Escuela Agrícola Panamericana, Zamorano

Food Science and Technology Department

Food Science and Technology Major

Graduation Research Project

Physicochemical and textural characteristics of jerky-style pet treats developed with ground swine pluck.

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Honduras, november 2023

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Acknowledgments

I would like to express my gratitude to the individuals and groups who have contributed to the success of my thesis. Their support and guidance have been invaluable thought this academic journey. Extending my appreciation to my internal advisor, Adela Acosta, D.Sc., for her feedback and time. I would also like to extend my sincere thanks to my two external advisors. First to Jessica Starkey, PhD. And her encouragement propelled me forward and for sharing her knowledge and quality to this work. I am thankful to Gerardo Abascal-Ponciano, M.Sc. For his dedication and valuable time to make a quality of this work.

I am also grateful to the members of the Starkey Lab. For their exchange of ideas, collaboration, and contribution to the research. Their support and passion for science have been inspiring and motivating.

Additionally, I want to acknowledge Fausto Mairena, M.Sc., and the coworkers of the Zamorano Meat Processing Plant, who generously provided access to the facilities and shared their practical insights. Their contribution was essential to the empirical aspects of this thesis. Also, a big thanks to all those who have supported me, whether through advice, resources, or simply a comment.

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Abstract

Pet food and treats are having a sustainable contribution to the co-products of the meat processing industry. Converting raw material into high protein, fat, and mineral products with specific nutritional components. Swine pluck (SPL) is the combination of heart, trachea, esophagus, and lungs removed together. The objective of this study was to create jerky-style pet treats from upcycling with swine pluck, to evaluate physiochemical and textural characteristics of treats and the proximal analysis (moisture, ash, protein, and fat content) of the optimal treatment. Raw SPL was grinded and mixed with different concentration (0.5, 0.75, 1%) of guar gum (GG) to provide structure, extruded into jerky strips, refrigerated overnight at 4°C and then dehydrated at 68°C for 6 hours. Water activity, pH and cook loss and hardness were determined with their respective methods. A CRD was used, and data was analyzed as a one-way ANOVA using the GLM procedure of SAS, separated by a Duncan multiple range test was done with an alpha of 0.05. PH, water activity and hardness values were higher in concentrations of 0.75 and 1% of GG, and samples were lower in cooking loss analysis in comparison to the control treatment. For proximal analysis, the samples with 0.75% resulted in a high crude fat of 27.6%, protein content of 53.6%, low moisture 10.0% and ash content of 1.4%. The minimal process of co-products combined with a structure forming agent provides a high-value attractive option for both the meat processing industry and pet food industry.

Key words: harvest products, meat animal processing coproduct, swine pluck, pet treat, upcycling.

Resumen

El alimento y bocadillos para mascotas están teniendo una contribución sostenible a los coproductos de la industria de procesamiento de carne. Convierte materia prima en productos con alto contenido de proteínas, grasas y minerales con componentes nutricionales específicos. El "SPL" (Swine Pluck), es la combinación de corazón, tráquea, esófago y pulmones retirados juntos. El objetivo de este estudio fue crear premios para mascotas de estilo "jerky" a partir del reciclaje con SPL de cerdo, para evaluar las características fisicoquímicas y texturales de los premios y el análisis proximal del tratamiento óptimo con los análisis de humedad, ceniza, proteínas y grasas. El SPL crudo fue molido y mezclado con diferentes concentraciones (0.5, 0.75, 1%) de goma de guar (GG) para proporcionar estructura, se extruyó en tiras tipo "jerky", se refrigeró durante la noche a 4°C. Luego se deshidrató a 68°C durante 6 horas. Se determinó la actividad de agua, pH, perdida por cocción y dureza. Se utilizó Diseño Completamente al Azar, se realizó un análisis de varianza con el programa SAS®, y se realizó una prueba de rango múltiple de Duncan con un alfa de 0.05. Los valores de pH, actividad de agua y dureza fueron más altos en concentraciones del 0.75% y el 1% de GG, y las muestras tuvieron una menor pérdida de cocción en comparación con el tratamiento control. Para el análisis proximal, las muestras con un 0.75% resultaron con grasa cruda del 27.6%, proteína del 53.6%, humedad del 10.0% y ceniza del 1.4%. El proceso mínimo de coproductos combinado con un agente formador de estructura proporciona una opción atractiva de alto valor tanto para la industria de procesamiento de carne como para la industria de alimentos para mascotas.

Palabras claves: Vísceras de cerdo, estilo jerky, subproducto del procesamiento de animales para carne, golosinas para perros.

Introduction

The global meat consumption rate has increased, and it is one of the major dietary protein sources. Meat processing creates both edible tissues and inedible offal. Almost 30% of swine liveweight and 44% of cattle liveweight form these tissues/organs that are not part of dressed carcass (Marti et al., 2012). Many of these varieties of meats are sold for a low value for the process of rendering and used as feed ingredients for different animals' diets (Meeker, 2006). Renders in the United States process nearly 25 million tons of animal co-products per year, while other countries of the European Union process about 15 million tons (Hamilton, 2016). Suitable solutions are important for innovative and viable developments to create high-added value from meat processing chains with the least environmental impact (Toldrá et al., 2021).

The meat industries, including slaughterhouse and processing sectors, generate huge amounts of edible and inedible residuals high in protein. The sectors included start with the chain from collection of raw materials and different stages of processing and final manufacture to elaborate a product (Mullen et al., 2015). It is a necessary underlying principle in this approach to help minimize the generation of food waste (Mullen et al., 2017). Most of the co-products are used in rendering, which pays very little for organs, but these could have better profitability if used for other products. Most meat co-products are usually made up of liver, heart, kidney, and tongue because of customs, religion, palatability and reputation (Florek et al., 2012). Industries are generating strategies to improve and have a sustainable valorization of co-products since there are various opportunities to exploit these high-protein meat processing co-products and produce in a sustainable process.

With the purpose of utilizing co-products is to recycle these co-products (raw animal organs) and converts them into various protein, fat, and mineral products with specific nutritional components and contributes to the sustainability of food animal production (Meeker & Meisinger, 2015). Without the rendering industry, the accumulation of unprocessed animal co-products can impede the meat industry and can be a serious potential hazard to human and animal health (Meeker, 2009). That is why rendering is important because it is what makes the meat animal industry more sustainable.

Production of food manufactures that contain swine pluck (**SPL**) are increasing. The SPL is a combination formed by the esophagus, trachea, lungs, and heart. This increase in usage is increasing the commercial value of the pluck. The pet food industry is benefiting from the co-product and consumer´s behavior to focus on developing premium product. This is reflected in expanding the range of pork products, influencing the economic performance of meat processing plants (Babicz et al., 2020).

The pet product industry is elaborating new products made of animal co-products and has reached $123.6 billion in sales for the year 2021 (American Pet Products Association [APPA], 2022). Pet food industries are using it as a starter material for value-added products (Khodaei et al., 2021). The pet food market is focusing on health issues and the use of natural ingredients. Many of the co-product are a high source of minerals, protein, lipids, etc. (Biel et al., 2019).

It is important to include a structure forming agent when creating a final product made from upcycling, which is a process that takes something considered waste and gives it a new purpose or a second chance of life, increasing the items´ value (Rom, 2017). Hydrocolloids contains gel-forming agents that helps restructure food materials and can be used for a better control of the shape, size, and, weight of the products manufactured (Laaman, 2010). Guar gum (**GG**) has an industrial application because of its low cost and its ability to form a viscous solution even at low concentrations (Demirci et al., 2014). Due to its thickening agent, this additive is frequently used because it is a water-soluble gum that reduces fat migration and helps digest amino acids in pet food.

Pets nowadays play a significant role, becoming more popular and viewed as an essential part of the family nucleus. Pet treats are evolving, producing treats their day-to-day meals and supplemental treats, also known as snacks. In most developed countries, most dogs consume more dry commercial pet food for at least half of their intake (Laflamme et al., 2008). According to Phillips et al. (2014) pet owners seek natural and organic kibbles, biscuit and jerky treats, manufacturers of these products must consider transitioning to a premium-quality ingredient, that is why the industry is specializing in the production, distribution, and sale of both dry and canned pet food and treat.

Pet treats are available in different ways, depending on final water activity (a_w) content, such as dry category, with the most sales. It is important to don´t go lower than 0.55 because the dog is unappetizing. For it to be consider dry pet food, it´s final water activity should be < 0.60 a_w (Samant et al., 2021). There are diverse types of dry pet snacks, for example jerky-style. Texture, and flavor attributes of this type of snack are the most important sensory attributes (Żochowska-Kujawska et al., 2017). Preparing jerky-style pet treats is an efficient method to extend meat´s shelf life (Kim et al., 2021). Various jerkies can be made using numerous recipes and meats from different species such as beef, poultry, game animals and pork (Han et al., 2007).

Pet food and treats are having a higher demand while the pet food industry is growing and promotes sustainability by upcycling low-value co-products from protein conversion companies into a higher-value pet nutrition products, and some pet owners may find this characteristic appealing.

This study was conducted to produce a jerky-style pet treat from swine pluck (co-product). Also, to evaluate physiochemical and textural characteristics of different concentration (0.5, 0.75, 1%) of the guar gum for each jerky-style treat. As final purpose was to establish the proximal composition of the optimal jerky-style pet treat and compare it with other commercial pet treats.

Materials & Methods

Study Location

Jerky Development

The jerky-style pet treats were elaborated at Auburn university Fortenberry, 1088 Auburn lakes Road, Auburn, Alabama and were also made at Zamorano University Meat Processing Plant, San Antonio de Oriente, Honduras

Location of Samples Analysis

The jerky-style pet treats were elaborated at Auburn University Poultry Science Building, 260 Lem Morrison Drive, Auburn, Alabama and analyzed at Zamorano Food Analysis Laboratory (LAAZ), San Antonio de Oriente, Honduras.

Raw Material

Finishing pigs harvested at the Auburn University Fortenberry Processing Plant on different days. Organs were stored in vacuum sealed bags at -20 C further processing and finishing pigs harvested at the Zamorano University Meat Processing Plant on different days. Heart, lungs, esophagus, and trachea were stored in sealed bags at -20°C until further processing.

Jerky Treats Production from Swine Pluck

Product Development

SPL (heart, lungs, esophagus, and trachea) was harvested stored at -4 °C. SPL was left to thaw for 24 hours at 4 °C (39 °F). Then SPL was cut into small pieces and grinded through 3/16" grinder plate. 900g of final mixture was measured using a weight scale. For the additive inclusion, 0.5, 0.75, and 1% of GG was weight based on the total weight and mix to the ground SPL for the different treatments. Slowly poured half of the total content of GG and mix for 2 minutes. The second half was added, and mixing process was repeated. Everything was mixed one last time for 30 seconds. Aluminum trays were covered with parchment on top for placing the final product. Mixture was introduced into a jerky gun with a dual-strip nozzle probe. The final product was placed on the aluminum tray with parchment paper. Jerky strips were extruded on to aluminum tray with parchment paper and then wrapped in plastic paper to prevent moisture loss in the cooler. Treats were left for 24 hours at 4 °C to allow gelation of GG into the product. The next day the dehydrator oven was pre-heated at max temperature (74°C) for 10 minutes. Jerky strips were placed into metal racks for dehydration and the oven was set to a 68 °C and dehydrate the product for 6 hours. The final product was stored in a controlled environment for subsequent analysis.

Combination of Treatments

GG was added to three different concentrations and a control treatment was used. The treatments had 1, 0.75, 0.5 and 0.0% of GG added to the final weight of the raw meat giving a total of 4 treatments. Description of the different treatments and their codification (TRT-100, TRT-75, TRT-50, and TRT-CC) depending on the different concentrations of GG used in each treatment. Table 1 shows the proportion of each of the treatments, with their respective percentages of GG.

Table 1

Description of different treatments of a jerky-style pet treat developed with ground SPL and different concentrations of GG.

Factor 1	Factor 2
Treatment codification	% of GG
TRT-100	1.0
TRT-75	0.75
TRT-50	0.5
TRT-CC	0

Note. SPL: swine pluck; GG: guar gum.

Physiochemical and Textural Analysis

Cooking Loss

The amount of cooking losses of the jerky-style pet treats was measured. Each sample was weighed before cooking (raw jerky before heat processing at 68 °C for 6 hours in dehydrator) and after cooking (cooked jerky). Total weight loss in the jerky strips after cooking was expressed as final cooking loss (%) by dividing the difference between the raw meat and cooked meat by the weight of the raw meat, represented in the following equation according to Pang et al. (2020) and Choe et al. (2013).

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

Where:

w1: weigh of raw product

w2: weigh of cooked product

PH Measurements

A direct probe was used to measure pH on eight samples from each treatment using a Benchtop pH-mV Meter – 0 to 14 pH Range (Sper Scientific 860031). Before each reading, the electrode of the pH meter was rinsed with distilled water and cleaned between each measurement. The instrument was calibrated and standardized using standard buffer solutions with a pH of 4.00 and pH 7.00, for every batch. Approximately 3 g of the jerky sample was cut into small pieces and 20 mL of distilled water was added. Slurry was then made, and pH measurement was recorded.

Water Activity (a_w)

The water activity of the pet treat was measured on six samples for each treatment. The instrument used for this analysis was the AQUALAB 4TE water meter. The equipment was first calibrated with a 0.999 a_w solution (8.57 mol/kg of LiCl in H_2O), which is the closest one to the a_w expected in the jerky strips. The samples were grinded with a blender and placed in the portable water activity cups, half-filled and then the reading started.

Hardness

Using a CT3 Brookfield (ASTM E83) texture analyzer, textural characteristics were performed for the different treatments. This analysis gives firmness (in newtons). The method used a Plain Vee Blade (TA-SBA-WB-10) probe for realizing the cut through the samples. Each of them was measured to reduced variability and the final area of the samples was: 30mm long, 10 mm width and 3 mm height. The samples were completely cut throw half with an activation energy of 0.67 N and with 3 mm/sec of speed test.

Proximal Analysis

For evaluating proximal analysis, the physiochemical and textural characteristics were analyzed. Based on these results, the treatment that can be described or selected as the “best” is the treatment with 0.75% of guar gum (TRT-75). For each product analyzed, samples for TRT-75 were submitted in representative triplicate samples into the following proximal analysis: moisture content, ash content, crude protein, and fat content.

Moisture Content

Moisture content was determined according to the method AOAC 950.46B. Each dry porcelain crucible was weight (C). Approximately 3 grams of the sample was weighted in the crucibles (C+MH). Using a conventional oven Binder FD534-UL at 105°C samples were dried for 18 hours. Each crucible was cooled and then weighed (C+MS). Total moisture content (%) was measured using the following formula:

$$\%M = \frac{(C+MS)-(C+DS)}{(C+MS)-(C)}\ x100 \quad [2]$$

Where:

M: Moisture content

C: weigh of porcelain crucible

MS: moist sample

DS: dry sample

Ash

Ash analysis was determined according to the method AOAC 923.03. Each dry porcelain crucible was weight (C). Approximately 3 grams of sample was weight in the crucible (C+MH). Using a Sybron Incinerator at 550°C samples were incinerated for 6 hours. Each crucible was cooled and then weighed (C+CZ). Total ash content (%) was measured using the following formula:

$$\%FA = \frac{(IC)\ x\ 100}{(MS)} \qquad [3]$$

Where:

FA: final ashes

IC: incinerated crucible

MS: moist sample

Protein

Protein analysis was determined according to the method AOAC 2001.11. The method was divided into three main steps. Starting with the FOSS Tecator 20 Digestor at 420°C. Samples were grinded and approximately 1 gram of the samples was weighted (PM). The samples were transferred to a digestion tube, adding 2 tablets catalyst called Kjeltabs. Under the gas hood, 15 ml of sulfuric acid were added using a calibrated dispenser. Tubes were placed on the digestor tube rack, and the samples were digested for one hour. The second step consists of distillation using the FOOS Kjeltec 8100 distillation unit with program #4. Titration is performed as the final step, using hydrochloric acid with 0.9420883 M of concentration. The protein percentage of the samples was calculated as indicated in the following equations:

$$\%\mathrm{N} = \mathrm{NHCL}\ \mathrm{x}\ \frac{\mathrm{Tc}}{\mathrm{M}}\mathrm{x}\frac{14\mathrm{g}}{\mathrm{mol}}\mathrm{x}100 \qquad [4]$$

Where:

N: normality of standardized hydrochloric acid, N

HCL: hydrochloric acid used, L

Tc: Corrected acid volume, L

M: weight of sample, g

Fat Content

For calculating the fat content of the samples, the method AOAC 982.23 was used in the pet treat. A solution was made with methanol and chloroform in a 2:1 ratio was prepared. Approximately 1 gram of the sample was weight and recorded as sample weight. The sample was mixed with the solution and was sealed with Petri film and aluminum foil. Rotavapor R-100 by Buchi was set to pressure 337 mbar and water bath to 65 °C. The distillation flask, along with the sample and the solution, was connected to the Rotavapor, and the distillation was initiated. Once no more solution was collected, the distillation flask was removed and placed in a desiccator for 24 hours. This was weighed and calculations were made by the acid hydrolysis crude fat formula.

Experimental Design

A Complete Randomize Design was used. Samples were submitted into replicates of pH, water activity, hardness, and cooking loss analysis, Data was analyzed as one-way ANOVA with the different concentrations of GG (1, 0.75, and 0.5) and the control treatment, using a GLM procedure of the SAS® program and using a Duncan multiple range test using an alpha of 0.05. A total of 6 replicates per treatment for pH, water activity (a_w) and harness analysis (n= 24 samples total per analysis) and 4 replicates for each treatment for cooking loss analysis (n= 16 samples total) of cooking loss analysis were used. The independent variable was the percentage of additive used in the different treatments for the jerky-style samples. The dependent variable were the different physiochemical and textural parameters being measured: pH, a_w, hardness and cooking loss of each treatment. For the

Statistical software: the analysis was done using the statistical program of SAS© version 9.4.

Results and Discussion

Physicochemical and Textural Results and Discussion

PH

The pH of meat products plays a key role in their safety, flavor, and shelf life. The initial pH value for a pork jerky is nearly 6.5 (Zhao et al., 2018). This value can vary depending on the recipe and process used in the product. According to Yim et al. (2012), it is best for the jerky treat to be less neutral because spoilage of various dried meat products by mold growth can be inhibited or delayed by lowering pH, and while in storage there are small decreases in pH level. According to Juneja et al. (2016), decreasing meat pH, interacts to inactivate Salmonella in jerky treats.

The higher the pH value of a meat product, the faster the Maillard reaction will occur in the product (Chen & Lin, 2017). The parameters of time, temperature and ingredients used in the manufacture can influence the Maillard reaction, as well as other characteristics in the final product, like for example flavor, color change, texture, and preservation.

Different treatments had a significant difference ($P < 0.05$) among the different percentages of GG. Samples with a lower percentage of GG showed a lower pH level, being the lowest pH level in the control treatment (TRT-CC). The pH mean obtained for the products with the different formulas (Table 2). TRT-100 and TRT-75 did not show significant differences which indicates that the addition of GG affects pH values making the product more neutral (Table 2). According to Mudgil et al. (2014), guar gum has an ability to form hydrogen bonding with water molecules, that is why the higher the application of guar gum, the higher the pH value.

It is crucial to know the pH value of the final product. If these result is near the isoelectric point of meat (5.2), the product holds the least amount of moisture and reduce dehydration time for the product (Bowser et al., 2016).

Table 2

PH results for a cooked jerky-style pet treat with ground SPL and different levels of GG.

Treatments	pH Value
	Mean ± SD
TRT-100	6.51 ± 0.10[a]
TRT-75	6.51 ± 0.14[a]
TRT-50	6.43 ± 0.11[b]
TRT-CC	6.39 ± 0.12[b]
CV (%)	1.95
p value	0.0004
sem	0.02386

Note. SPL: swine pluck; GG: guar gum; TRT-100: 1% GG addition; TRT-75: 0.75% GG addition; TRT-50: 0.50% GG addition; TRT-CC no GG addition; a-b: means with different letter are statistically different (P ≤ 0.05); SD: standard deviations; CV: coefficient of variation (%); SEM: Standard error of the mean.

Water Activity (a_w)

Water activity (a_w) is a measurement to know how much water is available in the product. The treatments observed had no significant differences in water activity (P > 0.05) despite having different concentration of guar gum shown in Table 3. The a_w value of the jerky-style treat with no added gum (TRT-CC) was the lowest of all treatments for this experiment (0.60 ± 0.02). The range of the a_w values were 0.551-0.7160 for all treatments. According to Joncheff (2023), jerky needs to have 0.75 level of a_w or lower, and also according to Nummer et al. (2004) jerky must have a_w of ≤ 0.85; indicating that all water activity values are acceptable for a jerky-style pet treat in the experiment.

When meat is treated with high temperatures, muscle protein are denatured, decreasing their water holding capacity and shrinkage of the protein network (van der Sman, 2007). It is important for jerky treats to have a stable a_w because of the growth of microorganisms and shelf life. A low a_w inhibits growth of most microorganisms in pork jerky, but most molds survive low a_w conditions resulting in a shorter storage period (Zhang et al., 2021). According to Choi et al. (2015), the mold´s growth ranges from 0.88-1.00 and yeast´s growth ranges from 0.88-1.00 in terms of a_w. However, there is the probability of some xerophilic molds and osmophilic yeasts have the capability of proliferate at low a_w from 0.60-0.65.

According to Quinton (1996) for ensuring product stability and achieving shelf-stability, it is essential to reduce the product's water activity (a_w) to a range of 0.70-0.85. This approach leads to a significant advantage to jerky-style products by obviating the need for refrigeration during commercial distribution, thanks to their low a_w, compared to alternative products. It is safer from microbial growth and for having a proper shelf-life.

Jerky-style product´s texture may vary because of its a_w. If this value is too high, activation of microorganisms and lipid oxidation can occur in the product final product, as well as lipid oxidation. Lipid oxidation significantly contributes to the decline in jerky quality. Water activity (a_w) specifically makes the reaction faster when is in a range from 0.3-0.7 (Wongwiwat & Wattanachant, 2015). They declare that this phenomenon could be attributed to the water molecules tying hydroperoxides with hydrogen bonds, leading to an inhibition of their composition processes and consequently impeding the advancement of oxidation.

According to Yang et al. (2009) this reaction occurs faster in heated meat compared to uncooked meat tissues. Apart from the natural and antioxidative levels found within muscles, various external or environmental elements (extrinsic) such as temperature, light exposure, and oxygen levels play a role in affecting lipid oxidation in meat food products.

Textural changes in the product are associated with the moisture content and water activity of the final product (Wongwiwat & Wattanachant, 2015). Jerky pet treats with a a_w below 0.75 will affect other texture properties, like being tougher (Esse & Saari, 2004).

Table 3

Water activity (a_w) results for a cooked jerky-style pet treat with ground SPL and different levels of GG.

Treatments	Water Activity (a_w) Values
	Mean ± SD
TRT-100	0.64 ± 0.05^{NS}
TRT-75	0.63 ± 0.06^{NS}
TRT-50	0.63 ± 0.06^{NS}
TRT-CC	0.60 ± 0.02^{NS}
CV (%)	7.55
p value	0.6092
Sem	0.02024

Note. SPL: swine pluck; GG: guar gum; TRT-100: 1% GG addition; TRT-75: 0.75% GG addition; TRT-50: 0.50% GG addition; TRT-CC no GG addition; NS: means not statistically different (P > 0.05); SD: standard deviations; CV: coefficient of variation (%); SEM: Standard error of the mean.

Hardness

The texture of meat products can vary greatly depending on the ingredients used and the thermal treatment applied during the process, leading to changes in connective tissue, soluble protein, and cohesion of myofibrillar proteins in the meat (Zayas & Naewbanji, 1986). These values are for characterizing different moisture products, but also define differences in total cutting force (Kim et al., 2010). In this study hardness was defined as the maximum force attained as a blade sheared to cut the jerky-style pet treat samples in half. The results are shown in Table 4 for the different treatments.

There were significant differences (P < 0.05) between the control treatment (TRT-CC) and the treatments with added guar gum. The control treatment has the lowest mean value (32.7 ± 11.02) for hardness analysis. The highest guar gum treatment (TRT-100) happens to be the hardest (41.84 ± 5.99) jerky-style pet treat. According Solano Minaya (2012) the percentage of total viscera had an effect on the hardness of the product, which decreases hardness if the final product´s formulation has more viscera (TRT-CC). Making the control treatment the softest according to the results obtained in Table 4. The final product resulted in a uniform appearance, maintain a fresh appearance (Krstonošić et al., 2021).

Table 4

Hardness results for a cooked jerky-style pet treat with ground SPL and different levels of GG.

Treatment	Hardness (N)
	Mean ± SD
TRT-100	41.84 ± 5.99[a]
TRT-75	41.66 ± 6.75[a]
TRT-50	39.39 ± 10.79[ab]
TRT-CC	32.70 ± 11.02[b]
CV (%)	23.73
p value	0.0743
Sem	2.8863

Note. SPL: swine pluck; GG: guar gum; TRT-100: 1% GG addition; TRT-75: 0.75% GG addition; TRT-50: 0.50% GG addition; TRT-CC no GG addition; a-b: means with different letter are statistically different (P ≤ 0.05); SD: standard deviations; CV: coefficient of variation (%); SEM: Standard error of the mean.

Cooking Loss

Samples were weighed before and after cooking. Total weight loss in the jerky-strip after cooking was expressed as cooking loss. It is defined as the percentage change in weight due to cooking, loss of water as well as fats and aromatic substances during dehydration because of rupture of cell membrane and modifications of protein´s structure. Cooking loss is considered a measure of the muscle´s water-holding capacity (Alvarado & Sams, 2004).

Treatments did not show differences in the percentage of cooking loss (P > 0.05) in any of the interactions. The range of all treatments was approximately from 69-72% shown in Table 5. According to the United States Department of Agriculture (2016) a pound of meat weighs about four ounces after being made into jerky, loosing approximately 75% of the total weight.

The control treatment (TRT-CC) had the most cook loss because it has no guar gum. The hydrocolloid decreased the cooking loss of the jerky pet treat to some extent. The hydrogen bonds between hydrocolloids and the moisture in the meat decreases total cooking loss.

The weight loss on treatments observed are affected by the water retention capacity attributed to the myofibrillar protein present in the meat (Hleap-Zapata et al., 2017). According to

Diao et al. (2016); myofibrillar proteins exhibit superior emulsifying characteristics in meat products, enhancing their ability to bind water and oil together.

Similar results were obtained by Demirci et al. (2014) indicating that the results of the control treatment (no gums added) had the highest cooking loss due to the high loss of fat and moisture during cooking. Other results by Song et al. (2002), demonstrated that the control treatment was higher in meat products than in those with added hydrocolloids. The inclusion of GG can enhance quality by stabilizing enzymatic processes and enhancing water retention capabilities, that is why it is used as a binder and lubricant (Ku et al., 2022).

Table 5

Cook loss results for jerky-style pet treat with ground SPL and different levels of GG.

Treatments	Cook Loss (%)
	Mean ± SD
TRT-CC	71.41 ± 1.01^{NS}
TRT-50	69.81 ± 2.28^{NS}
TRT-75	69.30 ± 1.35^{NS}
TRT-100	69.24 ± 3.48^{NS}
CV (%)	3.25
p value	0.2056
sem	0.7935

Note. SPL: swine pluck; GG: guar gum; TRT-100: 1% GG addition; TRT-75: 0.75% GG addition; TRT-50: 0.50% GG addition; TRT-CC no GG addition; NS: means not statistically different (P > 0.05); SD: standard deviations; CV: coefficient of variation (%); SEM: Standard error of the mean.

Proximal Analysis

For evaluating proximal analysis, treatment with 0.75% of guar gum (TRT-75) was selected because of its physiochemical and textural characteristics. TRT-75 had no differences (P > 0.05) in cooking loss and water activity, but it had a significant difference (P < 0.05) in pH and hardness analysis, indicating that it had a higher pH and a harder structure compared with the control treatment (TRT-CC). By the other hand, the application of guar gum is from 0.13-1.0% of an approximated use level for meat products (Krstonošić et al., 2021). For each analysis, samples of TRT-75 were submitted in triplicate and the following analysis were assessed: moisture content, ash content, crude protein, and fat content.

Moisture

The water- holding capacity of food protein systems are expressed by moisture content. Earl et al. (1996) describes moisture as the quantity of liquid extracted from a protein system through the application of pressure, it quantifies the volume of free water liberated within specific measurement conditions. Results for moisture content in a jerky-style pet treatment with 0.75% of guar gum added (TRT-75) are shown in Table 6. The mean for moisture sample was 10.01% ± 0.66 of the triplicate samples. Expecting to get a lower moisture content than in meat products with no gum added. It was observed by Demirci et al. (2014) that moisture contents of meatballs decreased the more gums added (xanthan, carrageenan, locust bean, and guar gum). This is because the gum forms a gelling when the formation of three-dimensional hydrogen bond networks between the two main molecules (mannose and galactose), with water trapped within these networks (Castañeda-Ovando et al., 2020).

The results obtained in the study categorizes the pet treat as a dry product because of its low moisture content. According to Hu (2016), pet foods can typically be categorized in depending of their moisture or processing, dry pet food typically has a moisture content ranging from 5% to 12%. A commercial pet treat by the Hill´s brand created a metabolic treat made of pork liver and has a final moisture content of 11% maximum.

Ash

The results for ash content in a jerky-style pet treatment with 0.75% of guar gum added (TRT-75) are shown in Table 6. According to the results the mean ash content was determined to be 1.38% in the triplicate analysis. It was observed by Demirci et al. (2014) that the ash content in meatballs increase proportionally with the quantity of gum added, especially in the increase of guar gum from 0.5% to 1% and further to 1.5%. A corresponding increase in the ash content of both raw and cooked meatball samples was obtained concluding that the addition of guar gum has an impact on enhancing ash content of meat products. The increase of ash is due to the salt content in partially hydrolyzed guar gum coming from its preparation process leading to a greater total ash content (Mortensen et al., 2017). This study also reported that commercial food-grade guar gum contains about 0.5-0.8% of ash.

Similar results were presented by Candogan and Kolsarici (2003), who studied low-fat sausages with hydrocolloids (carrageenan and pectin), and had a range for ash content from 2.13-2.65% and had a higher ash content than in treatments without carrageenan and pectin. In a separate investigation conducted by Kim et al. (2018), similar findings were ascertained, wherein the incorporation of hydrocolloids resulted in a coinciding elevation in ash content for meat products. The study consisted in the effect of hydrocolloids (alginic acid, konjac, and carrageenan) on the quality of restructured hams. Results obtained in the study align with previous research on the effects of adding guar gum in meatballs.

Protein

For crude protein analysis, the results obtained from the triplicate analysis show a mean protein content of 53.63% shown in Table 6. Most dried meat are extremely high in protein. As indicated as a traditional Pork Jerky by the brand Farmland Traditions, that only uses pork, vegetable glycerin and salt as ingredients and have a minimum of 50% for crude protein. The high levels of protein may due to the big use of offal. Villeda Sandoval (2003) said that for swine pluck such as heart and lungs have a total of 18% and 19% of protein respectively, kidney has 14% of crude protein (López-Martínez et al., 2023).

There is a big variety of jerky treats made from different organs from different animals, including beef, chicken, pork, sheep, duck, rabbit, etc. A commercial pork jerky by Kahoots brand has a minimum of crude protein of 65% and it only uses 4 ingredients total (pork, vegetable glycerin, vinegar powder, rosemary extract). Another commercial pet treat by the brand Pupdawgs made a pet treat with just one ingredient being beef lung, and the product has guaranteed analysis indicating that the final product has a minimum of 60% of crude protein. Another commercial product by the Stewart brand, shows a product with only one ingredient, in this case, beef liver, and has a minimum of 50%

of crude protein. Another pet treat by Vet Recommended made with only chicken as a natural single ingredient shows how high crude proteins levels may get depending on the animal and organ used. This treat resulted in an 86.89% of crude protein. Another commercial dog treat by Max & Neo brand shows how using just one ingredient, in this case turkey heart, raises levels of protein being 68% of crude protein as minimum.

Fat Content

Fat content results for the triplicate analysis in the treatment with 0.75% of guar gum added (TRT-75) was a mean of 27.6% of crude fat shown in Table 6. This product is high in fat because of the use of swine pluck. Some fats are source of energy and others contribute to the health of our canine (Wittich, 2019). According to Rai et al. (2013) gums is frequently employed in industry to improve consistency, water retention, and cooking output of processed products, while also helps to lower fat content. Hydrocolloids are employed in meat products to enhance their functional attributes and counteract the negative consequences of reducing fat content, lowering salt levels, and undergoing freeze/thaw cycles (Amini Sarteshnizi et al., 2015). The nutritionally balanced variety can either be a dry pet food formula to which water is added before canning, or it can be a high-fat product that includes animal ingredients, like meat and meat by-products (Ockerman & Hansen, 1999).

Table 6

Proximal composition for a cooked jerky-style pet treat from ground SPL and 0.75% level of GG.

Parameter	Mean ± SD	CV (%)
Moisture content (%)	10.01±0.66	6.63
Ash content (%)	1.38±0.04	2.97
Crude Protein (%)	53.63±2.39	4.47
Fat Content (%)	27.57±1.34	4.86

Note. SPL: swine pluck; GG: guar gum; SD: standard deviations; CV: coefficient of variation (%)

Conclusions

Jerky-style pet treat was made of ground swine pluck and the addition of guar gum.

PH, water activity and hardness were higher in concentrations of 0.75 and 1% of guar gum added, and samples were lower in cooking loss in comparison to the control treatment.

Pluck jerky treats with 0.75% of guar gum (TRT-75) had the following proximal analysis: 10.0% of moisture content, 1.4% of ash content, 54.6% of crude protein and 27.6% of fat content.

Recommendations and Future Directions

Conduct a microbiological analysis for the jerky-style pet treat made of swine pluck to assess the microbial load and safety of the product.

Determine the shelf-life evaluations of the pet treats and real-time storage studies under varying temperature and humidity conditions.

Consider packaging materials and storage conditions that can extend the shelf life of the jerky-style pet treat.

Evaluate the effects of incorporating additional hydrocolloids and the physiochemical and textural properties in a jerky-style pet treat.

Evaluate sensory attributes of the final product.

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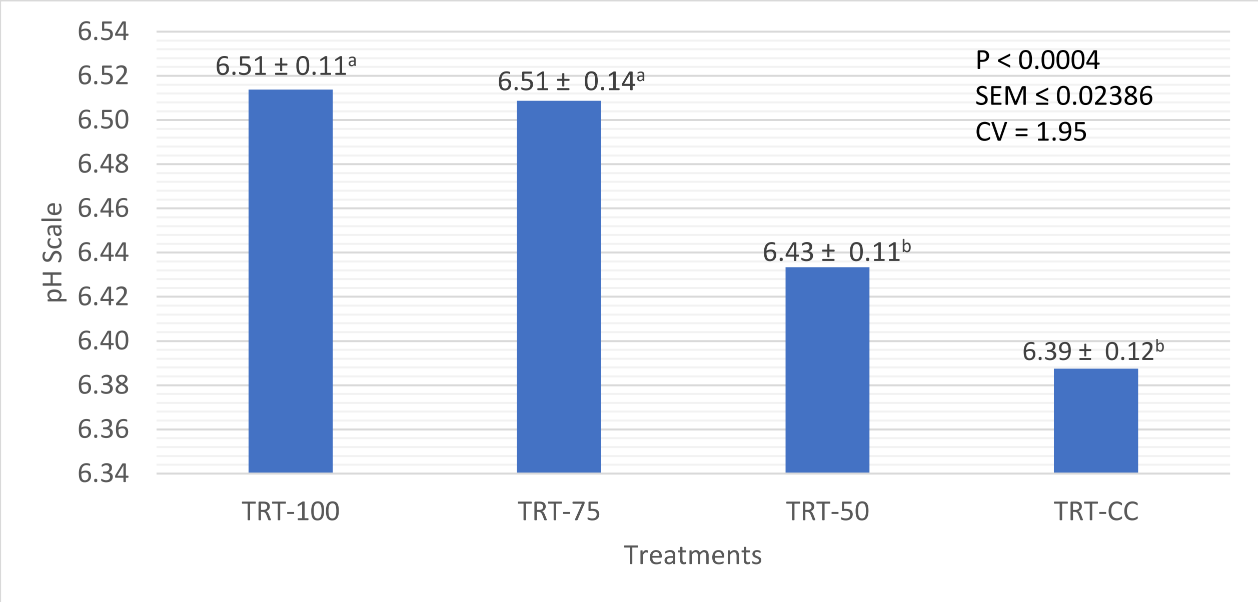
Annex

Annex A

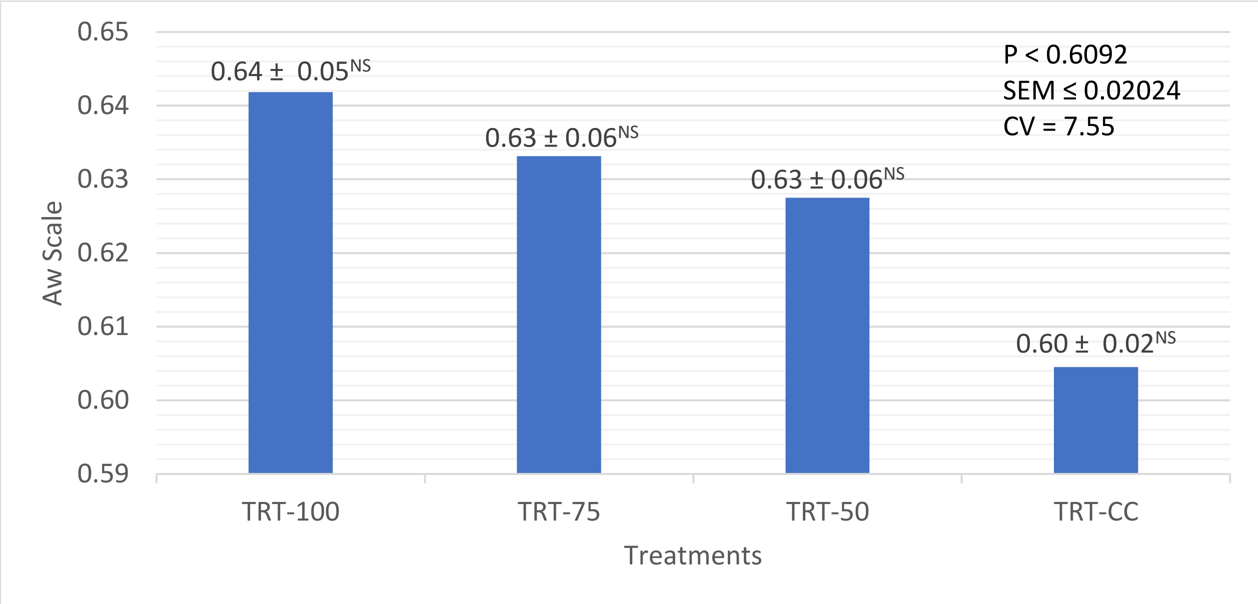
PH results of jerky-style pet treat with ground SPL and different concentration of GG.



Note. GG: guar gum; SPL: swine pluck; TRT-100: 1% GG addition; TRT-75: 0.75% GG addition; TRT-50: 0.50% GG addition; TRT-CC no GG addition. a-b: means with different letter are statistically different ($P \leq 0.05$); SEM; standard error of the mean; CV: coefficient of variation (%).

Annex B

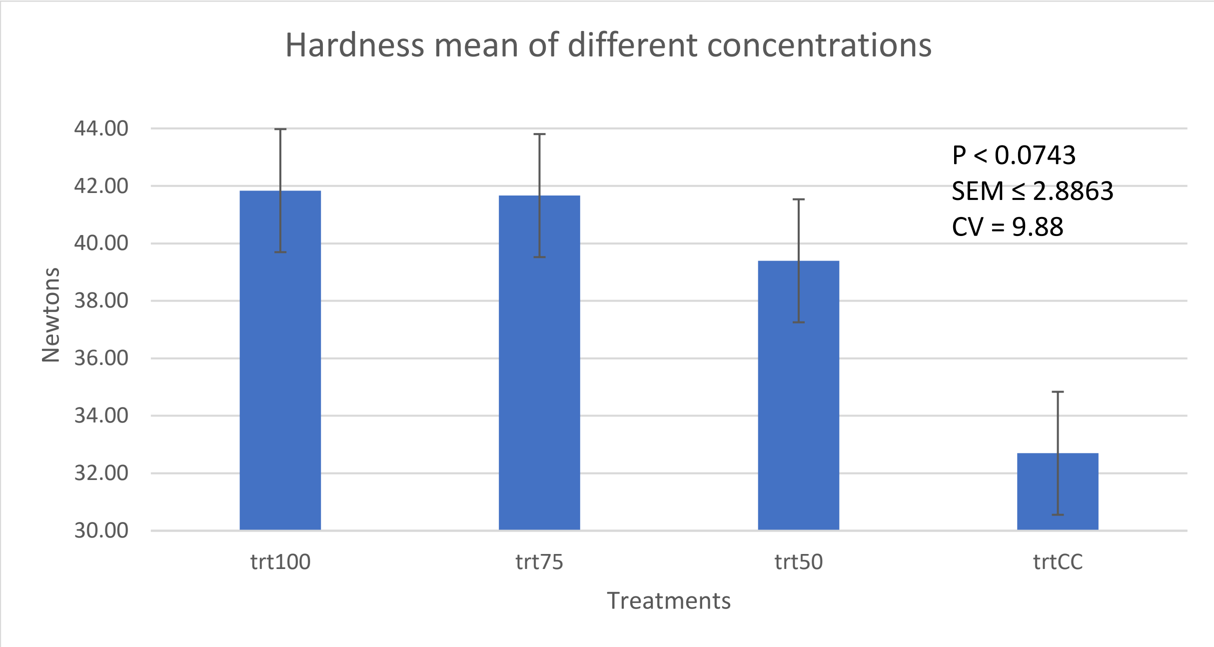
Water activity (aw) results of jerky-style pet treat with ground SPL and different concentration of GG.



Note. GG: guar gum; SPL: swine pluck; TRT-100: 1% GG addition; TRT-75: 0.75% GG addition; TRT-50: 0.50% GG addition; TRT-CC no GG addition. a-b: means with different letter are statistically different (P ≤ 0.05); SEM; standard error of the mean; CV: coefficient of variation (%).

Annex C

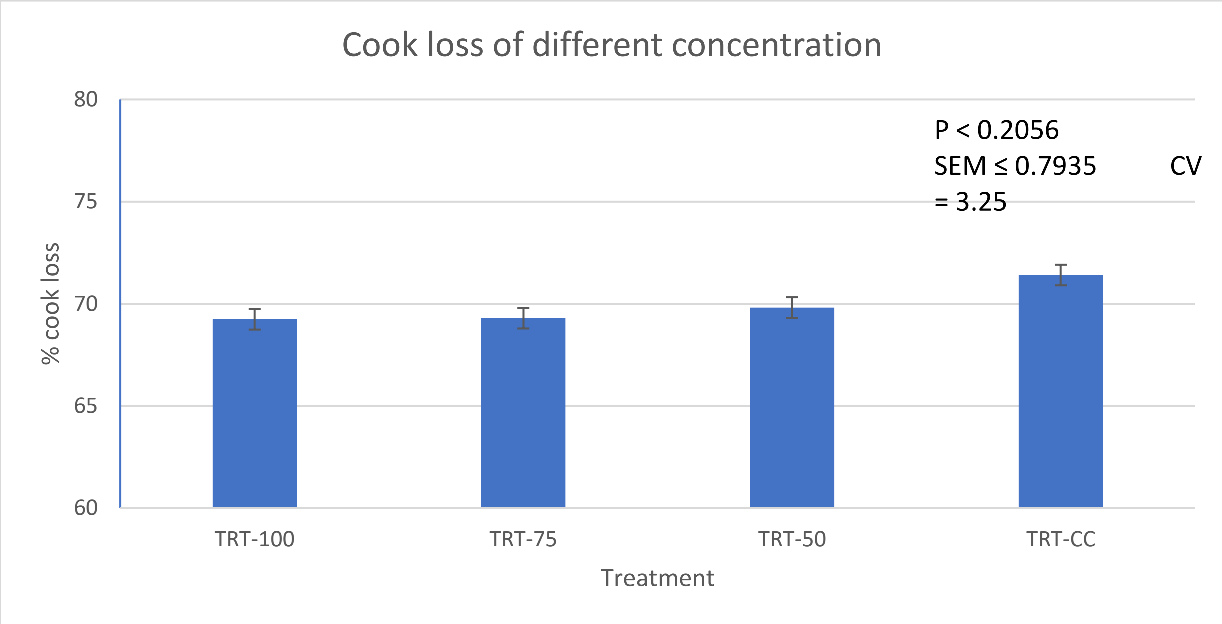
Hardness results of jerky-style pet treat with ground SPL and different concentration of GG



Note. GG: guar gum; SPL: swine pluck; TRT-100: 1% GG addition; TRT-75: 0.75% GG addition; TRT-50: 0.50% GG addition; TRT-CC no GG addition. a-b: means with different letter are statistically different (P ≤ 0.05); SEM; standard error of the mean; CV: coefficient of variation (%).

Annex D

Cooking loss results of jerky-style pet treat with ground SPL and different concentration of GG.



Note. GG: guar gum; SPL: swine pluck; TRT-100: 1% GG addition; TRT-75: 0.75% GG addition; TRT-50: 0.50% GG addition; TRT-CC no GG addition. a-b: means with different letter are statistically different (P ≤ 0.05); SEM; standard error of the mean; CV: coefficient of variation (%).

Annex E

Commercial Beef Lung Treat by Pupdawgs brand

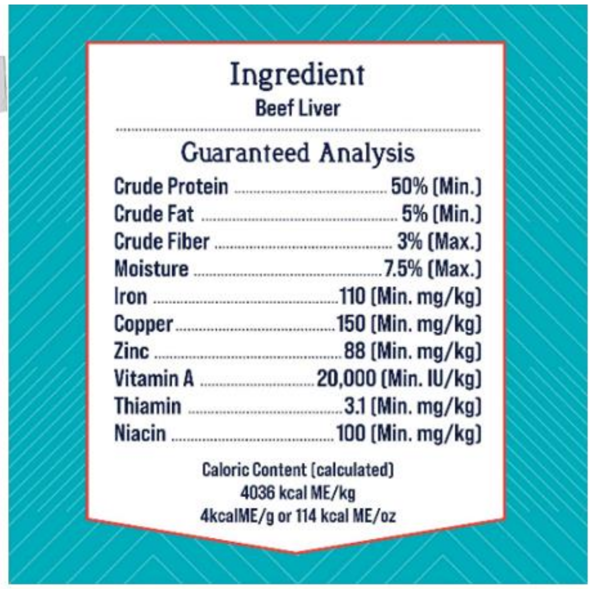
PUPDAWGS

GUARANTEED ANALYSIS

CRUDE PROTEIN (MIN)	60%
CRUDE FAT (MIN)	6%
CRUDE FIBER (MAX)	25%
MOISTURE (MAX)	8%

Annex F

Commercial Beef Liver Treat by Stewart brand.



Annex G

Commercial Chicken Jerky by Pet Recommended brand.

Annex H

Commercial Metabolic Treat by Hill´s brand.

Annex I

Commercial Turkey Heart treat by Max & Neo brand.

Annex J

Commercial Pork Jerky by Farmland Traditions brand.

Annex K

Commercial Pork Jerky by Kahoots brand.