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Effect of fat quality on sausage processing, texture, and sensory characteristics

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ABSTRACT

Fresh pork sausage was manufactured to determine the effects of animal diet (unsaturated or control) and inclusion of corn oil during processing (0% and 14% fat replacement). Bologna was manufactured to investigate only diet effects. Processing, textural, sensory, visual, and storage characteristics were evaluated. Processing yield was improved 2.9 percentage units in fresh sausage but reduced 1.8 units in bologna in unsaturated compared with control diets. Break strength of fresh sausage was reduced 0.6 kg by oil inclusion. Both unsaturated fat and including oil during processing resulted in softer texture of fresh sausage, while increased unsaturation in bologna resulted in firmer or unchanged textural properties. Fresh sausage with oil was lighter colored (5.3 L* units increased) with more fat smearing. In fresh sausage, lipid oxidation remained below 1 mg/kg MDA during 12 weeks frozen storage. Overall, changes in fat quality minimally affected sausage quality, likely providing acceptable products to consumers.

1. Introduction

In the United States, approximately 20% of pork is consumed as sausage products, such as bratwurst, frankfurters, and fermented sausages (National Pork Board, 2010). Fat is one of the most variable raw materials in sausage products, makes up a large percentage of sausage composition, and is important in the processing, textural, and sensory characteristics of sausage products (Paneras & Bloukas, 1994; Rust & Olson, 1988). Thus, the effect that changes in fat quality could have on subsequent sausage quality is important to understand. Generally, unsaturated, soft pork fat is considered to be poor quality due to issues with shelf-life and processing (Gatlin, See, Larick, Lin, & Odle, 2002; Leick et al., 2010). Altering fat to be more unsaturated can occur a variety of ways, including changes in swine feed ingredients and inclusion of alternate fat sources during product formulation. However, there is limited research available regarding the effects of fat quality on processing, textural, and sensory characteristics in different sausage products.

Distiller dried grains with solubles (DDGS) will likely continue to be an important feed ingredient for pork production in the coming years (Hoffman & Baker, 2011). As reviewed by Stein and Shurson (2009), DDGS inclusion which did not exceed the established limitations did not affect growth performance or carcass quality. These limitations are 20% for finishing pigs, 30% for grower pigs and lactating sows, and 50% for gestating sows. Limited research, however, has focused on the effect of feeding DDGS to pigs on sausage quality. Some researchers have found sausage products from pigs fed DDGS had increased fat smearing, increased product disfiguration, negatively affected sensory traits, and decreased storage stability (Legan, White, Schinckel, Gaines, & Latour, 2007; Varnold, 2009; Wert et al., 2009). These changes are thought to be the result of the increased fat unsaturation from feeding increased polyunsaturated fatty acid (PUFA), specifically C18:2, found in DDGS.

Similar to feeding DDGS, feeding unsaturated dietary fat can also alter fat quality and subsequent sausage quality as unsaturated dietary fatty acids are incorporated into pork adipose tissue and can increase PUFA content. This practice may offer human health benefits if a greater proportion of PUFA, especially long-chain n−3 PUFA, is incorporated in pork fat and, therefore, increased in consumer products. However, feeding pigs increased PUFA concentrations which led to softer texture of fresh sausage and salami (Severini, De Pilli, & Baiano, 2003; Shackelford, Miller, Haydon, & Reagan, 1990). Lipid oxidation was also increased in sausage products with greater fat unsaturation levels (Bryhni, Kjos, Ofstad, & Hunt, 2002; Hallenstvedt, Øverland, Rehnberg, Kjos, & Thomassen, 2012; St. John, Buyck, Keeton, Leu, & Smith, 1986). However, there were few processing defects or alteration of processing yields reported when fat unsaturation was increased from feeding dietary fat to pigs (Guillevic, Kouba, & Mourot, 2009; Shackelford et al., 1990). Processing yields were even improved in frankfurters from pigs fed 20% canola oil compared to frankfurters from pigs fed a control corn–soy diet (St. John et al., 1986).

Replacement of pork fat with oil during product formulation also affects fat quality but is typical when creating low-fat sausage products with increased PUFA concentrations. Addition of oil in fermented sausage caused processing defects, such as fatting out, oil exuding from product, and separation of meat from sausage casing (Bloukas,

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Paneras, & Fournitzis, 1997; Muguerza, Gimeno, Ansorena, Bloukas, & Astiasarán, 2001). Barring these issues, there is potential for increased processing yields from oil inclusion in sausage products (Bloukas et al., 1997; Choi et al., 2010). Oil inclusion had variable effects on sausage texture with a general trend for softer texture (Alvarez, Xiong, Castillo, Payne, & Garrido, 2012; Bishop, Olson, & Knipe, 1993; Muguerza et al., 2001). However, inclusion of fish oil up to 6% increased hardness, cohesiveness and adhesiveness of mortadella (Cáceres, García, & Selgas, 2008) Increased fat unsaturation from oil inclusion also increased off-flavor and TBARS values indicating greater lipid oxidation (Bishop et al., 1993; Bloukas et al., 1997). Furthermore, replacement of pork back fat with olive oil (50 or 100% replacement) resulted in declining overall acceptability of low-fat frankfurters (Pappa, Bloukas, & Arvanitoyannis, 2000).

Few studies have comprehensively investigated the effects of fat quality on processing yields, sensory and visual evaluation, and texture profile characteristics of various sausage products. Understanding fat quality in sausages continues to be important as consumers desire healthier products with less saturated fat and as producers continue to use alternative feed ingredients. The objectives of this study were to evaluate the effects of fat quality on various quality characteristics in fresh sausage and bologna. This was accomplished by feeding cull sows an unsaturated diet as well as including corn oil during processing to further increase unsaturation in sausage products.

2. Materials and methods

2.1. Animals

Animal use procedures were approved by the University of Illinois Institutional Animal Care and Use Committee. To alter fat iodine value (IV), cull sows (Génétiporc Fertilis-25, Génétiporc, Alexandria, MN), were fed experimental diets for 42 days prior to slaughter. Control sows ($n = 2$) were fed an ad libitum amount of corn–soy diet free of DDGS, while other sows ($n = 3$) were fed 3.2 kg/day of an unsaturated diet containing 50% DDGS. Diets were isocaloric and formulated to meet NRC requirements. At the end of the feeding period, sows were transported to the University of Illinois Meat Science Laboratory and slaughtered under inspection using humane practices. Control sows averaged 315 kg live weight at slaughter with an average of 214 kg carcass weight, while DDGS-fed sows averaged 287 kg live with 185 kg carcass weight on average.

2.2. Raw materials

Internal, subcutaneous and intermuscular fat tissues, free of visible lean, were collected 24 h postmortem from each carcass. Subcutaneous and intermuscular fat were combined for each carcass to generate fat trim. Lean tissue with minimal visible fat was pooled from all carcasses to obtain a homogenous, unbiased lean source. Fat trim from each carcass and pooled lean tissue were coarse ground separately though a 1.27 cm plate. Two 20 gram subsamples of fat trim and internal fat from each carcass and 5 lean tissue subsamples (30 g) from the pooled lean source were collected for proximate composition and fatty acid analysis. Internal fat was not ground, but two 20 gram subsamples per carcass were collected for proximate composition and fatty acid analysis. While analyses were being conducted, fat was held in vacuum packages and lean was held in oxygen permeable packages at 4 °C for 7 days.

2.3. Formulation

Target IV of raw materials were less than anticipated (Table 1); thus, corn oil was included to increase the degree of unsaturation in fresh sausage. Fat treatments for fresh sausage were created in a 2 × 2 factorial arrangement with factors being fat source (DDGS or control) and oil inclusion (0 or 14% fat replacement). These treatment combinations were formulated based on IV calculations and lipid content determination to achieve target IV of 68, 75, 75, and 82 for control, control + oil, DDGS, and DDGS + oil, respectively. Four master batches for each treatment combination were formulated to have 75:25 lean to fat ratio. Lean tissue, fat trim, and oil, if applicable, were mixed using a Hobart mixer–grinder (Model 4346, Hobart Corp., Troy, OH) then ground using a 4.76 mm grinder plate. Temperatures of each master batch were recorded after grinding.

Oil treatment was excluded from bologna processing, thereby a completely randomized design (CRD) was created with two treatments, control and DDGS, with target IV values of 65 and 75, respectively. Master blends of lean and fat were not generated. Instead, a new unbiased lean source was collected, coarse ground through a 2.54 cm grinder plate, then mixed and fine ground through 4.76 mm grinder plate. Fat trim and internal fat from each treatment were also coarse ground (2.54 cm) and then fine ground (4.76 mm).

2.4. Fresh sausage processing

Each treatment combination was replicated four times using 6.8 kg batches. Batches were mixed in a reverse action mixer (Mainca model RM-90, Mainca USA, Saint Louis, MO) with spices (0.7% dextrose, 0.3% black pepper, and 0.4% mustard seed), 1.3% salt, and 3% water. Temperatures were recorded after mixing and a 50 g sample was obtained for proximate composition, fatty acid profile analysis, water holding capacity and benchtop pH analyses. Batter was vacuum stuffed (Handtmann stuffer Model # VF 80, Biberach, Germany) into 4 × 3 × 26 poly-bag, oxygen impermeable casings, and samples were identified by securing a tag to the end of the casing. After all fresh sausage chubs were stuffed, chubs were frozen at −20 °C for 4 days. Patties (1.27 cm thick) were cut while frozen on a Biro bandsaw (Model 3334, The Biro MFG Company, Marblehead, OH). Patties were collected for texture profile analysis ($n = 2$), break strength ($n = 2$), visual evaluation ($n = 1$), and sensory evaluation ($n = 1$). Additionally, four patties were collected to evaluate shelf-life at 0, 3, 8, and 12 weeks of frozen storage. Patties were uniquely identified, separated by patty paper, and stored in boxes lined with oxygen permeable plastic at −20°C until analyses were conducted.

2.5. Bologna processing

Each treatment was replicated four times. For each replicate, 4.76 kg of lean and 2.04 kg of fat were combined to obtain a 70:30 lean to fat ratio. Lean tissue was blended on low speed in a bowl chopper (Meissner Maschinen Wallau Model #3560, Model and Maschinenfabrik Meissner and Co., Wallau, Germany) with spices (3.52% seasoning blend with salt, 0.24% sure cure) and 340 g of ice water for 2 min to allow sufficient protein extraction. Fat tissue and an additional 340 g of ice water were added, blade speed was increased to high, and batter was chopped until a bowl chopper reading of 14 °C. Batter was removed from the bowl chopper, and the replicate temperature was recorded. Bologna batter was stuffed into 3.5 cm fibrous casings using a Handtmann stuffer (Model # VF 80, Biberach, Germany). Two chubs were stuffed for each replicate and identified. Chubs were weighed and raw length and diameter were measured. Two samples (50 g) of batter were also collected for proximate composition, pH, drip loss, and fatty acid analyses. Bologna was cooked in an Alkar smokehouse (Lodi, WI) to an internal temperature of 63 °C then chilled at 2 °C overnight. Cooked and chilled bologna were weighed and measured to determine cook yield and changes in diameter or length. Cook yield was reported as a percentage and calculated using the equation: (cooked and chilled weight/uncooked weight) ∗ 100. Diameter and length change were calculated as (cooked and chilled measurement)−(uncooked measurement). Also, bologna were inspected for treatment-related defects before slicing. From each