Research Note: Effects of fiber source on the physicochemical properties of lean poultry meat products

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ABSTRACT Plant fiber addition (citrus A and B, apple, pea, bamboo, and sugar cane) to lean turkey meat was evaluated and texture, yield, and microstructure were compared to a control. The best 2 were the sugar cane and apple peel fibers which reduced cooking loss, and increased hardness by 20% compared to the control. The bamboo fibers significantly improved hardness but not yield, while the citrus A and apple fibers reduced cooking loss but did not affect hardness. The differences in the effect of fiber type on texture appear to be related to their origin (e.g., sugar cane and bamboo originating from large plants requiring strong fibers, compared citrus and apple fruits), and fiber length determined by the fiber extraction procedure.

Key words: dietary fiber, poultry meat, texture, turkey, water-holding capacity

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INTRODUCTION

Meat products are considered a very good source of protein, fat, and certain vitamins. However, they lack dietary fiber, which is recommended for adult consumers at a level of 30 to 40 g/d (Tungland and Meyer, 2002). Supplementing meat products with fiber can be beneficial to consumers, as well as help improve the texture and water retention of meat products.

Overall, quite a few plant fibers are actually part of the food industry waste stream (e.g., citrus peels, sugar cane residues), and end up in landfills or as inexpensive animal feed. Inclusion of plant fibers in meat products has been already reported in the literature for quite some time. However, we see today more of what is described by Mehta et al. (2015) as "novel trends in developing dietary fiber rich meat products." These trends appear to gain momentum especially when the food industry is further refining fiber isolation techniques, and as consumers focus more on sustainability. Few examples of successful trials employing plant fibers include the use of apple pulp to enhance the texture and nutritional profile of chicken nuggets (Verma et al., 2010), use of orange peel fibers to improve a bologna-type product (Viuda-Martos et al., 2010), and lemon albedo use to increase hardness in bologna (Fernández-Ginés et al., 2004). However, the latter also resulted in lower juiciness score. Therefore, the objective of the present study was to evaluate the effects of new fiber preparations, from 6 different plant sources, including fibers not commonly used by the meat industry, such as bamboo and sugar cane.

MATERIALS AND METHODS

Meat Products—Preparation

Lean turkey breast meat was obtained from a local processing plant, within 24-h postmortem. Visible skin, connective tissue, and fat were removed, and 12 fillets were portioned into 25 to 30 g cubes, which were mixed, vacuum packed (1 kg polyethylene bags), and frozen (−20°C) until used within 3 mo. Meat (74.06% moisture, 22.30% protein, 2.25% fat; determined in triplicates) for each of the 3 separate trials was thawed overnight and then chopped in a food processor (Braun, model UK1-Type 4259, Kronberg, Germany) for 30 s. The lean meat was then mixed with 2.5% salt and 40% water to obtain a protein content of 16% and a salt level commonly found in commercial meat products on the Canadian market. After adding the nonmeat ingredients, the mix was chopped for another 30 s to obtain a homogenous mass. The mix was then split into the different treatments and the various fibers were added at a 2.0% level. The fibers consisted of: citrus fiber A preparation (Citri-FI 100, Fiber Star, River Falls, WI. Average fiber length = 0.25 mm; width 0.13 mm), citrus fiber B preparation (Herbacel AQ Plus, Werder, Germany. Average

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length = 0.79; width 0.14 mm), apple fiber (Herbacel AQ. Average length = 0.75 mm; width 0.13 mm), pea fiber (Griffith Lab, Toronto, Ont, Canada. Average length = 0.93 mm; width 0.71 mm), bamboo fiber (Griffith Lab. Average length = 0.72 mm; width 0.16 mm), and sugar cane fiber (Griffith Lab. Average length = 0.93 mm; width 0.12 mm). A control treatment without any fiber was also produced. Treatments were then mixed with a spatula for 60 s, followed by a 1-h rest period at 4°C, and another 60 s mix to assure adequate distribution and hydration of all components. Later, three 35 g raw meat batters were stuffed into 50 mL polypropylene tubes (Fisher Scientific, Ottawa, Ont, Canada) which were centrifuged (Model 225, Fisher Scientific) at the low-speed setting for 30 s to remove any remaining air bubbles. This was followed by cooking in a computer-controlled water-bath (W-26, Haake, Berlin, Germany) from 20°C to an internal temperature of 72°C, within 1 h. A thermocouple (Fluke Co. Inc., Model # 52 KJ1, Everett, WA) was used to monitor the internal temperature. Treatments were then immersed in an ice water bath for 5 min and refrigerated overnight.

Cooking Loss

Cooking loss (%) was determined the following day, as the weight of fluid separating from the batters (samples removed from test tubes and liquid poured out); expressed as percentage of the raw batter weight.

Texture Profile Analysis

Parameters were determined using 6 cooked core samples (cut into small cylinders of 20 mm diameter, and 10 mm high) per treatment. Cores were compressed twice to 50% of their original height by a texture analyzer (Model TA.XT2, Texture Technologies Corp., Scarsdale, NY) equipped with a 30 kg load cell, at a crosshead speed of 1.5 mm/s. The following parameters were calculated: hardness, springiness, cohesiveness, chewiness, and gumminess (Bourne, 1978).

Microstructure

Samples (20 × 20 × 5 mm) were cut from the center of cooked meat batters, and then fixed and stained with hematoxylin and eosin (Youssef and Barbut, 2009). Slides were observed using a light microscope (BX60, Olympus Optical Ltd., Tokyo, Japan). Images were captured by a computerized image analysis system (Image-Pro Plus, Version 5.1, Media Cybernetics Inc., Silver Spring, MD). Fibers' length and width were also measured by light microscopy after fibers were spread on a glass slide and 100 of each type were counted.

Statistical Analysis

The experiment was designed as a complete randomized block, with 3 separate trials. The one-way ANOVA option of the GLM procedure was performed using the SAS software package (SAS Institute Inc., Cary, NC). Tukey's multiple comparisons were used to separate the means (employing $P < 0.05$) and data are reported as means ± standard deviations.

RESULTS AND DISCUSSION

The addition of the pea, bamboo, and sugar cane fibers significantly increased the hardness of the poultry meat compared to the control treatment, while the 2 citrus and apple fibers did not change the hardness compared to the control (Table 1). The increase for the former was about 20% and was due to enhancing the meat protein gel matrix by the presence of these specific fibers. Examining the microstructure of the resulting products (Figure 1) shows the different fibers (stained in dark red with the specific PAS stain used here for carbohydrates), embedded within the meat matrix. In terms of their size, the pea fibers were the biggest (average length 0.93, and width 0.72 mm) compared to the other ones, but this alone cannot explain the difference in texture between the 2 groups of fibers (citrus and apple vs. pea, bamboo, and sugar cane). An explanation can be a better interaction of the latter group of fibers with the meat proteins. Pluschke et al. (2019) also reported that an addition of 1 to 5% sugar cane fibers significantly reduced cooking loss of a hamburger-type product. Overall, it is logical to assume that the sugar cane and bamboo fibers are harder as they are designed to support large plants and not just the peels of citrus/apple fruits. The fact that particles, as plant fibers, can enhance the stiffness of a meat/food gel matrix has been modeled and described by Gravelle et al. (2017), where inert particles (4−10 μm glass beads) were added to a lean meat batter. The addition of 0.05 volume fraction significantly raised the gel hardness by a factor of 3.

Table 1. Texture profile analysis results for lean poultry meat batters supplemented with different plant fibers.

Treatment fiber	Hardness (N)	Cohesiveness (ratio)	Springiness (cm)	Chewiness (N mm)	Gumminess	Liquid loss (%)
1. Control	34.6 ± 1.18[a]	0.35 ± 0.01[a]	0.81 ± 0.02[a]	10.29 ± 1.12[ab]	11.91 ± 0.49[a]	11.05 ± 0.25[a]
2. Citrus 100	35.48 ± 0.83[a]	0.34 ± 0.01[a]	0.75 ± 0.01[b]	9.20 ± 0.78[a]	12.53 ± 0.68[a]	9.60 ± 0.27[b]
3. Citrus AQ	34.96 ± 0.88[a]	0.36 ± 0.01[ac]	0.76 ± 0.01[b]	9.89 ± 0.41[a]	12.79 ± 0.39[ab]	10.75 ± 0.46[ac]
4. Apple	36.09 ± 0.98[a]	0.37 ± 0.01[b]	0.77 ± 0.01[bc]	11.01 ± 0.44[abc]	13.75 ± 0.70[bc]	10.20 ± 0.31[bc]
5. Pea	40.05 ± 1.19[b]	0.35 ± 0.01[a]	0.80 ± 0.01[a]	10.09 ± 0.94[ab]	14.42 ± 0.58[c]	09.64 ± 0.35[bd]
6. Bamboo	39.24 ± 1.40[b]	0.37 ± 0.01[b]	0.79 ± 0.01[ac]	11.55 ± 0.28[bc]	14.52 ± 0.48[c]	10.72 ± 0.36[ac]
7. Sugar cane	41.09 ± 1.99[b]	0.36 ± 0.01[bc]	0.80 ± 0.01[a]	12.08 ± 0.87[c]	14.83 ± 0.69[c]	10.23 ± 0.39[cd]

[a-d]Means ($n = 18$ for texture parameters; $n = 9$ for liquid loss) and standard deviations with different letters are significantly different ($P < 0.05$).

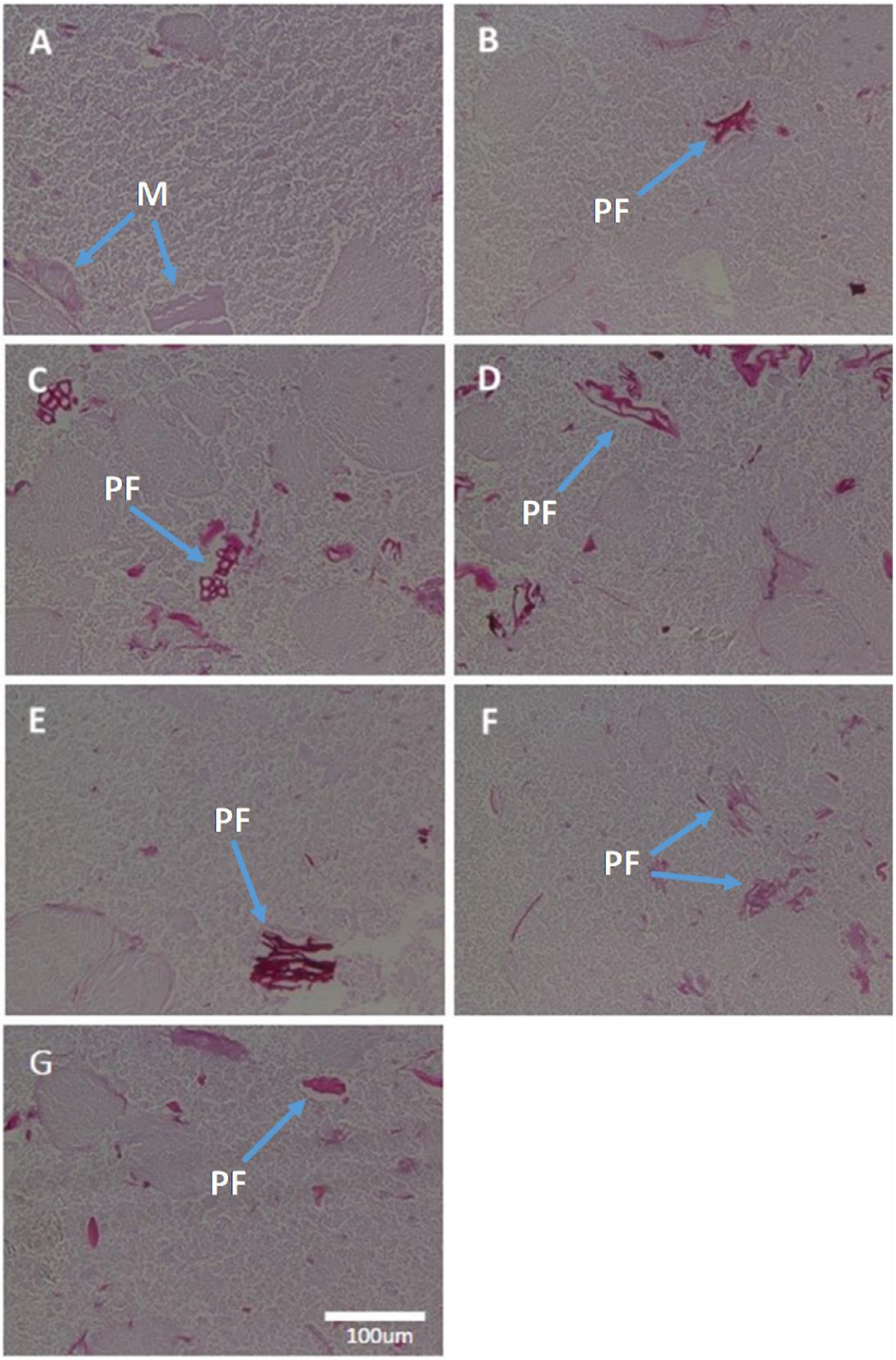

Figure 1. Micrographs of cooked lean poultry meat batters (A) control; (B) with Citri 100 fibers; (C) with Citrus AQ; (D) with Apple AQ fibers; (E) with pea fibers; (F) with bamboo fibers; (G) with sugar cane fibers. M, muscle fibers; PF, plant fiber stained with a carbohydrate stain. Bar = 100 um.

Several plant fibers are known for their water-holding capacity, and in this study 4 out of the 6 showed a significant contribution in reducing the cooking losses/improving yield (Table 1). It is interesting to note that the 2 types of citrus fibers varied in their effect, demonstrating that preparation procedure(s) and/or plant variety significantly affects the water-holding capacity when added to a meat system. This agrees with Rosell et al. (2009), who examined different plant fibers. The apple, pea, sugar cane, and citrus 100 fibers helped to significantly reduce the cooking loss compared to the control. This is an important contribution sought by the meat industry, where yield and juiciness of the final meat product are very important quality parameters.

Fiber addition also affected the springiness/recovery of the product after the first compression. This is an indication of the association between the fibers and the meat protein matrix (Gravelle et al., 2017). Overall, the 2 citrus and apple fibers significantly reduced the springiness compared to the control (Table 1). It is noteworthy to mention that these were the same 3 that did not affect the hardness compared to the control. Chewiness and gumminess values followed pretty much the hardness values, as hardness is also a major component in calculating both those terms. Cohesiveness, which is defined as the ratio of the work required for the second compression divided by the value of the first compression, shows how well a product withstand the second deformation relative to its resistance under the first one (Bourne, 1978). The values obtained (Table 1) show that the apple, bamboo, and sugar cane fiber treatments resulted in significantly higher cohesiveness values. This implies that those fibers can help increase the elasticity of the products to which they were added.

In summary, the results reveal that the ability of a specific plant fiber to improve the texture and yield of a meat product depends on its interaction with the meat protein matrix. The fibers used in this study are by-products of the food processing industry, and in many cases end up in the waste stream. Considering the recommendations for more fiber in our diet (Tungland and Meyer, 2002; Mehta et al., 2015), smart utilization of such by-products is of value to both the food industry and the individual consumer. The information generated here is of interest to the meat industry that is constantly looking for ways to enhance the texture, water-holding capacity, and nutritional value of processed meat products on the market.

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DISCLOSURES

The author has no conflict of interest related to the paper.

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