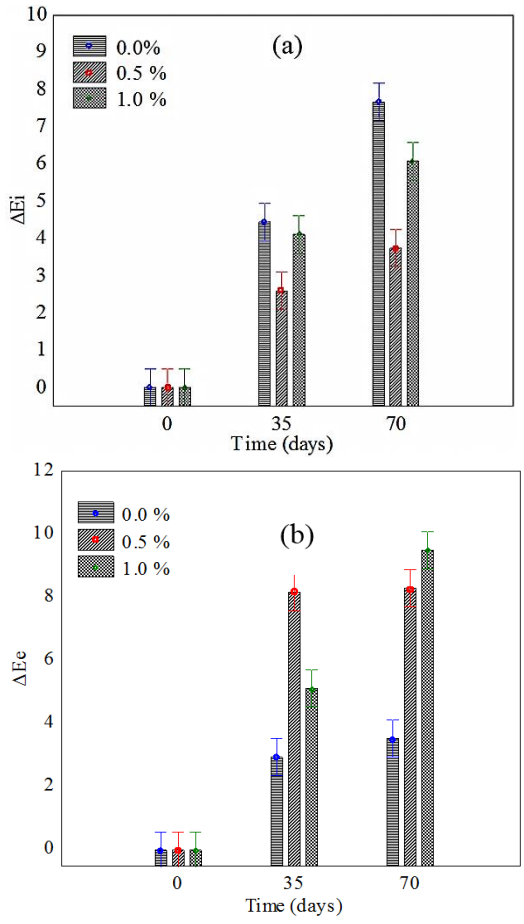

Figure 3. Variation of color a) internal ΔEi and b) external ΔEe depending of oregano essential oil concentration (%) and storage time (days).

The internal color of the Guinea pig meat can vary within the tones like follow: pale pink, pink, light red according to NTP 201.058 (2006). Sullivan *et al.* (2004) evaluated the effect of natural antioxidants, such as rosemary, sage, and catechins of

tea on the chicken nuggets. They found that addition of these compounds decreeses the total lipid oxidation and increases color stability and product stability. Oussalah *et al.* (2006) informed than compounds active of oregano essential oil in films with meat showing availability of 60.62% after 5 days stored at 4 °C, when was used with 2% of CaCl2.

Albarracín *et al.* (2012) had reported that thyme and rosemary essential oil, were able to reduce the oxidation of tilapia fillets in a range of 53.9 (2% of rosemary) to 94.7% (8% of thyme) in the twelfth day of refrigerated storage when compared with the oxidation observed in the sample control, suggesting inhibition of free radical by hydrogen donation of phenolic diterpenes such as carnosic acid, carnosol, rosmanol, rosmariquinone and rosmaridiphenol in the case of rosemary and, thymol and carvacrol for thyme.

Holman *et al.* (2017) have correlated the color instrumental with sensory acceptability of beef. They suggested acceptable value when a* values were equal to or above 14.5. In guinea pig meat values of L* both internal as external color was greater than 40 (data not showed).

3.2 Microbiological characteristics

In Table 2 is reported the psychrophilic bacteria count (*Micrococcuss*) that were identified by coloration Gram. The lower count was obtained in treatments T6 and T9 obtaining with 99 and 67 cfu/g respectively. This reduction was due, at higher content of carvacrol on oregano essential oil, that inhibits the growth of different strains. Although the action of carvacrol on *Listeria monocytogenes* can be inhibited by egg yolk and bovine serum albumin and temperatures lower (Veldhuizen *et al.*, 2007).

Table 2
Psychrophilic bacteria count (PBC) on guinea pig meat with oregano essential oil in storage

Treatment (Cxt)	PBC (cfu/g)
T1(0x0)	738±16^{a}
T2(0x35)	860±10^{b}
T3(0x70)	1593±26^{c}
T4(0.5x0)	760±16^{d}
T5(0.5x35)	247±4^{e}
T6(0.5x70)	99±4^{f}
T7(1x0)	783±14^{d}
T8(1x35)	181±15^{e}
T9(1x70)	67±21^{g}

Mean ± SD. C: Oregano essential oil concentration, t: storage time. Values with superscripts different (a, b, c, d, e, f and g) are significantly different ($p < 0.05$). Test Tukey.

Lemay *et al.* (2002) had evaluated the inhibitory effect of nisin, lactate of sodium and mustard essential oil in microorganisms inoculated experimentally in chicken meat (pH = 5) that were stored for 15 days at a temperature of restrictive growth. Mustard essential oil presented count significantly lower bacteria mesophilic aerobic while other antimicrobial agents had no significant effect on counts of mesophilic aerobic bacteria, *E. coli*, and *B. thermosphacta*.

Abdollahzadeh *et al.* (2014) reported effects of thyme essential oil at 0.8% and 1.2% of concentration, reaching a reduction of 2 log cfu/g on *Lysteria mococytogenes* at 6 days of store at 4 °C in minced fish, attributing to the content of polyphenols like thymol, carvacrol, acid caffeic and trans-cinnamaldehyde, which are present in products such as oregano (Albarracín *et al.*, 2012). De Barros *et al.* (2012) had found that minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) of oregano essential oil for *Staphylococcus aureus* on meat was 0.6 and 1.25 µL/mL respectively. Marques *et al.* (2015) have reported values MBC between 6.25 until 100 µL/mL and values MIC between 25 until 100 µL/mL for *Staphylococcus aureus*, values that depending of the strain and colonizing surfaces. Dussault *et al.* (2014) had added minimal inhibitory and maximal tolerated concentration of oregano essential oil on *Listeria monocytogenes* (521 and 313 ppm), *Staphylococcus aureus* (417 and 104 ppm), *Bacillus cereus* (261 and 313 ppm), *Salmonella typhimurium* (625 and 313 ppm), *Escherichia coli* (625 and 417 ppm) and *Pseudomonas aeruginosa* (2083-1042 ppm), being strains Gram positive more sensitive than Gram negative. Moraes-Lovison *et al.* (2017) reported for *Staphylococcus aureus* not differences significates both for MIC as MBC of oregano essential oil until day 90 of storage, but for *Escherichia coli* increased mainly in MBC. Govaris *et al.* (2010) suggested for improved activity against *Salmonella enteritidis* in minced sheep meat, by combinate oregano essential oil (0.6%) with nisin (1000 UI/g).

In Figure 4 the samples unpreserved (0%) showed a great proliferation of bacteria with an initial count of 738 cfu/g (0-day) and final count of 1593 cfu/g (70-day). However, the samples with preservative (0.5% and 1%) showed an accelerated decline of bacteria count at 35 days, followed by a slow decline to 70 days of storage. This happens by the antimicrobial action of carvacrol and thymol content in this essential oil, that can easily reach the

cytoplasmic membrane of bacteria, altering its structure and functions, interfering with cellular energy (ATP) generation system (Jayasena and Jo, 2013; Rivera *et al.* 2015). These researchers, explain that the presence of hydroxyl groups in constituents phenolic of essential oil, is very important for antimicrobial activity, and the mechanism action, include degrade the cell wall, disturb the phospholipid bilayer of the cytoplasmic membrane and damage the membrane proteins leading increasing the permeability membrane cell and loss of cellular constituents, disrupt the proton motive force, electron flow, active transport, coagulate the cell contents, impair a variety of enzyme systems including the enzymes involved in the energy regulation and synthesis of structural components and, being able to inactivate or destroy genetic material.

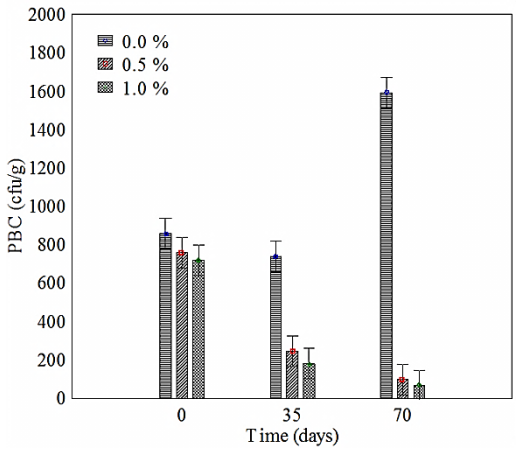

Figure 4. Psychrophilic bacteria count (cfu/g).

Hulankova *et al.* (2013) by application of oregano essential oil (0.2%), caprylic acid (0.5%) and citric acid (1%) on minced beef vacuum packed, they reached to reduce count of psychotropic bacteria by more than 2.5 log cfu/g, at 3 °C for 10 days with better score sensory than the control. While that lonely oregano essential oil reached 1.5 log cfu g^{-1}. Karabagias *et al.* (2011) reported that with oregano essential oil (0.3%) lamb meat samples reached 7 log cfu/g in 6-7 days, representing the upper microbiological limit for acceptable quality meat on.

Solis (2011) used oregano and thyme essential oil in bird meat, like antibacterial against *Salmonella spp.*, and *S. aureus*. He reported better results with thyme essential oil. Rea (2011) evaluated the antimicrobial activity of the cumin (*Cuminun cynimun*) essential oil as potential biopreservative in flesh of trout, against *E. Coli*. Their results showed a reduction of 2-4 log cfu/mL. Hernández *et al.* (2007) evaluated four concentrations of thymol-carvacrol (0, 0.05, 0.10 and 0.15%) on pig meat to 0, 24, 72 and 120 hours. The treatment with 0.15% was the better, indicating that the pathogens evaluated in this type of meat showed lower sensitivity compared with the evaluated in the guinea pig meat.

3.3 Sensory Characteristics

In the sensory evaluation was analyzed appearance, internal color, external color, odor and, texture. The values are presented in the Table 3 and showed like profile in the Figure 6. In each characteristic the treatment T6 have little variation when compared with control sample T1. Solis (2011) analyzed the effect of thyme and oregano essential oil to concentrations 0%, 0.25%, 0.5%, 1% and 1.25% during 0, 10 and 15 days of storage on color, odor and texture of chicken breast. The best result was with oregano essential oil at 0.5% after 15 days of storage. Rea (2011) conducted a study of the effect of thyme oil on trout, but the sensory attributes analyzed were not improved with the essential oil used. However, in our study oregano essential oil maintained acceptable characteristics during the evaluated time. The action of oregano essential oil decreases the oxidation of fats, preserving odor and color. Hilvay (2015) reported preservation of the color, odor and taste of guinea pig meat injected with oregano essential oil (0.30%) during 40 days at 4 °C. In our work the sensory characteristics of guinea pig meat with 0.5% of oregano essential oil were preserved until 70 days, this longer shelf life is explained by the lower storage temperature -10 °C and vacuum packaging. However, levels greater than 1% of oregano essential oil can imparted a very strong taste that allowing rejected the product. So, is suggested like maxim level 0,1% for this product (Chouliara *et al.*, 2007). However, Govaris *et al.* (2010) suggest to use 0.8 to 1% for enhance the sensory characteristics of minced beef or sheep meat, and Hulankova *et al.* (2013) suggest limits lesser as 0.2%. The oregano essential concentration to use will depend of composition of the essential oil (Burt, 2004), the stage of harvest and parts of the plant used in the extraction (Jordán *et al.*, 2013).

Appearance

In the Table 3 is showed that the appearance of the samples fresh (T1) and with 0.5% of oregano essential oil at 70 days of

storage (T6) not present significant difference ($p < 0.05$). The appearance is the one main characteristic in the choice of the consumer (Thomas *et al.*, 2006). Ozdikmenli and Demirel (2015) showed that in meat ball the appearance decreased by increased the concentration of oregano essential oil, similar behavior was meet in this work with 1% oregano essential oil, being more accentuated with the increase of storage time.

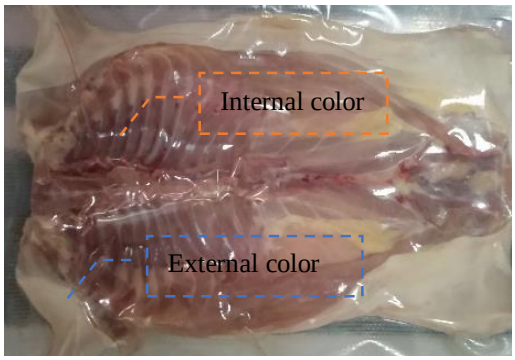

Figure 5. Position for measure color internal (meat) and external (skin).

External color

The treatments T1 and T4, achieved a higher score for external color categorized like acceptable by the panelists. The consumer has learned through experience that the color of the fresh beef is bright red and it is unacceptable when present a big variation of the color (Beriain *et al.*, 2009), this behavior also is applied to guinea pig meat.

Internal color

The treatments T1 and T6 obtained a higher score by the panelists, being an internal color acceptable of the guinea pig meat. The treatment T6 despite have 70 days of storage, obtained the same assessment in this characteristic as the T1, this happens because the oil of oregano helps keep the color of the meat for longer (Solis, 2011). This result is in accordance with the values reported with the colorimeter.

Odor

The treatments with higher score were T1, T4 and T6 (7.41, 7.00 and 6.83 respectively). This assessment tells us that these treatments presented the characteristic smell of the meat of guinea pig. In a sensory evaluation carried by Flores-Mancheno *et al.* (2016) reported the odor as an indicator of quality of meat should have a "normal smell" or equal to fresh guinea pig meat; without rancid odor. Atrea *et al.* (2009) indicated that the oregano essential oil to 0,4% improved shelf-life of Mediterranean octopus packed in vacuum by 20 days at 4°C, keeping desirable and pleasant the odor. Pesavento *et al.* (2015) also suggested to use 0.5% of the oregano essential oil concentration in meat. Krkić *et al.* (2013) reported that after of 7 month the odor and flavor of sausage were better for those coated, resulted of lesser content aldehydes by lipid oxidation.

Guinea pig meat at 70 days of storage without oregano essential oil, presented the lower score sensorial, signal of degradation of proteins and fats that releasing volatile compounds, despite the score was 4.33 representing an assessment regular in the scale used.

Texture

The best treatments in texture are T1 and T6 (7.66 and 7.56 respectively) indicating that these samples were firm to touch, both muscle tissue and fat (Gupta and Abu-Ghannan, 2011). Boleman *et al.* (1997) stated that the attributes that influence the acceptability general of meat are juiciness, texture and flavor. Solis (2011) reported a very good, tender, strong, nice and juicy texture of chicken meat with thyme and oregano oil when compared to fresh chicken meat after 15 days of storage.

Table 3
Sensory characteristics of the guinea pig meat with oregano essential oil in storage

Treatment (Cxt)	Texture	Odor	Internal color	External color	Appearance
T1(0x0)	7.66±0.49^{a}	7.41±0.52^{a}	7.75±0.62^{a}	7.75±0.62^{a}	7.67±0.49^{a}
T2(0x35)	5.58±1.62^{b}	5.83±0.94^{b}	5.25±0.75^{b}	5.42±0.79^{b}	5.58±0.62^{b}
T3(0x70)	4.08± 1.37^{c}	4.33±1.23^{c}	3.91±0.51^{c}	4.50±1.31^{c}	4.08±1.37^{c}
T4(0.5x0)	7.50± 0.52^{a}	7.00±0.60^{a}	7.91±0.79^{a}	7.75±0.52^{a}	7.50±0.52^{a}
T5(0.5x35)	7.08± 0.49^{ad}	6.41±0.67^{ad}	7.25±0.62^{a}	7.17±0.58^{a}	7.08±0.29^{ad}
T6(0.5x70)	7.56± 0.49^{a}	6.83±0.58^{ad}	8.00±0.60^{a}	7.67±0.65^{a}	7.58±0.51^{a}
T7(1x0)	7.00± 0.49^{a}	6.33±1.23^{ad}	6.50±0.67^{bd}	6.83±0.83^{ab}	7.00±0.95^{ad}
T8(1x35)	6.41± 0.49^{d}	6.25±1.22^{d}	6.00±1.27^{d}	6.00±1.28^{b}	6.41±0.79^{b}
T9(1x70)	5.25± 1.71^{b}	5.58±1.08^{b}	5.25±0.75^{b}	4.92±0.90^{bc}	5.25±1.71^{b}

Mean ± SD. C: concentration, t: time of storage. Means with superscripts different (a, b, c and d) in the same column are significantly different ($p < 0.05$). Wilcoxon test.

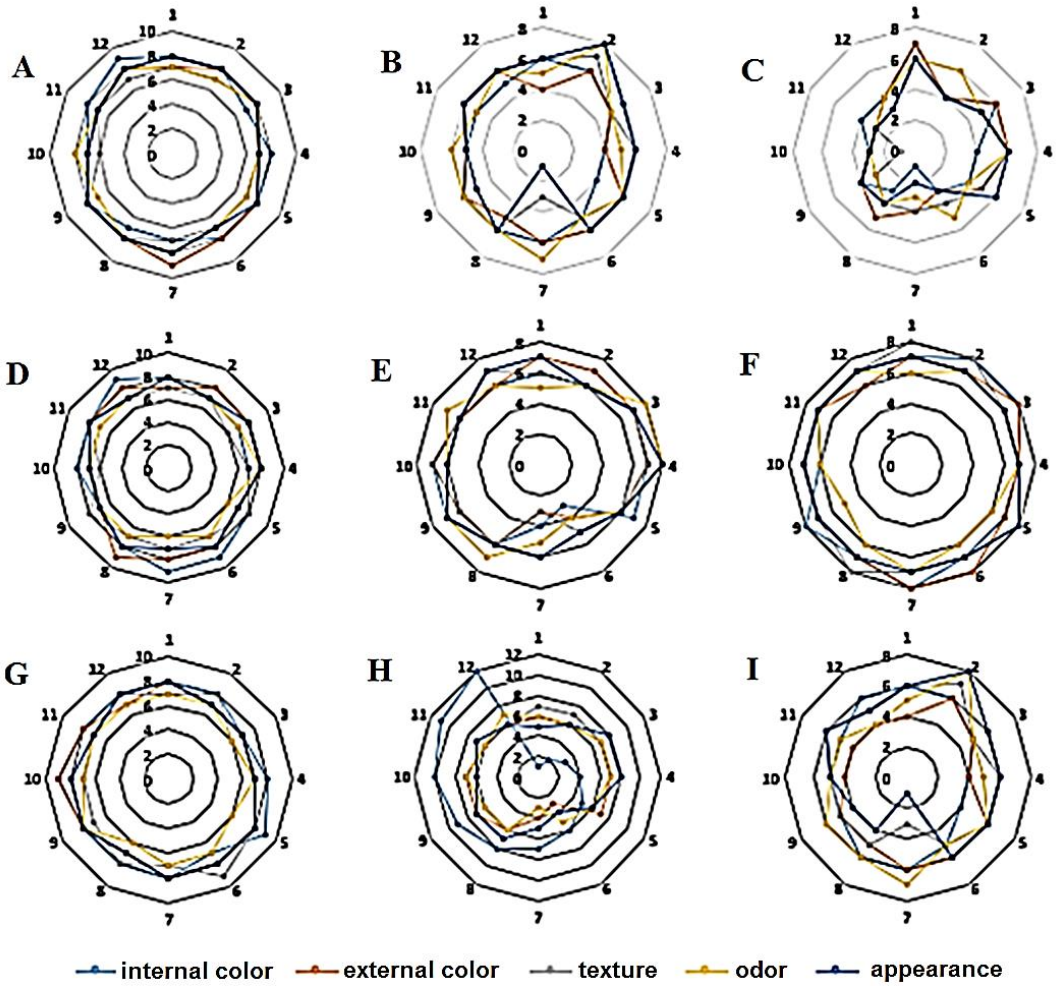

Figure 6. Sensory profile of guinea pig meat at different concentrations of oregano essential oil: with 0% to the 0 days (A), 35 days (B) and 70 days (C); with 0.5% to the 0 days (D), 35 days (E) and 70 days (F); and with 1% to the 0 days (G), 35 days (H) and 70 days (I).

4. Conclusions

Oregano essential oil applied like emulsion represent an important alternative for preserve guinea pig meat vacuum packed. The concentration recommended is 0.5% which allowed maintained the quality physicochemical, microbiological and sensorial reaching a shelf life of 70 days at -10 °C. This information will allow the people involved in the production chain of guinea pigs to adopt an alternative for the conservation of meat, being able to reach more distant markets, both national and international.

This technology requires more studies on characterization and quantification of actives compounds in essential oils of plants and optimize doses for application on meat products. Also, is important to develop equipment for applying the essential oils emulsified or nanoemulsioned in meat processing lines.

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