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The Effects of Replacing Pork Fat with Cold-Pressed Coconut Oil on the Properties of Fresh Sausage

Wannee Tangkham[1] & Frederick LeMieux[1]

[1]School of Agricultural Sciences, McNeese State University, Lake Charles, LA, United States

Correspondence: Wannee Tangkham, School of Agricultural Sciences, McNeese State University, United States.

E-mail: wtangkham@mcneese.edu

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Abstract

The effects of substituting coconut oil on the chemical composition, microorganism, and sensory properties of fresh sausages were investigated. This experiment evaluated three (0, 10%, 20%) levels of cold-pressed coconut oil (CPCO) and pork fat stored at 3°C for 14 days. The following treatments: 1) control (20% pork fat: 0% CPCO), 2) 0% pork fat: 20% CPCO and 3) 10% pork fat: 10% CPCO were replicated three times. Treatments were analyzed for pH value, % moisture content, % drip loss, lipid stability (thiobarbituric acid-reactive substances TBARS), aerobic plate counts, *Escherichia coli*, *Staphylococcus aureus*, and sensory analysis. The initial moisture content of fresh sausage in this experiment ranged from 63.44 to 65.67%. Fresh sausage with 20% CPCO inhibited the growth of aerobic bacteria and obtained the highest TBARS values (4.25 mg MDA/kg) compared to the control treatment. In addition, fresh sausage (10% pork fat and 10% CPCO) decreased the % drip loss, pH value and obtained the highest overall rating (6.45) of sensory testing (n = 75). No *E. coli* and *S. aureus* were found in this study for 14 d at 3°C.

Keyword: cold-pressed coconut oil, properties of fresh sausage, pork fat

1. Introduction

Fresh sausage is the mixtures of coarse or finely ground meats, fat and spices stuffed into casing (USDA, 2005). According to the USDA (2005), fresh pork sausage may contain water up to 3% and fat up to 30% of the total ingredients in the product. Fat quality is important in fresh sausage products that stabilizes meat emulsions, reduces cooking loss, improves water-holding capacity (WHC) and provides juiciness and hardness (Pietrasik & Duda, 2000; Yoo, Kook, Park, Shim, & Chin, 2007). Fresh sausage with high animal fat content has high levels of saturated fatty acids and cholesterol (Özvural & Vural, 2008). These may be associated with several types of obesity, hypertension, cardiovascular and coronary heart diseases (Özvural & Vural, 2008). Therefore, changing fat into oil during formulation is more common as consumers desire less saturated fat, which might reduce the level of health issues.

Several animal fat replacers such as vegetable oils, fibers and vegetable proteins have been used for meat products (Zhang, Xiao, Samaraweera, Lee, & Ahn, 2010). However, vegetable oil contains high amounts of unsaturated fat which might affect the water holding, binding capacity, processing yield, and texture of sausage (Acton, Ziegler, Burge, & Froning, 1982). Consequently, these can cause an effect of meat quality and impact economic loses. (Legan, White, Schinckel, Gaines, & Latour, 2007; Varnold, 2009).

Coconut oil is a medium-chain fatty acid which is easily absorbed in the intestine, without the need of pancreatic lipase enzyme action (Liau, Lee, Chen, & Rassol, 2011; Mora-Gallego, Guàrdia, Serra, Gou, & Arnau, 2016). Coconut oil also has antiviral, anti-bacterial and anti-fungal properties. These properties may reduce the susceptibility to microbial and oxidative spoilage off-flavors in fresh pork sausage. Coconut oil might be a good alternative choice of oil as an emulsion stability. No study has examined the incorporation of coconut oil in fresh pork sausage. The objective of this study was to determine the effect of coconut oil on properties of fresh pork sausage which could help improve the shelf-life, quality, and flavor of the fresh sausage.

2. Method

2.1 Preparation of Fresh Pork Sausage

Fresh pork ham and pork back fat were purchased from a local market in Lake Charles, Louisiana. Lean materials and pork back fat were minced via meat grinder (Model W777 #5 LEM^{TM}) through a 3 mm plate. Samples were subjected to three treatments: 20% pork fat, 20% cold-pressed coconut oil (CPCO) and the combination of 10% pork fat and 10% CPCO and were stored at 3 ℃.

Other ingredients included: 6.92% cook wine (Holland House, Mizkan America, Inc.), 2.31% vinegar (Kroger Co Cincinnati, Ohio), 1.36% sugar (Domino Foods, Inc., Yonkers, NY), 1.21% garlic powder (Bolner's Flesta Products Inc., San Antonio, Texas), 1.17% salt (Morton Salt, Inc., Chicago, IL), 0.66% funnel (Lucerne Foods, Inc., Pleasanton, CA), 0.58% parsley (Adams Flavors, Foods & Ingredients, LLC., Gonzales, TX), 0.23% black pepper (Kroger Co Cincinnati, Ohio) and 0.16% ground nutmeg (Adams Flavors, Foods & Ingredients, LLC., Gonzales, TX). The samples were allowed to age for 12 hours at 3°C. The sausage samples were then cooked in an oven (Hotpoint Model # RB526DHWW) at 177°C for 30 min. Each sample was evaluated for consumer product acceptance. Samples were stored at 3 ℃ for future physicochemical and microbiological analyses. Three replicates of each treatment were analyzed for pH, % moisture, % drip loss, color (L*, a*, b*), lipid stability (TBARS), aerobic plate counts, *E. coli, S. aureus*, and sensory analysis through 14 d.

2.2 pH Test

Each sausage treatment was replicated three times and evaluated for pH with a probe electrode portable meter (Model 2000 VWR Scientific) and results are expressed as the mean and standard error of the mean (SEM). Calibration of the pH meter was accomplished using pH 7 and pH 4 standardization buffers before use.

2.3 Moisture Content

Moisture content was determined according to the design method of the Association of Official Analytical Chemists (AOAC, 2000). Crucibles were heated at 102 ℃ for 3 h and transferred to a desiccator to cool and record dry crucible weight. Each 3 g sausage sample (n = 9) was weighed and dried in a hot air oven (Model 26 Precision Thelco) at 102 ℃ for 24 h. After drying, crucibles were moved to the desiccator to cool and obtain dry sample weight. The total moisture content was determined by dividing the difference between the initial weight (IW) and dry weight (DW) and dividing by initial weight.

$$[(IW-DW)/IW] \quad (1)$$

2.4 Drip Loss Analysis

For determination of exudation and weight retention during storage, all treatment samples (n = 9) were weighed separately at the time of initial sampling at days 1, 4, 7, 9, and 14. Weight loss was calculated as the difference of final sample weight and initial sample weight divided by the initial weight for fresh pork sausage.

2.5 Color Test

Color was measured at three different locations, with three replications, on the surface of each sausage treatment with a Minolta spectrophotometer (Model CR-10 portable) using an 8 mm aperture, 10 ° observer angle, D65 illuminant source in terms of L* (white = 100, black = 0), a* (+40 = red, -40 = green), b* (+40 = yellow, -40 = blue). The colorimeter was calibrated to a white plate before use.

2.6 TBARS Test

The thiobarbituric acid-reactive substances (TBARS) method (Tarladgis, Watts, Younathan, & Jr. Dugan, 1964) was used to measure lipid oxidation. A fifteen gram sample of each sausage (n = 9) was blended with 30 mL of trichloroacetic acid solution. The sample solution was filtered through Whatman No. 1 filter paper. Five ml aliquots of the filtrate were transferred to separate test tubes (in duplicate) and mixed with 5 mL of 0.02 M TBA. The mixture was vigorously agitated in a vortex and was heated in a boiling water bath (100°C) for 45 min to develop a pink color. After cooling the reaction mixture under running water the absorbance was determined at 530 nm using a Beckman Du-640 spectrophotometer against a blank containing 5 mL of distilled water and 5 mL of TBA reagent. The TBA value used to express the results were calculated from standard curves and known dilutions of tetraethoxypropane (TEP) and the results were expressed as mg malondialdehyde (MDA)/kg sausage.

2.7 Microbial Counts

Fresh sausage was assayed for three undesirable microorganisms: aerobic plate counts, *E. coli*, and *S. aureus* following the standards of the AOAC (2000). The following protocol was used for aerobic plate counts, *E.*

coli and *S. aureus*. Buffered peptone water (BPW) was added as a diluent option for serial dilutions. Following 3M™ Petri film plating instructions, each 1.0 ml of sample with three replications was aseptically transferred and was plated on 3M™ petrifilm to determine the enumeration (log CFU/g) of *E.coli* and *S. aureus*. All samples were incubated for 24-48 hours at 37℃. Data were collected from countable plates (30-300 colonies per plate). The counted colonies were reported as CFU/g.

2.8 Sensory Analysis

All participants were volunteers solicited through advertisements posted in the Agricultural Sciences building on the McNeese State University Campus. The test room was illuminated with cool, natural, fluorescent lights. The participants were presented with three digit randomly coded samples. Each preparation was evaluated for consumer product acceptance and purchase intent. Using a 9-point hedonic scale, 75 untrained participants evaluated the fresh sausage for acceptability of appearance, color, texture, flavor, taste and overall liking (9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4= dislike slightly, 3 = dislike moderately, 2 = dislike very much, 1= dislike extremely). Participants were required to cleanse their palates with water between tasting the samples

2.9 Statistical Analysis

The Proc GLM procedures of SAS windows (SAS, 2003) were used to evaluate the significance of differences of the obtained data. The PDIFF option of LSMEANS was employed to determine significance among treatments. All data are presented as means and a significance level of $P<0.05$ was used for statistical analysis of means from treatments.

3. Results and Discussion

3.1 pH

The initial pH values of each individual sausage treatment ranged from 6.07 to 6.25 (Figure 1) which is similar to earlier findings (Cocolin, Rantsiou, Iacumin, Urso, & Cantoni, 2004; Lee et al., 2015). Over the 14 day experimental period, changes in pH over each treatment profile exhibited significant differences ($P<0.05$). Our results showed that the pH values in each treatment followed a general decrease over the experimental period (Figure 1). Fresh sausage (10% pork fat and 10% CPCO) had the lowest pH value ($P<0.05$) at 5.61 after refrigerated storage compared to other treatments at 3°C for 14 days. These results are consistent with those reported by H. Wang, Ren, Liu, Zhu, and W. Wang (2013); Wenjiao, Yunchuan, Junxiu, and Yongkui (2014) and Suckow, Danielski, Borges, and Macedo (2016).

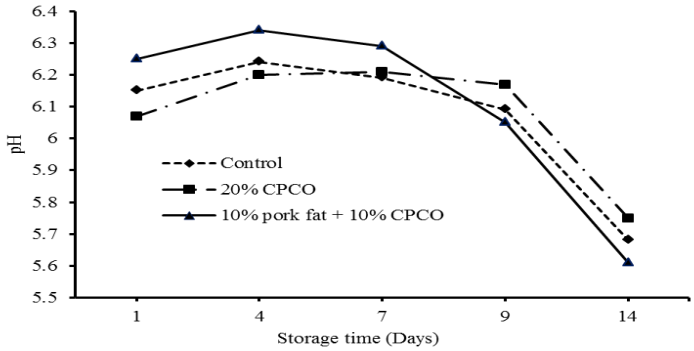

Figure 1. pH values of fresh pork sausage stored at 3 ℃ for 14 days. SEM = 0.02

3.2 Moisture Content

Moisture contents of the three fresh sausage treatments are shown in Table 1. There was no difference in moisture contents over 14 d storage regardless of treatment (Table 1), which is similar to the findings of Zamudio-Flores et al. (2015). The average initial moisture content of the three treatments ranged between 63.44-65.67%. The initial water content of each of the three treatments increased slightly during the course of the experiment, which may be due to the gain of moisture/water from the internal atmosphere of the refrigerator during the storage period (Liu, Tsau, Lin, Jan, & Tan, 2009). Therefore, modified atmosphere packaging might become a critical factor in the commercial market for fresh sausage (Tangkham, Janes, LeMieux, & McMillin, 2014).

Table 1. Moisture content (%) of fresh pork sausage stored at 3 ℃ for 14 days

% Moisture Content (SEM = 1.36)			
Day	Control	20% CPCO	10% pork fat + 10% CPCO
1	65.14	65.67	63.44
4	66.75	65.19	64.80
7	69.53	65.19	65.57
9	69.25	68.82	66.37
14	69.21	69.25	68.79

3.3 Drip Loss

Drip loss of the fresh pork sausage was affected (P<0.05) by cold-pressed coconut oil treatments and storage time (Figure 2). The drip loss of fresh sausage (20% pork fat) increased significantly (P<0.05) over 14 d storage (Figure 2). On d 14, fresh pork sausage (10% pork fat and 10% CPCO) had the lowest percent drip loss (P<0.05) (Figure 2). This might be due to the stability of emulsion products in coconut oil (Knipe, 1987; Cheng & Sun, 2008). Therefore, the cold-pressed coconut oil is effective in producing stable emulsions.

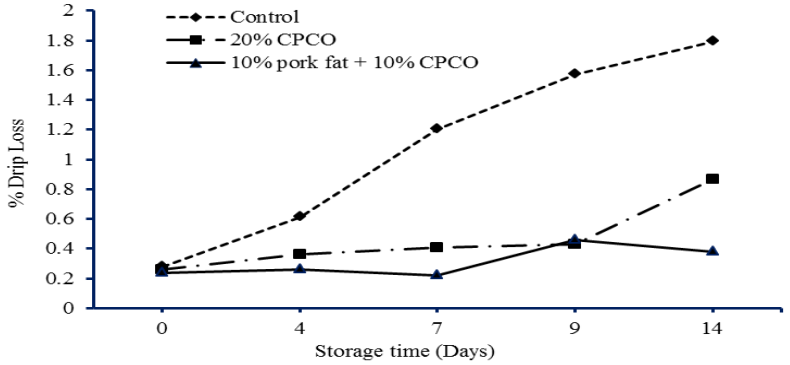

Figure 2. Drip loss (%) of fresh pork sausage stored at 3 ℃ for 14 days. SEM = 0.42

3.4 Color Test

Color is an important factor in the marketing of meat products because it influences consumers buying decisions. Replacing pork fat with oil in fresh sausage can cause color changes which may result in consumer discriminating against discolored sausage. In this study, there were differences observed in the L* (lightness) values between treatments stored at 3 ℃ for 14 days (Figure 3). Our results indicate that cold-pressed coconut oil increases the lightness of fresh pork sausage. These results are consistent with those reported by Lee et al. (2015) for emulsion-type pork sausages and by Baer and Dilger (2014), who found that oil causes fat smearing on the meat surface and L* value increases during storage in sausage.

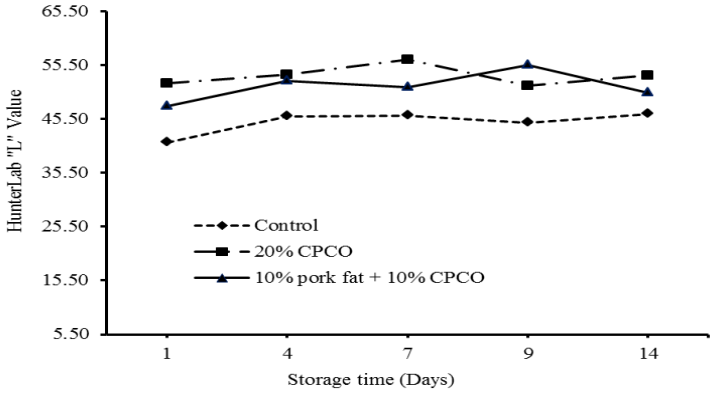

Figure 3. HunterLab “L” value of fresh pork sausage stored at 3 ℃ for 14 days. SEM = 1.16

There was a significant difference (P<0.05) observed in a* values between treatments. Redness a* values for all samples decreased (P<0.05) with storage time. Regarding instrumental color, fresh pork sausage (10% pork fat and 10% CPCO) showed the lowest a* value at 6.25 for 14 days (Figure 4). This value was similar to the study of Wenjiao, Yunchuan, Junxiu, and Yongkui (2014) and Suckow, Danielski, Borges, and Macedo (2016) for shelf-life of pork sausage. This means a loss of redness in color of the meat and the transition of its color to brownish red by formation of metmyoglobin. This indicates that an increase in unsaturation causes fat smearing in fresh sausage. Therefore, replacing pork fat by cold-pressed coconut oil in fresh sausage can impact the color quality of pork sausage (Suckow, Danielski, Borges, & Macedo, 2016).

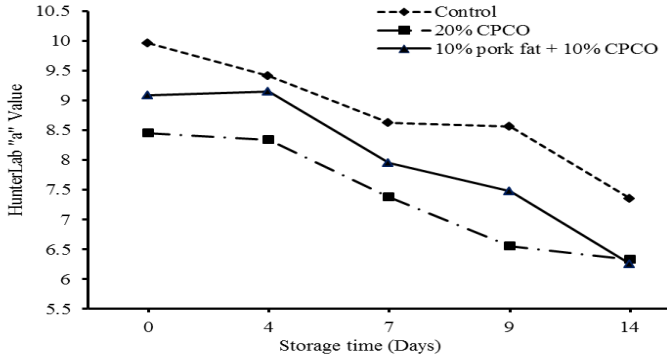

Figure 4. HunterLab “a” value of fresh pork sausage stored at 3 ℃ for 14 days. SEM = 0.32

With regard to b* (yellowness) values, there were significant differences (P<0.05) among the treatments at various storage times (Figure 5). Fresh pork sausage with 10% pork fat and 10% CPCO had the highest (P<0.05) yellowness b* value at 14.40 throughout 14 days of storage. Cold-pressed coconut oil treatments appeared to give the sausage higher yellowness than the control treatment.

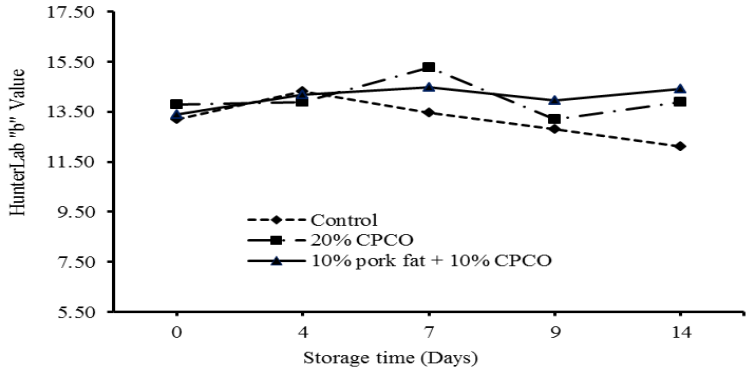

Figure 5. HunterLab “b” value of fresh pork sausage stored at 3 ℃ for 14 days. SEM = 0.94

3.5 Lipid Stability (TBARS)

Fat quality commonly affects lipid oxidation which causes rancid flavor and off-flavor in meat products. Thiobarbituric acid reactive substances (TBARS) test is a method used to detect oxidative deterioration of fresh sausage. In this study, there was a significant effect (P<0.05) in TBARS values of fresh pork sausage throughout the 14-day storage period (Figure 6). The initial TBARS values of fresh sausage in this experiment ranged from 0.78 to 1.40 mg MDA/kg. Previous studies found that consumers can detect the threshold of rancidity at TBARS of 0.5 mg MDA/kg in meat (Gray & Pearson, 1987) and 1.0 mg MDA/ kg in sausage products (Bloukas, Paneras, & Fournitzis, 1997). However, the TBARS values were higher (P<0.05) in fresh sausage with 20% CPCO at 4.25 mg MDA/kg on day 14 at 3°C. This is probably due to the oil interfering with the reaction between TBA and MDA which is similar to previous findings (Bloukas, Paneras, & Fournitzis, 1997; Muguerza, Gimeno, Ansorena, Bloukas, Astiasarán, 2001; Choi et al., 2010). Our study also showed that fresh pork sausage with

cold-pressed oil had the greatest TBARS value which indicates short term shelf-life. However, proper storage and packaging of these products can slow lipid oxidation in fresh sausage and still provide a desirable product for consumers.

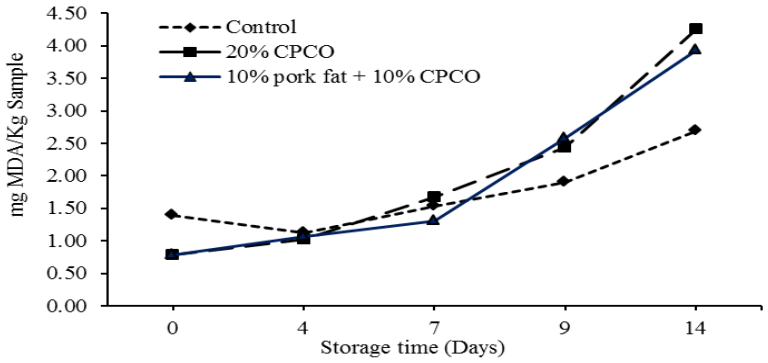

Figure 6. TBARS (thiobarbituric acid-reactive substances) values of fresh pork sausage stored at 3 ℃ for 14 days. SEM = 0.014

3.6 Microbial Counts

In this study, fresh sausage was assayed for aerobic plate count, *E.coli* and *S. aureus*. The initial aerobic plate count of fresh pork sausage in this experiment ranged from 4.78 to 6.10 log CFU/g. These results are consistent with those reported by Cocolin, Rantsiou, Iacumin, Urso, and Cantoni (2004). There were no differences amongst treatments over the 14 d period. However, sausage with 20% CPCO seemed to provide the most stable microbial environment. Additionally, there was no *E. coli* or *S. aureus* detected throughout the 14 d of storage at 3 ℃. This suggested that cold-pressed coconut oil can inhibit the growth of aerobic plate counts.

Table 2. Aerobic Plate Count (Log CFU/g) of fresh pork sausage stored at 3 ℃ for 14 days

Aerobic Plate Count (Log CFU/g) (SEM = 0.25)			
Day	Control	20% CPCO	10% pork fat + 10% CPCO
1	5.92[a]	6.10[a]	4.78[b]
4	6.70[a]	6.55[a]	7.02[a]
9	5.71[a]	5.62[a]	5.58[a]
14	6.44[a]	6.26[a]	6.36[a]

3.7 Sensory Analysis

Using the hedonic scale, untrained participants (n = 75) evaluated the fresh pork sausages for appearance, color, texture, flavor, taste and overall liking (Table 3). With reference to taste and texture, Fresh sausage with 20% CPCO obtained the lowest score 5.08 and 5.09, respectively. This was due to the higher unsaturation of fat resulting in a softer texture and fat smearing (Legan, White, Schinckel, Gaines, & Latour, 2007; Varnold, 2009). Therefore, cold-pressed coconut oil affects fat smearing on the sausage surface and a softer texture which is similar to the previous studies reporting that higher unsaturated fat produced a softer texture in meat products (Shackelford, Miller, Haydon, & Reagan, 1990; Bishop, Olson, & Knipe, 1993; Bloukas, Paneras, & Fournitzis, 1997; Muguerza, Gimeno, Ansorena, Bloukas, & Astiasarán, 2001).

Other findings observed that the higher levels of unsaturated fat content in the fresh sausage can affect the flavor score (St. John, Buyck, Keeton, Leu, & Smith, 1986; Shackelford, Miller, Haydon, & Reagan, 1990; Bryhni, Kjos, Ofstad, & Hunt, 2002; Hallenstvedt, Øverland, Rehnberg, Kjos, & Thomassen, 2012). However, our study showed that flavor, appearance, color, and overall liking, scores among all three treatments were not different ($P>0.05$) (Table 3) which is similar to a previous studies (Choi et al., 2010). Fresh sausage (10% pork fat and 10% CPCO) obtained the highest overall sensory analysis rating (n = 75). Suggesting that combined pork fat with cold-pressed coconut oil can be a viable alternative to traditional fresh pork sausage.

Table 3. Consumer acceptance scores for sensory attributes and overall liking of fresh pork sausage

Properties	Control	20% CPCO	10% pork fat + 10% CPCO	SEM
Appearance	7.04[a]	6.40[a]	6.95[a]	0.24
Color	6.40[a]	6.18[a]	6.53[a]	0.24
Texture	6.29[a]	5.09[b]	6.42[a]	0.28
Flavor	6.05[a]	5.43[a]	6.11[a]	0.28
Taste	6.04[a]	5.08[b]	6.25[a]	0.29
Overall liking	6.36[a]	5.78[a]	6.45[a]	1.12

[a,b]LSMeans with different superscripts within a row is significantly different (P<0.05).

4. Conclusions

Fat quality is important for quality and sensory characteristics in fresh pork sausage. Fat is often considered a value-added product due to their increased economic value and shelf-life. The results of this study provide valuable insight into the quality, safety, shelf-life and consumer acceptance of the fresh pork sausage. Specifically, sensory participants rated 10% pork fat and 10% CPCO the highest overall liking (6.45) of fresh sausage. Cold-pressed coconut oil replacement decreased (P<0.05) the % drip loss, and pH value. Therefore, fresh sausage with cold-pressed coconut oil might be a marketable alternative to original fresh sausage.

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