Sodium Alginate and Calcium Lactate (Algin) Effect on Beef or Poultry Co-product Blends Used in a Pet Jerky Product

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Presented by

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Abstract. Pet products are a growing market. An experiment was designed to evaluate the applicability of dried organ meat blends as pet food treats using beef and chicken co-products, as well as sodium alginate and calcium lactate (Algin) as a structuring agent. Objectives of the study were to evaluate the effect of sodium alginate and calcium lactate on the physicochemical characteristics in mixtures of dried organ meat blends for pets based on heart and liver from beef and chicken, the effect of the structuring agent according to the species of animal used, and the color stability over time. A Completely Randomized Design (CRD) with a factorial arrangement of three by two was used, with 12 treatments and 10 replicates for a total of 120 experimental units. The physicochemical variables evaluated were cooking loss, pH, Aw, expressible moisture, and color change over time. Higher percentage inclusions of sodium alginate, calcium lactate, and heart caused a reduced loss by cooking ($P < 0.001$) and expressible moisture ($P < 0.001$). No differences in pH were observed regardless of treatment ($P = 0.6538$). Mixtures that had a greater loss by cooking presented a lower Aw ($P < 0.001$). Over the first three days, all treatments experienced a change in darkness and yellowness color values based on CIE L* a* b*. Changes in color values, established that visual change in color can be observed. An analysis of the final product formulations is recommended.

Key words: Heart, liver, water.

Resumen. Los productos para mascotas son un mercado en crecimiento. Se diseñó un experimento para evaluar la aplicabilidad de mezclas de carne de órganos como golosina seca para mascotas utilizando coproductos de carne de res y pollo, y alginato de sodio y lactato de calcio (Algin) como agente estructurante. Se utilizó un Diseño Completamente al Azar (DCA) con arreglo factorial de tres por dos, con 12 tratamientos y 10 repeticiones para un total de 120 unidades experimentales. Las variables fisicoquímicas evaluadas fueron pérdida de cocción, pH, Aw, humedad expresable y cambio de color con el tiempo. La mayor cantidad de Algin y corazón causaron una pérdida reducida por cocción ($P < 0.001$) y humedad expresable ($P < 0.001$). No se observaron diferencias en el pH independientemente del tratamiento ($P = 0.6538$). Las mezclas que tuvieron una mayor pérdida por cocción presentaron una menor Aw ($P < 0.001$). Durante los primeros tres días, todos los tratamientos experimentaron un cambio en los valores de color de oscuridad y amarillez basados en CIE L * a * b *. Cambios en los valores de color, establecieron que se puede observar un cambio visual de color. Se recomienda un análisis de las formulaciones del producto final.

Palabras clave: Agua**,** corazón, hígado.

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1. INTRODUCTION

Production of meat from animals generates a large amount of lower value co-products, this amount varies according to animal species. In the poultry industry, assuming a 70% yield during processing, the aggregate of co-products from processing chickens for meat globally is 45.9 million tons (Seidavi *et al*. 2019). In the beef industry, the volume of co-products (included organs, fat, skin, feet, abdominal, and intestinal content, bone and blood) of cattle represent 51% of the live weight (Aguirre *et al*. 2014). Animal co-products are simply the parts of animals that are not typically consumed in developed countries, which would include organ meats. United States population rarely consumes a wide variety of organ meats (liver, hearts, kidneys, tripe, etc.) that other cultures consider delicacies (Thompson 2008). Increasing values of these co-products, is common, and foods for animals are a great use of these nutritious but lower value co-products. to develop animal foods, including pet foods.

Currently, the pet food industry has grown steadily, thanks to increased consumption of commercially prepared foods (Zicker 2008). North America has more than 163 million dogs and cats that consume, as an important part of their diet, animal products (Okin 2017). In the second quarter of 2018, Americans spent nearly 800 million USD on pet products on the retail website Amazon alone, representing growth of more than 30% compared to a similar period in 2017 according to the American Association for Pet Products (APPA). Trend on the rise, according to analysts, as pets occupy an increasingly preferred place in 68% of households.

In Latin America, in 2017 more than 5.9 million tons of balanced pet food were consumed, generating an approximate market value of 6,719.1 million dollars. Growth forecast for this region is 30% for the next 10 years. Countries with greatest importance in this market are Brazil and Mexico, where they have a similar penetration rate. Other countries in Latin America are constantly growing and with opportunities to opt for this new market. Argentina is the third country with the highest consumption on the continent, followed by Colombia, Chile, and Uruguay. One of the biggest problems in Latin America is the high number of imported products, which prevents growth of local industries. Innovation is a key factor in growth of this type of industries. Rise in consumption of pet food makes this market interesting for new entrepreneurs, in Latin America, the penetration rate is less for European countries and the United States, this is due to the culture of this region, in which excessive spending on pet products is not common. (Franco 2018).Most common source of these products is poultry and beef, due to the low value of the co-products from processing for human consumption from the meat and poultry industry and high levels of protein they provide.

Poultry protein meals are a very popular protein source for use in pet foods (Meeker 2006). Their low costs generate a high production of pet food using poultry co-products meals and fats. Beef co-products are also widely used, especially organ meats. To produce pet food, organs such as liver and heart can be used. In beef, liver represents 1.0-1.5% of liveweight and heart 0.3-0.5%. While in poultry, liver represents 1.6-2.3% and heart 0.3-0.8%. (Meeker 2006).One of the most important pet food manufacturing segments is pet treats, some of which, are produced as dehydrated meat products or jerky. Jerky is a ready-to-eat product that does not require refrigeration at point of sale (Coradini *et al*. 2019). Dehydrated jerky is a snack food in high demand owing to its rich flavor, nutritional value, and storage stability without refrigeration (Kim *et al*. 2014). This product consists of dehydrated and cook meat mixtures, to increase shelf life by decreasing water activity (Aw).

Another segment of the pet food industry is sausages, these are meat product made of finely ground and seasoned meat, which may be fresh, smoked, or pickled; and which is then usually stuffed into a casing. Pet sausages are generally used as a snack, they are high in protein and fat. Fat is one of the most variable raw materials in sausage products (Baer and Dilger 2014), this contributes in flavor and texture in the product, so its levels must be regulated. Structure of the sausages needs a stabilizer so that the union between fat and water is correct, creating an adequate emulsion between these two components. Use of alginate to form a gel is common in this type of product. Alginate's ability to form a strong and coherent gel and water binding capacity are two essential factors to obtain a desirable meat emulsion in sausage production. (Savadkoohi *et al*. 2014).

Gels change the structure of food and allow more stable products to be developed. In this study, Algin was used, which is the combination of sodium alginate and coated calcium lactate. Alginate is widely used in the food industry, it is derived from brown algae, it is a polysaccharide like a glycosaminoglycan composed of two monosaccharides, β-D-mannuronic acid and α-Lguluronic acid (Binder *et al*. 2009). For correct performance of the alginate, it is necessary to add some source of calcium, since gelation rate is directly proportional to calcium concentration (Lee and Rogers 2012). It is common to use calcium lactate in combination with alginate, increased levels of lactate may produce a considerable improvement in sensory and cohesion properties of alginate in gel restructured products (Ensor *et al*. 2009).

The objectives of this study were:

- To evaluate the effect of Algin in physicochemical parameters on heart and liver blends (beef and chicken) of a jerky raw and cooked treat for pets.
- To determine the effect of proportion of beef or chicken viscera blends (percentage of heart and liver) in physicochemical parameters of a jerky raw and cooked treat for pets.
- To analyze the change in color over time of the co-product beef or chicken raw and cooked blends.

2. MATERIALS AND METHODS

Location
This experiment was conducted at Auburn University's Poultry Processing Plant. Physicochemical analyzes were carried out in the Starkey laboratory of Department of Poultry Science at Auburn University. Statistical analysis was carried out at Zamorano University, in Honduras.

Weighing
This experiment was conducted by using four main products: chicken liver (CL), chicken heart (CH), beef liver (BL) and beef heart (BH). 24 kg of each product were weighed.

Grinding
Raw products were ground individually using an industrial grinder provided by the Poultry Science facilities of Auburn University. Each product was ground to an equal mince particle (10-mm diameter). After grinding, each product was placed in a separate and labeled container prior to mixture.

Mixture
Prior to this step, 12 containers were cleaned and labeled for our 12 treatments. In each one, liver and heart of each specie (Chicken or Beef) was mixed manually at three different ratios until a uniform blend is formed. This step was performed twice.

Structure forming
To provide a more stable structure to our mixtures, Algin was used as a structure forming agent. Algin is a combination of two functional ingredients: sodium alginate and calcium lactate. (Alginate is a hydrocolloid; it plays a role of thickener and forms thermo-irreversible gel in presence of calcium). Slow release encapsulated calcium lactate was used to increase the yield of sodium alginate. Therefore, two different dosages of Algin (0.5% and 1% manufactures recommended inclusion) were tested on each of six heart-liver formulations to produce final batches.

For the first Algin dosage (1%), the functional ingredients were at the following proportions:
- Sodium alginate: 1% of total mixture
- Calcium lactate: 0.85% of total mixture.

For the second Algin dosage (0.5%), the functional ingredients were at the following proportions:

- Sodium alginate: 0.5% of the total mixture
- Calcium lactate: 0.42% of the total mixture

These proportions are the manufacturer's recommended dosage for gelation of stabilized meat mixtures. Inclusion rates of 0.85 and 0.42% of calcium lactate is associated with mentioning 1 and 0.5% of sodium alginate in the document.

Sodium alginate was sprinkled into each of meat slurries and the mixture was stirred until a complete blend was formed. Then, calcium lactate was added as the mixture was being stirred. Table 1 shows the proportion of each of the treatments, with their respective percentages of heart, liver and Algin.

Table 1. Ratio of products in mixtures.

Chicken liver (%)	Chicken heart (%)	Beef liver (%)	Beef heart (%)	Algin (%)
25	75			1.0
25	75			0.5
50	50			1.0
50	50			0.5
75	25			1.0
75	25			0.5
		25	75	1.0
		25	75	0.5
		50	50	1.0
		50	50	0.5
		75	25	1.0
		75	25	0.5

Preparation of final batches

Product mixtures were fed into an extruder with a 20 mm thick three-dimensional outlet rectangle. Products were then wrapped in plastic and refrigerated. Samples for further analysis were stored at refrigerated temperatures and were analyzed immediately after product manufacture.

Dehydration and cooking

40 samples of each treatment were placed in a commercial smokehouse to be dehydrated at a temperature of 93.3 °C (200 °F) for 2 hours and 30 minutes.

Variable analysis

After 48 hours, the products prepared for jerky were sliced into 25.4 × 63.5 mm (1 × 2.5 in), then resulting samples were weighed and placed on metal racks for dehydration. A total of 40 samples were generated from each treatment. In remaining products, 10 samples from each treatment was cut into 38.1 × 38.1 mm (1.5 × 1.5 in) in for color measurement. Additionally, 10 other samples from each treatment were sliced into 25.4 × 25.4 mm (1 × 1 in) for expressible moisture. Finally, 10 more products from each treatment were shaped into spherical forms and wrapped with plastic for water activity and pH measurements.

Cooking loss analysis

Final cooking loss was measured by dividing the difference between aliquots of raw meat and cooked meat products by weight of raw meat (AOAC, 950.46B), depicted in the Equation 1:

$$\frac{w1-w2}{w1} \times 100 \qquad [1]$$

Where:

w1: weight of raw products   w2: weight of cooked products.

NB. For weighing, samples were placed onto a weighing paper.

Water activity

This variable was assessed by using 10 samples of raw and 10 samples for cooked meat products. For analysis, samples were transferred in the Aqualab instrument and results were shown on the screen after a few minutes.

Expressible moisture

This variable was assessed only in 10 samples of raw meat products by using the filter-pressed method. This method measured the amount of liquid that can be squeezed from the protein system by application of external forces. To begin, six filter papers (35.0 um pore size and 75-mm diameter, (Ahlstrom Munksjo) were weighed. Then, three were placed on each side of the meat and the complex (meat + filter paper) was weighed again. Additionally, the complex was pressed at 5 kg for 5 minutes. After 5 minutes, crushed meat was discarded, and filter papers were weighed to calculate expressible moisture.

To determine expressible moisture, Equation 2 was used:

Expressible moisture = (Filter paper after test-Filter paper only)/ (Complex weight - Filter paper only) ×100.   [2]

pH

pH of 10 samples of raw meat products was measured by using a Hach pH meter model No. H170G.

Color

Color variation on 10 samples of raw and 10 for cooked products were measured in terms of CIE L*, a*, b* values using a Minolta colorimeter. Data on color was taken on day 0, day 3, day 5 and day 7. A Delta E analysis was performed to assess behavior of color over time, depicted in Equation3:

$$\sqrt{(L_2-L_1)^2+(a_2-a_1)^2+(b_2-b_1)^2} \quad [3]$$

Experimental design and statistical analysis

A Completely Randomized Design with a 3 × 2 factorial arrangement was used, in which mixtures of liver and heart and concentrations of Algin are the factors that interact with each other to produce physicochemical changes in the final product (Table 2). Liver and heart of each specie was mixed to generate 3 different combinations of 25% liver - 75% heart, 50% liver - 50% heart and 76% liver - 25% heart. Three mixtures were then combined with two dosages of our functional ingredients (Algin) to generate a total of 12 different treatments (Table 2). 10 replicas per treatment were performed to generate a total of 120 experimental units.

For the statistical analysis, SAS® version 9.4 was used to perform an ANOVA and DUNCAN separation test to find statistical differences between treatments. LS means was used to assess interaction among treatments. All analysis was performed with a significance level of 95%.

Table 2. Description of treatments evaluated in the study.

Factor 1	***Factor 2***
Proportion of ingredients	**Percentage of Algin (%)**
25CL75CH	0.5
25CL75CH	1.0
50CL50CH	0.5
50CL50CH	1.0
75CL25CH	0.5
75CL25CH	1.0
25BL75BH	0.5
25BL75BH	1.0
50BL50BH	0.5
50BL50BH	1.0
75BL25BH	0.5
75BL25BH	1.0

3. RESULTS AND DISCUSSION

Cooking loss

Cooking loss is defined as the percentage change in weight and dimensions in food due to cooking. This is due to the loss of water (as well as fats and aromatic substances) during the application of heat, because of the rupture of the cell membrane and modifications of proteins in relation to changes in the three-dimensional structure. (Alvarado and Sams 2004) mentioned that cooking losses are considered a measure of the muscle's water-holding capacity.

Illustrated in Table 3, differences were observed ($P < 0.05$) among different treatments, mixtures with a lower percentage of Algin and a greater quantity of liver showed increased loss of weight by cooking (Table 4). According to Gault (2005), the use of gelling agents increases water retention in food, thereby decreasing the amount of water that is lost by cooking the product. Greater amount of water, the greater the loss due to cooking, this can be observed in mixtures with a higher percentage of liver, since it has a greater amount of water in its structure. This is caused by the type of protein from which beef and chicken heart and liver are made. Heart, being a striated muscle, has a greater amount of myofibrillar proteins compared to liver (Dhanasettakorn *et al*. 2011). This type of protein retains more water than proteins of the liver (smooth proteins), for this reason the greatest loss by cooking occurs in mixtures with a greater amount of liver in its formulation.

Beef heart and liver have higher calcium values, with a total of 6 and 11% respectively compared to chicken heart and liver with a total of 1.9 and 1%. Calcium is an agent that increases effectiveness of sodium alginate in water retention in meat mixtures (Lee and Rogers 2012).

There are differences in cooking losses depending on type of viscera used (beef or poultry), treatments based on beef heart and liver had a lower cooking loss than treatments based on chicken liver and heart. Beef has a higher amount of protein in the composition of the heart and liver, with a total of 40 and 27.1% respectively, compared to the percentage of protein from chicken heart and liver with a total of 36 and 15.5% respectively (Lin *et al*. 2011).

Table 3. Probability of the different sources for cooking loss for poultry and beef heart and liver jerky pet treat.

Source	**Pr>F**
Comb	<0.0001
Algin	<0.0001
Rep	0.7486
Comb*Algin	<0.0001

Table 4**.** Comparisons of means and standard deviations (SD) of percentage cooking loss for poultry and beef heart and liver jerky pet treat.

Blends	**Algin (%)**	**Total cook loss (%)**
		Mean ± SD
25BL75BH	0.5	45.994 ± 2.59^{H}
25BL75BH	1.0	44.139 ± 3.57^{HI}
25CL75CH	0.5	61.270 ± 1.46^{D}
25CL75CH	1.0	54.660 ± 2.60^{E}
50BL50BH	0.5	47.749 ± 3.84^{G}
50BL50BH	1.0	42.645 ± 2.86^{IJ}
50CL50CH	0.5	71.720 ± 3.81^{A}
50CL50CH	1.0	53.730 ± 4.11^{F}
75BL25BH	0.5	45.283 ± 1.98^{H}
75BL25BH	1.0	41.774 ± 2.20^{J}
75CL25CH	0.5	65.650 ± 4.74^{B}
75CL25CH	1.0	63.040 ± 3.61^{C}
CV (%)		6.72

A-E. Means in the same column with different letter are statistically different ($P \leq 0.05$).
CV: Coefficient of variation (%).
CL: Chicken Liver, CH: Chicken Heart, BL: Beef Liver, BH: Beef Heart.
25, 50 and 75 is a percentage.
Algin (%): Percentage of sodium alginate and respective percentage calcium lactate.

pH

Treatments did not show difference in pH ($P > 0.05$) in any of the interactions. The pH was the same in all the treatments, regardless of the amount of Algin, the meat-based mixture, and amount of water the product possessed. At pH considered high (> 6.0) or below the isoelectric point, the number of charges available increases, which in turn increases water holding capacity of meat (Gault 2005). On the other hand, an approximation to the isoelectric point (5.4-5.7) determines a loss of the holding capacity (Hamm 2008).

Water activity

There were no differences observed in water activity among treatments ($P > 0.05$) in any of the raw product and Algin combinations. Cooked product (Table 5) had differences ($P < 0.05$), both for beef and poultry, with a lower water activity being observed in treatments with a lower amount of Algin. This is related to loss due to cooking, since products with higher inclusions of Algin demonstrated reduced water loss during cooking, which decreased the moisture of these treatments. According to (Harmayani *et al*. 2001), Algin decreases cooking loss by retaining more water during heat exposure. Lower the humidity in a food, the lower its water activity. Treatments with a higher percentage of liver also showed less water activity (Table 6). Percentage of water in liver is greater than that of heart, at time of cooking mixtures with more liver lost more water, which was observed in water activity of the cooked product. Water activity in meat is a factor that can determine bacterial growth, meat naturally contains around 75% water (Hooffman *et al*. 2014) Water activity depends on the amount of water the product contains. In chicken-based blends, water activity was lower, due to the lower amount of water caused by a greater cooking loss. This results are similar to those obtained for (Allen *et al*. 2004).

Table 5. Probability of the different sources for cooked water activity for poultry and beef heart and liver jerky pet treat.

Source	**Pr>F**
Comb	<0.0001
Algin	<0.0001
Rep	0.0621
Comb*Algin	<0.0001

Table 6. Comparisons of means and standard deviations (SD) of water activity for cooking poultry and beef heart and liver jerky pet treat.

Blends	**Algin (%)**	**Water activity**
		Mean ± SD
25BL75BH	0.5	0.9800 ± 0.004^{A}
25BL75BH	1.0	0.9630 ± 0.012^{BC}
25CL75CH	0.5	0.9727 ± 0.008^{AB}
25CL75CH	1.0	0.9793 ± 0.018^{ABC}
50BL50BH	0.5	0.9390 ± 0.009^{ABC}
50BL50BH	1.0	0.9690 ± 0.011^{D}
50CL50CH	0.5	0.9012 ± 0.019^{AB}
50CL50CH	1.0	0.9767 ± 0.013^{F}
75BL25BH	0.5	0.9560 ± 0.006^{ABC}
75BL25BH	1.0	0.9640 ± 0.009^{C}
75CL25CH	0.5	0.8967 ± 0.012^{E}
75CL25CH	1.0	0.9214 ± 0.013^{D}
CV (%)		1.97

A-E. Means in the same column and row with different letter are statistically different ($P \leq 0.05$).
CV: Coefficient of variation (%).
CL: Chicken Liver, CH: Chicken Heart, BL: Beef Liver, BH: Beef Heart.
25, 50 and 75 is a percentage.
Algin (%): Percentage of sodium alginate and respective percentage calcium lactate.

Expressible moisture

Expressible moisture is one measurement of water-holding capacity of food protein systems; it is defined as the amount of liquid squeezed from a protein system by application of force and it measures the amount of loose water released under measurement conditions. (King *et al*. 2013).

There was difference in expressible moisture observed among treatments (P > 0.05) (Table 7). As Algin was reduced, expressible moisture increased for both the raw beef and chicken combinations (Table 8). Treatment with the highest amount of expressible moisture for chicken was 75CL25CH0.5 and for beef it was 75BL25BH0.5. This is due to the increased amount of liver in the mixture and the low amount of Algin. Liver, as it has more water and less protein, releases more water when subjected to pressure. Treatments that resulted in reduced Algin. Poultry-based treatments had higher values of expressible moisture compared to those made with beef, caused by the lower amount of protein and calcium in its composition, protein allows meat to retain water while calcium increases effectiveness of sodium alginate (Maysonnave *et al*. 2019).

Table 7. Probability of the different sources for expressible moisture for poultry and beef heart and liver jerky pet treat.

Source	**Pr>F**
Comb	<0.0001
Algin	<0.0001
Rep	0.5225
Comb*Algin	<0.0001

Table 8. Comparisons of means and standard deviations (SD) of expressible moisture for poultry and beef heart and liver jerky pet treat.

Blends	**Algin (%)**	**Water loss Mean ± SD**
25BL75BH	0.5	10.960 ± 1.371^{D}
25BL75BH	1.0	7.4580 ± 1.211^{E}
25CL75CH	0.5	18.840 ± 1.804^{B}
25CL75CH	1.0	11.870 ± 1.903^{D}
50BL50BH	0.5	11.470 ± 1.674^{D}
50BL50BH	1.0	8.8280 ± 1.212^{E}
50CL50CH	0.5	22.608 ± 1.512^{A}
50CL50CH	1.0	14.442 ± 1.542^{C}
75BL25BH	0.5	17.904 ± 1.762^{B}
75BL25BH	1.0	9.2540 ± 1.254^{E}
75CL25CH	0.5	23.340 ± 2.002^{A}
75CL25CH	1.0	17.240 ± 1.125^{B}
CV (%)		13.11

A-E. Means in the same column and row with different letter are statistically different ($P \leq 0.05$).
CV: Coefficient of variation (%).
CL: Chicken Liver, CH: Chicken Heart, BL: Beef Liver, BH: Beef Heart.
25, 50 and 75 is a percentage.
Algin (%): Percentage of sodium alginate and respective percentage calcium lactate.

Color

Color in meat is the main guiding attribute for consumers to determine if meat is fresh or not, therefore, looking for methods to maintain color becomes one of the main problems for processors. Color of muscle in beef carcass is red-violet because iron in deoxy myoglobin is in a ferrous state. When exposed to oxygen, iron is reduced and oxymyoglobin is formed, which gives it a bright red color. Prolonged exposure to oxygen oxidizes iron and iron changes a ferric state and becomes methemoglobin, which has a brownish-brown color. (Gill 2016). In chicken meat, which have reduced concentrations of myoglobin, oxidation occurs more slowly and affects color change less, so paler colors are observed (Allen *et al*. 2004). This color usually changes on the surface of meat and causes consumer rejection. In CIELAB color spectrum, low L values indicate darkness and high values are light (Mathias and Ah-Hen 2014). For a * value, low values indicate green tones and high values indicate red tones. For b * value, low values indicate blue tones and high values indicate yellow tones (Hoffman *et al*. 2012).

L value

Differences ($P < 0.05$) was observed in the variable L (luminosity) between the raw treatments (Table 9), a change was observed in the first three days, with the luminosity stabilizing over time. For the main effect of Algin concentration, it was observed that products with lower concentrations of added Algin had a higher average value for luminosity, so the product was observed to be darker in color, this was caused by reduced concentrations of water in products with a lower percentage of Algin, since water can create more crystalline shades in meats.

Products with mixtures of poultry heart and liver had higher L values compared to mixtures of beef heart and liver. Beef viscera has a higher concentration of myoglobin (Wu *et al*. 2020), for this reason beef muscle color is more intense, which can be observed when comparing mixtures of beef and chicken meat base, this results in increased color values for a, but reduced color values for L, in poultry, viscera has less intense colors, this allows a greater amount of light to be reflected, which increases the value L color in analyses. This results are similar to those obtained for (Andreou *et al*. 2018).

In Table 9 differences were observed ($P < 0.05$) between different treatments. Treatments did not show a difference regardless of the concentration of added Algin. Mixtures with the largest amount of heart showed higher means of L value.

Table 9. Comparisons of means and standard deviations (SD) of color value L (Luminosity) for raw poultry and beef heart and liver jerky pet treat over time (Day 0, 3, 5 and 7).

Blends	**Algin (%)**	**Day 0 Mean ± SD**	**Day 3 Mean ± SD**	**Day 5 Mean ± SD**	**Day 7 Mean ± SD**
25BL75BH	0.5	39.46 ± 1.83^{DE}	42.47 ± 0.90^{B}	44.65 ± 1.13^{A}	43.04 ± 1.68^{AB}
25BL75BH	1.0	39.16 ± 1.21^{E}	41.42 ± 1.14^{BC}	44.19 ± 1.23^{A}	41.99 ± 0.34^{BC}
25CL75CH	0.5	42.04 ± 3.16^{IJK}	44.72 ± 1.16^{BC}	44.50 ± 1.19^{BC}	44.86 ± 3.25^{BC}
25CL75CH	1.0	40.37 ± 2.15^{L}	42.62 ± 1.42^{HIJ}	42.88 ± 1.26^{FG}	45.16 ± 1.16^{BC}
50BL50BH	0.5	36.16 ± 1.33^{FG}	38.56 ± 1.83^{E}	39.23 ± 1.83^{DE}	40.83 ± 1.83^{CD}
50BL50BH	1.0	36.40 ± 0.83^{F}	38.75 ± 2.83^{E}	39.11 ± 1.45^{E}	39.75 ± 1.83^{D}
50CL50CH	0.5	41.73 ± 1.34^{JK}	49.95 ± 1.16^{A}	43.69 ± 1.16^{DEF}	43.20 ± 1.16^{EF}
50CL50CH	1.0	41.80 ± 2.16^{JK}	43.38 ± 1.56^{EFG}	44.61 ± 1.16^{BC}	45.26 ± 2.36^{B}
75BL25BH	0.5	30.76 ± 1.83^{L}	32.87 ± 1.83^{JK}	34.29 ± 1.83^{HIJ}	33.44 ± 6.83^{IJK}
75BL25BH	1.0	32.31 ± 1.83^{KL}	34.63 ± 2.03^{GHI}	35.65 ± 1.83^{FG}	35.56 ± 4.83^{GH}
75CL25CH	0.5	41.08 ± 1.16^{KL}	42.64 ± 1.16^{IGIJ}	42.77 ± 1.16^{GH}	42.89 ± 1.20^{FG}
75CL25CH	1.0	40.18 ± 0.99^{IL}	41.72 ± 1.59^{JK}	41.90 ± 1.16^{JK}	42.07 ± 3.13^{IJK}
CV (%)			2.709		

A-L. Means in the same column and row with different letter are statistically different ($P \leq 0.05$).
CV: Coefficient of variation (%).
CL: Chicken Liver. CH: Chicken Heart, BL: Beef Live. BH: Beef Heart.
25, 50 and 75 is a percentage.
Algin (%): Percentage of sodium alginate and respective percentage calcium lactate.
L has a scale 0-100, 0 is black and 100 is white.

In cooked products (Table 10), it was observed that L value increased in the first three days, on day five and seven differences in color change decreased. Product turned darker shades over time. Products with 1% percentage of Algin had a higher average than treatments with 0.5%. This occurred because product with 1% Algin had a lower cooking loss (Table 5), so mixtures with 1% Algin deteriorated faster due to their greater amount of water, this leads to darker colors as time passes. Mixtures with the highest percentage of heart reduced values for Luminosity.

Cooked treatments (Table 10) showed a difference ($P < 0.001$) between treatments, all treatments showed an increase in the L value in the first 3 days, stabilizing over time. Treatments with a higher percentage of Algin showed higher means of L value, this due to its higher percentage of water, which is why its deterioration is faster. The mixtures with larger inclusions of heart showed a higher value for L.

Table 10**.** Comparisons of means and standard deviations (SD) of color value L (Luminosity) for cooking poultry heart and liver jerky pet treat over time (Day 0, 3, 5 and 7).

Blends	**Algin (%)**	**Day 0 Mean ± SD**	**Day 3 Mean ± SD**	**Day 5 Mean ± SD**	**Day 7 Mean ± SD**
25BL75BH	0.5	26.17 ± 1.80^{FGH}	28.86 ± 1.87^{DE}	31.69 ± 1.12^{AB}	32.09 ± 1.87^{AB}
25BL75BH	1.0	28.81 ± 1.87^{DE}	31.68 ± 1.56^{AB}	32.79 ± 1.76^{A}	32.33 ± 1.53^{AB}
25CL75CH	0.5	26.06 ± 2.15^{HIJ}	30.30 ± 2.15^{EF}	31.16 ± 2.15^{CDE}	32.98 ± 2.15^{C}
25CL75CH	1.0	30.76 ± 1.15^{DEF}	36.43 ± 2.12^{AB}	38.30 ± 2.15^{A}	39.17 ± 2.22^{A}
50BL50BH	0.5	36.16 ± 1.83^{FG}	38.56 ± 1.83^{E}	39.23 ± 1.83^{DE}	40.83 ± 1.83^{CD}
50BL50BH	1.0	36.40 ± 1.65^{F}	38.75 ± 1.23^{E}	39.11 ± 1.86^{E}	39.75 ± 1.76^{D}
50BL50BH	0.5	23.36 ± 1.87^{J}	24.26 ± 1.87^{IJ}	25.71 ± 1.87^{GHI}	25.79 ± 1.87^{GHI}
50BL50BH	1.0	26.81 ± 1.23^{FG}	30.92 ± 1.87^{BC}	32.63 ± 1.84^{A}	32.68 ± 1.87^{A}
75BL25BH	0.5	30.76 ± 1.83^{L}	32.87 ± 1.15^{JK}	34.29 ± 1.85^{HIJ}	33.44 ± 1.83^{IJK}
75BL25BH	1.0	32.31 ± 1.52^{KL}	34.63 ± 1.76^{GHI}	35.65 ± 1.34^{FGH}	35.56 ± 1.83^{FGH}
75BL25BH	0.5	24.80 ± 01.98^{HIJ}	25.61 ± 1.87^{GHI}	26.72 ± 1.76^{FG}	26.75 ± 1.87^{FG}
75BL25BH	1.0	27.55 ± 1.70^{EF}	29.75 ± 1.87^{CD}	31.71 ± 1.23^{AB}	32.35 ± 1.34^{AB}
CV (%)			7.1915		

A-J. Means in the same column and row with different letter are statistically different (P ≤ 0.05).
CV: Coefficient of variation (%).
CL: Chicken Liver, CH: Chicken Heart, BL: Beef Live, BH: Beef Heart.
25, 50 and 75 is a percentage.
Algin (%): Percentage of sodium alginate and respective percentage calcium lactate.
L has a scale 0-100, 0 is black and 100 is white.

Value a.

Addition of poultry meat resulted in higher a* or increased redness values (P < 0.001) when compared to those containing beef products. Over time, meat products darken because of lipid oxidation, this occurs the same way in cooked product (Table 11). Andreou *et al*. (2018) obtained increases in color value a as time increased, results similar to those obtained in this study. In beef, the opposite happens, values reduce (P < 0.001) over time, these are similar to results obtained by When oxidized, myoglobin takes brown tones, reducing the reddish appearance of meat, in liver and heart of chicken contains lower concentrations of myoglobin there by resulting in lower occurrences of brown tones than observed in beef (Lin *et al.* 2011).

No difference was observed in Algin concentrations (P > 0.05). Mixtures with a higher percentage of heart have higher reddish tones, this mainly occurs since the heart is naturally darker than the liver, this for both raw and cooked chicken and beef.

Table 11. Comparisons of means and standard deviations (SD) of color value a (green to red values) for raw poultry heart and liver jerky pet treat over time (Day 0, 3, 5 and 7).

Blends	**Algin (%)**	**Day 0 Mean ± SD**	**Day 3 Mean ± SD**	**Day 5 Mean ± SD**	**Day 7 Mean ± SD**
25BL75BH	0.5	11.20 ± 0.52^{AB}	9.76 ± 0.52^{FG}	9.34 ± 0.52^{GHI}	8.35 ± 0.52^{MN}
25BL75BH	1.0	11.06 ± 0.52^{AB}	9.87 ± 0.52^{EF}	9.12 ± 0.52^{HIJK}	8.43 ± 0.52^{MN}
25CL75CH	0.5	11.73 ± 0.63^{CD}	11.21 ± 0.63^{GHI}	14.23 ± 0.63^{A}	14.25 ± 0.63^{A}
25CL75CH	1.0	10.61 ± 0.63^{CD}	10.76 ± 0.63^{I}	12.56 ± 0.63^{D}	12.46 ± 0.63^{DE}
50BL50BH	0.5	10.55 ± 0.52^{D}	9.96 ± 0.52^{E}	9.10 ± 0.52^{HIJK}	8.26 ± 0.52^{N}
50BL50BH	1.0	10.93 ± 0.52^{AB}	10.69 ± 0.52^{C}	8.99 ± 0.52^{IJKL}	8.34 ± 0.52^{MN}
50CL50CH	0.5	11.41 ± 0.63^{GH}	11.53 ± 0.63^{FGH}	13.13 ± 0.63^{BC}	13.66 ± 0.63^{B}
50CL50CH	1.0	11.66 ± 0.63^{FG}	11.15 ± 0.63^{HI}	11.60 ± 0.63^{FGH}	12.87 ± 0.63^{CD}
75BL25BH	0.5	10.80 ± 0.52^{B}	9.19 ± 0.52^{HIJ}	8.30 ± 0.52^{MN}	8.59 ± 0.52^{LMN}
75BL25BH	1.0	11.39 ± 0.52^{A}	9.46 ± 0.52^{FGH}	8.73 ± 0.52^{JKL}	8.70 ± 0.52^{KLM}
75CL25CH	0.5	11.55 ± 0.63^{FGH}	12.36 ± 0.63^{DE}	12.43 ± 0.63^{DE}	13.46 ± 0.63^{B}
75CL25CH	1.0	11.47 ± 0.63^{FGH}	11.28 ± 0.63^{GHI}	11.59 ± 0.63^{FGH}	11.98 ± 0.63^{EF}
CV (%)			5.22		

A-I. Means in the same column and row with different letter are statistically different ($P \leq 0.05$).
CV: Coefficient of variation (%).
CL: Chicken Liver, CH: Chicken Heart, BL: Beef Live, BH: Beef Heart.
25, 50 and 75 is a percentage.
Algin (%): Percentage of sodium alginate and respective percentage calcium lactate.
A has a scale -60 to +60, -60 is green and +60 is red.

Value b.

B-value is of vital importance in meat products, this is a quality parameter since the degree of yellow color in meat products is not desirable. In Table 12, it is observed that, over time, the value b decreases, in the first three days the change is the most significant, while after five to seven days changes are stabilized. Lower value b means an increase in yellowish shades of product, which is considered an undesirable aspect in characteristics of meat products. Viscera have yellowish and greenish tones when they are not properly handled, these are not desirable in meat products (Girolami *et al*. 2013).

In Table 13, the b-values of raw poultry and beef treatments, b-value increased with lower inclusions of Algin were showed, this due to a lower amount of water thanks to its low retention compared to higher inclusions of Algin. Treatments with a higher percentage of liver had higher b values, in which it was observed that higher inclusions of heart increased rate of deterioration in mixtures since heart contains higher levels of fat in contrast to liver (Trampel *et al*. 2015). Fat is a determining factor in change of yellow tones in meat products, since a process that causes yellow color is oxidation of fat (Forrest 2009). In Table 14 the cooked poultry and beef product showed similar results, with an increase in b value at a lower amount of Algin. In raw (Table 13) and cooked (Table 14) beef products, a behavior equal to that of chicken is observed, with higher b values when Algin inclusion decreases, and a lower b value in mixtures with a higher percentage of heart due to its higher concentration of fat.

Products with a beef-based blends displayed lower b-values compared to products with a chicken-based blends, this was caused by the difference in percentage of heart fat and beef liver with heart and chicken liver. Beef has higher levels of fat so its oxidation will be increased. (Lin *et al*. 2011).

Table 12. Comparisons of means and standard deviations (SD) of color value a (green to red values) cooking poultry heart and liver jerky pet treat over time (Day 0, 3, 5 and 7).

Blends	**Algin (%)**	**Day 0 Mean ± SD**	**Day 3 Mean ± SD**	**Day 5 Mean ± SD**	**Day 7 Mean ± SD**
25BL75BH	0.5	4.88 ± 0.64^{G}	4.14 ± 0.64^{H}	3.96 ± 0.64^{H}	3.83 ± 0.64^{H}
25BL75BH	1.0	5.44 ± 0.64^{FG}	4.89 ± 0.64^{G}	4.94 ± 0.64^{G}	4.98 ± 0.64^{G}
25CL75CH	0.5	7.78 ± 0.56^{B}	5.44 ± 0.56^{CDEF}	5.44 ± 0.56^{CDEF}	5.26 ± 0.56^{DEFG}
25CL75CH	1.0	8.20 ± 0.56^{AB}	4.75 ± 0.56^{HIJ}	4.31 ± 0.56^{J}	4.29 ± 0.56^{J}
50BL50BH	0.5	6.03 ± 0.64^{CD}	5.84 ± 0.64^{DEF}	5.96 ± 0.64^{CDEF}	6.05 ± 0.64^{CDE}
50BL50BH	1.0	6.27 ± 0.64^{BC}	5.4 ± 0.64^{FG}	5.67 ± 0.64^{EF}	5.71 ± 0.64^{EF}
50CL50CH	0.5	5.71 ± 0.56^{CD}	4.76 ± 0.56^{HIJ}	4.96 ± 0.56^{FGHI}	4.60 ± 0.56^{IJ}
50CL50CH	1.0	5.47 ± 0.56^{BC}	4.92 ± 0.56^{GHI}	4.49 ± 0.56^{IJ}	4.52 ± 0.56^{IJ}
75BL25BH	0.5	6.67 ± 0.64^{AB}	6.81 ± 0.64^{AB}	7.12 ± 0.64^{A}	6.99 ± 0.64^{A}
75BL25BH	1.0	6.38 ± 0.64^{BC}	6.41 ± 0.64^{BC}	6.38 ± 0.64^{BCD}	6.36 ± 0.64^{BCD}
75CL25CH	0.5	7.84 ± 0.56^{B}	5.89 ± 0.56^{C}	5.31 ± 0.56^{DEF}	5.14 ± 0.56^{EFGH}
75CL25CH	1.0	7.83 ± 0.56^{B}	4.90 ± 0.56^{GHI}	4.63 ± 0.56^{IJ}	4.60 ± 0.56^{IJ}
CV (%)			10.075		

A-J. Means in the same column and row with different letter are statistically different ($P \leq 0.05$).
CV: Coefficient of variation (%).
CL: Chicken Liver, CH: Chicken Heart, BL: Beef Live, BH: Beef Heart.
25, 50 and 75 is a percentage.
Algin (%): Percentage of sodium alginate and respective percentage calcium lactate.
A has a scale -60 to +60, -60 is green and +60 is red.

Table 13. Comparisons of means and standard deviations (SD) of color value b (yellow to blue hues) for raw poultry and beef heart and liver jerky pet treat over time (Day 0, 3, 5 and 7).

Blends	**Algin (%)**	**Day 0 Mean ± SD**	**Day 3 Mean ± SD**	**Day 5 Mean ± SD**	**Day 7 Mean ± SD**
25BL75BH	0.5	12.59 ± 0.62^{BC}	12.48 ± 0.62^{BC}	12.65 ± 0.78^{AB}	11.81 ± 0.62^{DE}
25BL75BH	1.0	12.64 ± 0.62^{ABC}	12.81 ± 0.62^{A}	12.53 ± 0.42^{BC}	11.84 ± 0.62^{DE}
25CL75CH	0.5	14.38 ± 0.58^{BCD}	13.47 ± 0.58^{HI}	12.75 ± 0.64^{JK}	12.07 ± 0.58^{L}
25CL75CH	1.0	13.86 ± 0.58^{EFGH}	13.08 ± 0.89^{IJ}	12.48 ± 0.52^{KL}	12.25 ± 0.58^{KL}
50BL50BH	0.5	10.73 ± 0.62^{HI}	11.62 ± 0.62^{EF}	11.53 ± 0.62^{EF}	11.12 ± 0.62^{FGH}
50BL50BH	1.0	12.32 ± 0.62^{CD}	12.19 ± 0.62^{CD}	12.46 ± 0.87^{C}	11.78 ± 0.62^{DE}
50CL50CH	0.5	14.92 ± 0.58^{AB}	13.87 ± 0.58^{DEF}	14.06 ± 0.58^{DEF}	12.71 ± 0.58^{JK}
50CL50CH	1.0	13.21 ± 0.58^{EFG}	13.68 ± 0.58^{GH}	13.71 ± 1.43^{GH}	13.39 ± 0.58^{HI}
75BL25BH	0.5	10.08 ± 0.66^{J}	10.22 ± 0.62^{J}	10.46 ± 1.26^{IJ}	11.22 ± 0.62^{FGH}
75BL25BH	1.0	10.78 ± 0.62^{GHI}	11.29 ± 0.62^{EFG}	11.10 ± 1.42^{FGH}	11.78 ± 0.62^{DE}
75CL25CH	0.5	15.21 ± 0.58^{A}	14.89 ± 0.32^{AB}	15.12 ± 0.76^{AB}	14.64 ± 0.58^{BC}
75CL25CH	1.0	15.22 ± 0.53^{A}	14.35 ± 0.58^{CDE}	14.28 ± 0.52^{CDE}	13.80 ± 0.58^{FGH}
CV (%)			4.2104		

A-L. Means in the same column and row with different letter are statistically different ($P \leq 0.05$).
CV: Coefficient of variation (%). CL: Chicken Liver, CH: Chicken Heart, BL: Beef Live, BH: Beef Heart. 25, 50 and 75 is a percentage.
Algin (%): Percentage of sodium alginate and respective percentage calcium lactate.
B has a scale -60 to +60, -60 is yellow and +60 is blue.

Table 14. Comparisons of means and standard deviations (SD) of color value b (yellow to blues hues) for cooking poultry and beef heart and liver jerky pet treat over time (Day 0, 3, 5 and 7).

Blends	Algin (%)	Day 0 Mean ± SD	Day 3 Mean ± SD	Day 5 Mean ± SD	Day 7 Mean ± SD
25BL75BH	0.5	8.51 ± 1.38^{J}	11.82 ± 1.65^{EFG}	11.81 ± 1.22^{EFG}	11.85 ± 1.65^{EF}
25BL75BH	1.0	8.98 ± 1.65^{J}	11.26 ± 1.22^{FGHI}	12.09 ± 1.34^{CDE}	11.35 ± 1.32^{FGHI}
25CL75CH	0.5	11.68 ± 1.23^{EF}	15.68 ± 1.57^{BC}	16.75 ± 1.53^{AB}	17.06 ± 1.65^{A}
25CL75CH	1.0	12.52 ± 1.53^{DE}	15.46 ± 1.63^{BC}	16.16 ± 1.53^{ABC}	16.35 ± 1.57^{ABC}
50BL50BH	0.5	7.35 ± 1.85^{K}	10.54 ± 1.42^{HI}	10.76 ± 1.22^{GHI}	10.35 ± 1.13^{BC}
50BL50BH	1.0	8.38 ± 1.92^{JK}	12.24 ± 1.87^{BCD}	12.78 ± 1.22^{ABC}	13.08 ± 1.22^{ABC}
50CL50CH	0.5	8.00 ± 1.53^{I}	9.90 ± 1.53^{H}	11.05 ± 1.53^{FGH}	10.28 ± 1.53^{H}
50CL50CH	1.0	12.98 ± 1.53^{DE}	15.18 ± 1.53^{C}	16.20 ± 1.53^{ABC}	16.50 ± 1.53^{ABC}
75BL25BH	0.5	8.15 ± 1.22^{JK}	12.07 ± 1.22^{DEF}	12.61 ± 1.22^{BCD}	11.51 ± 1.22^{FGH}
75BL25BH	1.0	8.63 ± 1.22^{J}	13.29 ± 1.22^{AB}	13.69 ± 1.22^{A}	13.21 ± 1.22^{ABC}
75CL25CH	0.5	10.15 ± 1.53^{H}	11.84 ± 1.53^{DEFG}	11.93 ± 1.53^{DEF}	11.64 ± 1.53^{EFG}
75CL25CH	1.0	10.50 ± 1.53^{GH}	12.25 ± 1.53^{DEF}	13.16 ± 1.53^{D}	12.7 ± 1.53^{DE}
CV (%)			11.686		

A-I. Means in the same column and row with different letter are statistically different ($P \leq 0.05$).
CV: Coefficient of variation (%).
CL: Chicken Liver, CH: Chicken Heart,
BL: Beef Live, BH: Beef Heart.
25, 50 and 75 is a percentage.
Algin (%): Percentage of sodium alginate and respective percentage calcium lactate.
B has a scale -60 to +60, -60 is yellow and +60 is blue.

Delta E.

Delta E is a value used to interpret the difference between two shades of CIELAB colors, when this value approaches 2.3, in any case being less than 3, we speak of the JND or just noticeable difference that occurs between two levels of intensity of a sensory stimulus. Or what is the same, a color difference very hardly observable. (Hebbinghaus and Srivastav 2014). Delta E values do not show a difference between the raw (Table 15) and cooked (Table 16) treatments ($P < 0.05$) for chicken and beef. All values are greater than three, so it can be understood that color differences between days are visible by consumers.

Table 15. Comparisons of means and standard deviations (SD) of delta E for raw poultry and beef heart and liver jerky pet treat over time.

Blends	Algin (%)	Day 0-3 Mean ± SD	Day 0-5 Mean ± SD	Day 0-7 Mean ± SD
25BL75BH	0.5	3.669 ± 0.85^{A}	55.671 ± 1.54^{B}	4.988 ± 0.98^{AB}
25BL75BH	1.0	3.898 ± 0.89^{AB}	55.501 ± 1.23^{B}	4.231 ± 0.87^{B}
25CL75CH	0.5	3.419 ± 0.29^{A}	53.437 ± 1.13^{D}	4.244 ± 0.23^{AB}
25CL75CH	1.0	3.183 ± 0.59^{AB}	53.136 ± 1.85^{D}	5.233 ± 1.98^{A}
50BL50BH	0.5	3.742 ± 0.76^{AB}	53.758 ± 1.04^{CD}	5.346 ± 01.58^{A}
50BL50BH	1.0	3.833 ± 1.13^{AB}	56.095 ± 1.75^{A}	4.375 ± 0.54^{AB}
50CL50CH	0.5	3.345 ± 1. 89^{B}	53.319 ± 1.01^{D}	3.630 ± 0.13^{C}
50CL50CH	1.0	3.366 ± 0.89^{B}	53.349 ± 1.34^{D}	4.185 ± 0.76^{B}
75BL25BH	0.5	3.089 ± 0.76^{AB}	54.677 ± 1.76^{C}	4.106 ± 0.23^{B}
75BL25BH	1.0	3.262 ± 0.89^{AB}	54.465 ± 1.13^{BC}	4.478 ± 0.76^{AB}
75CL25CH	0.5	3.385 ± 0.32^{B}	53.437 ± 1.76^{CD}	3.315 ± 0.43^{C}
75CL25CH	1.0	3.409 ± 1.45^{B}	54.048 ± 1.87^{BC}	3.425 ± 0.65^{BC}
CV (%)		12.15	15.23	17.81

A-D. Means in the same column with different letter are statistically different ($P \leq 0.05$).
CV: Coefficient of variation (%), CL: Chicken Liver CH: Chicken Heart, BL: Beef Live BH: Beef Heart, 25, 50 and 75 is a percentage. Algin (%): Percentage of sodium alginate and respective percentage calcium lactate.

Table 16. Comparisons of means and standard deviations (SD) of delta E for cooking poultry and beef heart and liver jerky pet treat over time.

Blends	Algin (%)	Day 0-3 Mean ± SD	Day 0-5 Mean ± SD	Day 0-7 Mean ± SD
25BL75BH	0.5	6.938 ± 2.56^{A}	7.796 ± 2.53^{A}	9.317 ± 2.75^{A}
25BL75BH	1.0	7.382 ± 2.24^{A}	9.340 ± 1.25^{A}	10.150 ± 6.36^{A}
25CL75CH	0.5	4.353 ± 2.87^{B}	3.764 ± 2.54^{B}	3.419 ± 3.56^{B}
25CL75CH	1.0	5.684 ± 2.35^{AB}	7.632 ± 2.65^{A}	8.062 ± 5.98^{A}
50BL50BH	0.5	3.779 ± 5.76^{B}	4.522 ± 2.87^{B}	4.470 ± 2.46^{B}
50BL50BH	1.0	4.737 ± 2.34^{B}	5.136 ± 2.06^{B}	5.035 ± 6.96^{B}
50CL50CH	0.5	5.675 ± 4.65^{A}	6.648 ± 2.05^{AB}	7.110 ± 2.36^{A}
50CL50CH	1.0	4.749 ± 4.03^{AB}	5.285 ± 2.07^{BC}	4.761 ± 1.65^{B}
75BL25BH	0.5	3.767 ± 3.23^{B}	4.427 ± 2.34^{C}	3.950 ± 3.36^{B}
75BL25BH	1.0	6.256 ± 2.03^{A}	7.518 ± 2.76^{A}	7.792 ± 2.35^{A}
75CL25CH	0.5	4.919 ± 1.34^{AB}	5.718 ± 2.34^{BC}	4.801 ± 2.76^{B}
75CL25CH	1.0	5.326 ± 2.54^{A}	6.607 ± 2.76^{AB}	6.749 ± 2.87^{A}
CV (%)		37.11	35.43	35.14

A-C. Means in the same column with different letter are statistically different ($P \leq 0.05$). CV: Coefficient of variation (%). CL: Chicken Liver CH: Chicken Heart, BL: Beef Live BH: Beef Heart. 25, 50 and 75 is a percentage Algin (%): Percentage of sodium alginate and respective percentage calcium lactate.

4. CONCLUSIONS

- Algin (Sodium Alginate and Calcium Lactate) influenced the mixtures in which, the greater the quantity of Algin, there was less cooking loss, greater water activity, greater intensity, or color change. It works more effectively in mixtures of beef compared with mixtures of chicken.

- The greater the amount of liver, the greater the cooking loss, less Aw, greater expressible moisture, and more intense colors.

- The color in the blends change from day 0 onwards. The blends with the highest amount of heart had darker colors.

5. RECOMENDATIONS

- Evaluate the color change by adding some type of preservative to the mixture to determine the final formulation.
- Evaluate different times and temperatures to find the most appropriate of those according to the formulation used.
- Perform cost analysis to compare with the different treatments and define the most profitable blend.
- Perform sensory analysis of the product in pets.
- Conduct microbiological analysis to determine shelf life.
- Evaluate blends of viscera from different animals in the same treatment.

6. REFERENCES

Aguirre Riofrío EL, Armijos Cabrera DR, Zhinin Quezada L. 2014. Evaluación de métodos de pesaje en vivo y determinación del rendimiento a la canal en bovinos manejados al pastoreo. Tsafiqui. Nutrición Animal, (5):8. doi:10.29019/tsafiqui.v0i5.278.

Allen CD, Russell SM, Fletcher DL. 2004. The relationship of broiler breast meat color and pH to shelf-life and odor development. Poult Sci. 76(7):1042–1046. eng. doi:10.1093/ps/76.7.1042.

Alvarado CZ, Sams AR. 2004. Early postmortem injection and tumble marination effects on broiler breast meat tenderness. Poult Sci. 83(6):1035–1038. eng. doi:10.1093/ps/83.6.1035.

Andreou V, Tsironi T, Dermesonlouoglou E, Katsaros G, Taoukis P. 2018. Combinatory effect of osmotic and high pressure processing on shelf life extension of animal origin products – Application to chilled chicken breast fillets. Food Packaging and Shelf Life. 15:43–51. doi:10.1016/j.fpsl.2017.11.002.

Baer AA, Dilger AC. 2014. Effect of fat quality on sausage processing, texture, and sensory characteristics. Meat Science. 96(3):1242–1249. eng. doi:10.1016/j.meatsci.2013.11.001.

Binder MD, Hirokawa N, Windhorst U, editores. 2009. Encyclopedia of Neuroscience. Berlin, Heidelberg: 1st ed. Springer Berlin Heidelberg. ISBN: 978-3-540-23735-8.

Coradini MGL, Maia DSV, Iglesias MA, Haubert L, Lopes GV, da Silva DAL, Nero LA, da Silva WP. 2019. Occurrence and characterization of Listeria monocytogenes from beef jerky processing line. J Food Sci Technol. 56(1):436–442. eng. doi:10.1007/s13197-018-3505-3.

Dhanasettakorn K, Grün IU, Lin M, Ellersieck M. 2011. Studying physiochemical changes in a new pasta product containing beef heart by vibrational spectroscopy. Sens. & Instrumen. Food Qual. 3(2):122–129. doi:10.1007/s11694-009-9078-0.

Ensor Sa, Ernst Ea, Sofos Jn, Schmidt GR. 2009. Quality Characteristics of Restructured Turkey Meat with Variable Alginate/Calcium-Lactate Ratios. J Food Science. 54(3):558–560. doi:10.1111/j.1365-2621.1989.tb04650.x.

Franco. 2018. Panorama de Pet Food para América Latina. México. Accessed. 20/07/2020 https://www.petfoodlatinoamerica.com/wp-content/uploads/2019/08/petfood-11-1.pdf.

Forrest JC. 2009. Principles of meat science. San Francisco: Freeman. 2nd ed. 417 p. (A Series of books in food and nutrition). ISBN: 0716707438.

Gault NFS. 2005. The relationship between water-holding capacity and cooked meat tenderness in some beef muscles as influenced by acidic conditions below the ultimate pH. Meat Science. 15(1):15–30. doi:10.1016/0309-1740(85)90071-3.

Gill CO. 2016. Extending the storage life of raw chilled meats. Meat Science. 43:99–109. doi:10.1016/0309-1740(96)00058-7.

Girolami A, Napolitano F, Faraone D, Braghieri A. 2013. Measurement of meat color using a computer vision system. Meat Science. 93(1):111–118. eng. doi:10.1016/j.meatsci.2012.08.010.

Hamm R. 2008. Biochemistry Of Meat Hydration. En: Mrak EM, Stewart GF, Chichester CO, editores. Advances in food research. Vol. 10. New York: Academic Press. p. 355–463 (Advances in Food Research; v. 10).

Harmayani eni, sofos jn, schmidt gr. 2001. Effect of sodium lactate, calcium lactate and sodium alginate on bacterial growth and aminopeptidase activity. J Food Safety. 11(4):269–283. doi:10.1111/j.1745-4565.1991.tb00058.x.

Hebbinghaus N, Srivastav A. 2014. Multicolor Discrepancy of Arithmetic Structures. En: Chen W, Srivastav A, Travaglini G, editores. A Panorama of Discrepancy Theory. Vol. 2107. Cham: Springer International Publishing. p. 319–424 (Lecture Notes in Mathematics).

Hoffman LC, Vermaak A, Muller N. 2012. Physical and chemical properties of selected beef muscles infused with a phosphate and lactate blend. SA J. An. Sci. 42(4). doi:10.4314/sajas.v42i4.1.

King AJ, Fitzpatrick DP, Cooper JE. 2013. A modification of a method to determine expressible moisture in ground, dark poultry meat. Poult Sci. 75(11):1433–1436. eng. doi:10.3382/ps.0751433

Kim J-S, Lee E-J, Choi EH, Kim Y-J. 2014. Inactivation of Staphylococcus aureus on the beef jerky by radio-frequency atmospheric pressure plasma discharge treatment. Innovative Food Science & Emerging Technologies. 22:124–130. doi:10.1016/j.ifset.2013.12.012.

Lee P, Rogers MA. 2012. Effect of calcium source and exposure-time on basic caviar spherification using sodium alginate. International Journal of Gastronomy and Food Science. 1(2):96–100. doi:10.1016/j.ijgfs.2013.06.003.

Lin S, Hsieh F, Huff HE. 2011. Effects of Lipids and Processing Conditions on Degree of Starch Gelatinization of Extruded Dry Pet Food. LWT - Food Science and Technology. 30(7):754–761. doi:10.1006/fstl.1997.0271.

Mathias-Rettig K, Ah-Hen K. 2014. El color en los alimentos un criterio de calidad medible. agrosur. 42(2):57–66. doi:10.4206/agrosur.2014.v42n2-07.

Maysonnave GS, Mello RdO, Vaz FN, Ávila MM de, Pascoal LL, Rodrigues ACT. 2019. Physicochemical characterization of by-products from beef cattle slaughter and economic feasibility of commercialization. Acta Sci. Anim. Sci. 42:e46545. doi:10.4025/actascianimsci.v42i1.46545.

Meeker DL. 2006. Essential rendering: All about the animal by-products industry. [Alexandria, Va.]: National Renderers Association; Fats and Proteins Research Foundation; Animal Protein Producers Industry. 302 p. ISBN: 0-9654660-3-5.

Okin GS. 2017. Environmental impacts of food consumption by dogs and cats. PLoS One. 12(8). eng. doi:10.1371/journal.pone.0181301.

Savadkoohi S, Hoogenkamp H, Shamsi K, Farahnaky A. 2014. Color, sensory and textural attributes of beef frankfurter, beef ham and meat-free sausage containing tomato pomace. Meat Science. 97(4):410–418. eng. doi:10.1016/j.meatsci.2014.03.017.

Seidavi AR, Zaker-Esteghamati H, Scanes CG. 2019. Chicken processing: impact, co-products and potential. Worlds Poult Sci J. 75(1):55–68. doi:10.1017/S0043933918000764.

Thompson A. 2008. Ingredients: where pet food starts. Top Companion Anim Med. 23(3):127–132. eng. doi:10.1053/j.tcam.2008.04.004.

Trampel DW, Sell JL, Ahn DU, Sebranek JG. 2015. Preharvest feed withdrawal affects liver lipid and liver color in broiler chickens. Poult Sci. 84(1):137–142. eng. doi:10.1093/ps/84.1.137.

Wu Y-HS, Lin Y-L, Huang C, Chiu C-H, Nakthong S, Chen Y-C. 2020. Cardiac protection of functional chicken-liver hydrolysates on the high-fat diet induced cardio-renal damages via sustaining autophagy homeostasis. J Sci Food Agric. 100(6):2443–2452. eng. doi:10.1002/jsfa.10261.

Zicker. 2008. Evaluating pet foods: how confident are you when you recommend a commercial pet food? Top Companion Anim Med. 23(3):121–126. eng. doi:10.1053/j.tcam.2008.04.003.