Meat Science 145 (2018) 352–362

Contents lists available at ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Replacement of pork fat in frankfurter-type sausages by soybean oil oleogels structured with rice bran wax

Taylor L. Wolfer[a], Nuria C. Acevedo[b], Kenneth J. Prusa[a,b], Joseph G. Sebranek[a,b], Rodrigo Tarté[a,b,*]

[a] Department of Animal Science, 215 Meats Laboratory, 914 Stange Rd., Iowa State University, Ames, IA 50011-1001, USA
[b] Department of Food Science and Human Nutrition, 2312 Food Sciences Building, 536 Farm House Lane, Iowa State University, Ames, IA 50011-1057, USA

ARTICLE INFO

Keywords:
Fat replacement
Frankfurter
Meat products
Oleogels
Rice bran wax
Soybean oil

ABSTRACT

The objective of this study was to assess the impact of replacing pork backfat with rice bran wax oleogels on the organoleptic properties of frankfurter-type finely-comminuted sausages. Frankfurters were formulated using the following treatments as lipid replacement: 1) pork fat (PF); 2) soybean oil (SBO); 3) 2.5% rice bran wax oleogel (2.5 RBW); 4) 10% rice bran wax oleogel (10 RBW); and 5) 2.5% rice bran wax oleogel sheared less during frankfurter production (RBW/LS). In general, control PF was darker and redder than other treatments. TPA revealed oleogel treatments to be similar ($P > .05$) to pork fat treatment for firmness, chewiness, and springiness. Additionally, sensory evaluation revealed that replacing pork fat did not influence cured frankfurter aroma, but cured frankfurter flavor was significantly reduced ($P < .05$). Furthermore, lipid oxidation significantly ($P < .05$) differed between PF and 10 RBW. The results show that rice bran wax oleogels have the potential to successfully replace pork fat in comminuted products.

1. Introduction

Fats and oils are critical for both human health and food quality. The *2015–2020 Dietary Guidelines for Americans* (2015) recommends 30% of caloric intake from fats and oils, with most of that energy consumption in the form of unsaturated fatty acids. These recommendations align with much of the modern literature that agrees unsaturated fatty acids and polyunsaturated fatty acids are important for reducing biomarkers for cardiovascular disease (Dyerberg et al., 2004), reducing plasma cholesterol (Vafeiadou et al., 2015), increasing satiation (Maljaars, Romeyn, Haddeman, Peters, & Masclee, 2009), and decreasing inflammatory cytokines (Han et al., 2002).

All these health benefits are overcome by the fact that meat processors rely heavily on highly-saturated animal fat to give their products the proper texture and flavor. Substitution of animal fat with vegetable oil in finely-comminuted products can lead to increased hardness and chewiness (Youssef & Barbut, 2010; Zetzl, Marangoni, & Barbut, 2012), as well as lighter and less red color (Álvarez et al., 2011; Youssef & Barbut, 2010). Furthermore, lipid oxidation is increased when saturated fat is replaced with unsaturated fat, but this is not a practical concern in cured meat products because of the potent antioxidant capabilities of sodium nitrite (Álvarez et al., 2011; Berasategi et al., 2014). Replacement of fat with vegetable oil in comminuted products can also result in processing challenges such as increased greasy residue on processing equipment (Baer & Dilger, 2014), and decreased emulsion stability in finely-comminuted products (Álvarez et al., 2011; Youssef & Barbut, 2010). Animal fat is a fundamental ingredient in processed meat products and, as such, is difficult to replace.

Oleogels, gels in which the liquid phase is oil, are a relatively novel fat replacement technology. They provide both the nutritional benefits of oils (Stortz, Zetzl, Barbut, Cattaruzza, & Marangoni, 2012), and the positive organoleptic and technological attributes of harder, more saturated fats (Barbut, Wood, & Marangoni, 2016a; Barbut, Wood, & Marangoni, 2016b; Zetzl et al., 2012). Oleogels require a gelling molecule that can stack into an organized scaffold in order to structure the vegetable oil (Marangoni & Garti, 2011). One such source of gelling molecule is rice bran wax. Rice bran wax has been shown to produce an oleogel at 1:99 rice bran wax:liquid oil (Blake, Co, & Marangoni, 2014; Dassanayake, Kodali, Ueno, & Sato, 2012). Oleogels made with 10% rice bran wax can be firm and brittle, despite a solid fat content of < 7%. Rice bran wax oleogels increase in melting temperature as the

* Corresponding author at: Department of Animal Science, 215 Meats Laboratory, 914 Stange Rd., Iowa State University, Ames, IA 50011-1001, USA.
E-mail addresses: tlwolfer@iastate.edu (T.L. Wolfer), nacevedo@iastate.edu (N.C. Acevedo), kprusa@iastate.edu (K.J. Prusa), sebranek@iastate.edu (J.G. Sebranek), rtarte@iastate.edu (R. Tarté).

https://doi.org/10.1016/j.meatsci.2018.07.012
Received 15 May 2018; Received in revised form 9 July 2018; Accepted 10 July 2018
0309-1740/

concentration of rice bran wax increases. Dassanayake, Kodali, Ueno, and Sato (2009) reported the melting temperature of oleogels produced with 1%, 3%, 5%, and 10% rice bran wax to be 54.3 °C, 57.8 °C, 60.8 °C, and 65.2 °C, respectively. In addition to the concentration of the gelling agent, other oleogel manufacturing variables, such as cooling rate, type of gelling agent, and length of storage time, can influence the melting temperature and firmness of the final oleogel (Dassanayake et al., 2009; Dassanayake et al., 2012; Toro-Vazquez et al., 2007).

There has been very little research on the use of oleogels in food products, and even less within processed meats. Zetzl et al. (2012) and Barbut et al. (2016a), utilized ethylcellulose and canola oil to create oleogels for a partial fat replacement in beef frankfurters. Replacing animal fat with oleogels resulted in frankfurters with intermediate characteristics to those produced with animal fat and those produced with native canola oil. Moreover, replacing beef fat with ethylcellulose oleogel improved cook yields (Barbut et al., 2016b).

No research has studied rice bran wax oleogels as a potential animal fat replacement in pork frankfurters. This study is also unique in that it is the only known study that tracks the shelf-life of meat products containing oleogels. Additionally, no known research has attempted to use oleogels to replace nearly all of the animal fat in the product.

It should be noted that rice bran wax, though listed as GRAS (Generally Recognized as Safe) in the United States, is presently only approved as a coating in candy, fresh fruits and fresh vegetables, and as a plasticizer in chewing gum. (Rice Bran Wax, 2017), Approval has not been petitioned for its use in other food products, so therefore it isn't currently approved as an ingredient in meat products. It was chosen for this study because it gels oil effectively at low concentrations (Blake et al., 2014; Dassanayake et al., 2012), produces a white gel with a fat-like appearance, and is relatively inexpensive compared to other potential gelators. Demonstration of its effectiveness as a functional ingredient for other food applications could awaken interest and lead to the reconsideration of its regulatory status as a meat and food ingredient.

It is hypothesized that oleogels produced with rice bran wax and soybean oil will result in pork frankfurters with processing characteristics and texture attributes similar to those of frankfurters produced with pork fat. The objective of this research is to characterize the impact of oleogels as an animal fat replacement on processing characteristics, texture, color, lipid oxidation, and sensory properties over time.

2. Materials & methods

2.1. Oleogel preparation

Based on subjective firmness, appearance, and flavor, two different concentrations of rice bran wax, 2.5% and 10% wt/wt, were selected for oleogel production. Correct amounts of soybean oil (ADM Grain Eastern Trading, Decatur, IL, USA) and rice bran wax (Koster Keunen, Inc., Watertown, CT, USA) were weighed and mixed in a 7.57-L stainless steel bowl and placed in a 121 °C convection oven (Model #LGEF3045KFJ, Frigidaire, Charlotte, NC, USA). After achieving the target temperature of 90 °C, which required approximately 2 h, solutions were stirred every 7 min for 30 min before being removed from the oven.

The stainless steel bowls were then covered with aluminum foil and stored at 2.7 °C. Cooling rate was determined by placing a temperature logger in the geometric center of the oleogel solution. The average cooling rate for the three replications was −1.44 °C min^{-1}. Two 2.5% rice bran wax oleogels and one 10% rice bran wax oleogel were made for each replication. Oleogels were prepared 5–7 d prior to use in frankfurters to ensure proper setting of the gel matrix.

Table 1
Proximate composition of pork raw materials used in frankfurter preparation. Values in parentheses represent standard deviation.

	Moisture (%)	Lipid (%)	Protein (%)
Pork knuckles	75.24 (± 0.91)	1.82 (± 0.98)	22.02 (± 0.15)
Pork backfat	14.79 (± 0.18)	78.61 (± 0.29)	2.87 (± 0.96)

2.2. Frankfurter preparation

2.2.1. Frankfurter materials and formulations

Five frankfurter treatments were produced using the following lipid replacements or strategies: 1) pork back fat (PF); 2) soybean oil (SBO); 3) oleogel produced with soybean oil and 2.5% rice bran wax (2.5 RBW); 4) oleogel produced with soybean oil and 10% rice bran wax (10 RBW); and 5) oleogel produced with soybean oil and 2.5% rice bran wax added later in the bowl-chopping step of the frankfurter batter (RBW/LS) in order to reduce the amount of shear applied to the oleogel.

Trimmed pork knuckles and pork backfat were obtained from a commercial meat packing plant. Upon receipt at the Iowa State University Meat Laboratory, the raw meat materials were immediately stored at −1 °C for no longer than 5 d and analyzed for proximate composition (Table 1). All meat raw materials and nonmeat ingredients used in all three replications were from the same production lot, except for lipid source.

Trimmed pork knuckles were used in all treatments to reduce the amount of fat derived from the lean trimmings. This allowed for maximum animal fat replacement using oleogels while still maintaining a final lipid content similar to that commercial frankfurters. Frankfurter batters were formulated to target a lipid content of 18.16%. There was an anticipated cook/chill yield of 88%; so theoretical lipid content in the final product was 20.6%. Meat block was 73% for all treatments. The 2.5 RBW and RBW/LS treatments used the same type of oleogel, but the frankfurters were processed differently, which will be explained in the next section.

2.2.2. Frankfurter processing

Frankfurters were made in the Iowa State University Meat Laboratory, Ames, IA, according to the treatment formulas shown in Table 2. The meat block for each treatment batch weighed 13.61 kg, and total batch weight was 18.55 kg. On the day of production, whole pork knuckles and pork backfat were pre-ground through a 9.53-mm grinder plate. Oleogels and soybean oil were not pre-ground. For the PF, SBO, 2.5 RBW, and 10 RBW treatments, ground knuckles and water/ice were added to a bowl chopper (Krämer & Grebe VSM65, Biedenkopf, Germany) with salt, phosphate, dextrose, curing salt, cure accelerator, and spices, and were chopped under vacuum. After the batter reached 4.4 °C, the lipid source corresponding to each treatment (pork backfat, soybean oil, 2.5% RBW oleogel, or 10% RBW oleogel)

Table 2
Frankfurter treatment formulations (values expressed in percentages).

	PF	SBO	2.5 RBW	10 RBW	RBW/LS
Knuckles	51.38	55.62	55.62	55.62	55.62
Pork backfat	21.91	–	–	–	–
Soybean oil	–	17.67	–	–	–
2.5% RBW oleogel	–	–	17.67	–	17.67
10% RBW oleogel	–	–	–	17.67	–
Water/ice (50/50)	21.99	21.99	21.99	21.99	21.99
Salt	1.63	1.63	1.63	1.63	1.63
Dextrose	0.76	0.76	0.76	0.76	0.76
Phosphate	0.38	0.38	0.38	0.38	0.38
Curing salt (6.25% $NaNO_2$)	0.18	0.18	0.18	0.18	0.18
Sodium erythorbate	0.04	0.04	0.04	0.04	0.04
Seasoning	1.73	1.73	1.73	1.73	1.73