Evaluation of Citrus Fiber as a Natural Alternative to Sodium Tripolyphosphate in Alternatively-cured Pork Bologna

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Summary and Implications

Citrus fiber was tested in alternatively cured, all-pork bologna as a potential natural replacer of sodium tripolyphosphate (STPP). The STPP control, 0% STPP treatment and treatments containing various levels of citrus fiber (CF) (0.50%, 0.75%, 1.00%) all maintained acceptable quality throughout 98 days of refrigerated shelf-life. Results indicate that citrus fiber has potential to serve in a system with other binders as a natural alternative to phosphates in processed meat products, but not as a standalone single replacement source.

Introduction

The increasing consumer demand for so-called "clean" label and natural food products, devoid of ingredients that must be labeled by their chemical names, has brought into focus key meat processing ingredients such as nitrite, erythorbate, lactate and phosphate. While natural sources of the first three have been commercialized, a natural source of phosphate remains elusive. Therefore, approaches to replace phosphates have focused on non-phosphate-containing naturally-sourced ingredients that possess functional properties that mimic those of phosphates. Recently citrus fiber has gained some industry attention as one of these potential phosphate replacers. As a byproduct of the juice industry that would otherwise go unutilized, citrus fiber offers promising advantages in the creation of a phosphate-free meat product. Citrus fiber is obtained from orange (*Citrus sinensis*) pulp or juice vesicles and has a high internal surface area, water holding capacity and apparent viscosity. Pectin and cellulose have been reported to be the most predominant polysaccharides in citrus fiber. Pectin's inherent viscous properties and its predominance in citrus fiber contributes to citrus fiber's functionality. Hemicellulose, another important component of citrus fiber, has viscous properties when hydrated. The properties and structure of hemicellulose contribute to citrus fiber's water holding capacity and viscosity.

Materials and Methods

Two control and three treatment groups of all-pork bologna, formulated to a target finished fat content of 27%, were manufactured. The treatment groups consisted of a positive control (STPP) containing 0.50% sodium tripolyphosphate based on the meat block, and a negative control made with no phosphate (No STPP). The three treatment groups consisted of product made with three levels of citrus fiber (CF): 0.50%, 0.75% and 1.00%. Other ingredients contained in all experimental groups were salt (1.5%), seasonings (1.64%), celery juice powder (0.34%), cherry powder (0.31%), dried vinegar (0.25%), and water/ice (adjusted from 18.8% to 19.7% depending on level of phosphate or citrus fiber in order to keep the meat block constant). Fresh boneless pork cushions and pork back fat were obtained from a commercial packing plant, transported to the ISU Meats Laboratory, and frozen until three days prior to the day of production. On the day of production, cushions, non-meat ingredients and water/ice were added to a bowl chopper and comminuted under vacuum to 4.4°C. Pre-ground backfat was then added and vacuum comminution continued to 13°C. At this point, batter samples were collected for emulsion stability analysis. Batters were stuffed into 20.3 x 76.2 cm pre-stuck red fibrous casings and cooked to 72°C. Samples were chilled for 18 h at -1.1°C, sliced (14 g/slice), vacuum-packaged (4 slices/package) and stored at 1.1°C for the remainder of the study, either in the dark (DK) or under retail display simulation (RD) with fluorescent lights (RD samples for color evaluation only). Packaging day was designated as Day 0. Instrumental texture (texture profile analysis [TPA]), internal and external color (CIE Lab; illuminant D65, 2.54-cm aperture, 10° observer angle) and lipid oxidation (thiobarbituric acid-reactive substances) were analyzed on days 0, 14, 42, 70, and 98. Sensory evaluation by a ten-member trained panel was performed on days 14, 42, 70, and 98. The study was replicated three times and data were analyzed using the PROC MIXED procedure of the Statistical Analysis System (SASv9.4, SAS Institute, Cary, NC, USA). Differences between treatments and within treatments over time were determined using the Tukey-Kramer pairwise comparison method with significance at $P < 0.05$.

Results and Discussion

Bologna raw emulsions were more stable for the positive phosphate control than for the 0.50% and 1.0% CF treatments, but total (cook and chill) yields were unaffected by treatment (Table 1).

Color a (DK), a (RD) and L (RD) values were not significantly different ($P > 0.05$) between treatments (Table

2). However, L (RD), b (DK) and b (RD) values were significantly different ($P < 0.05$) between the negative control and the 0.50% citrus fiber treatment, with the 0.50% CF treatment samples being darker than the 0% phosphate control. The b (DK) and b (RD) values were significantly higher ($P < 0.05$) in all three CF treatments than in the positive and negative controls, indicating a slight yellowing of the bologna samples, most likely due to the yellow hue of the citrus fiber. While statistically significant, the magnitude of this difference is slight and can be considered to be of little practical importance since there were no visual sensory changes detected by the sensory panel. The hardness of the 1.00% citrus fiber treatment was significantly greater ($P < 0.05$) than for all other treatments (Table 3). According to TPA analysis (Table 3), resilience and cohesiveness for all citrus fiber treatments, and springiness for the 0.50% citrus fiber treatment were significantly less ($P < 0.05$) than in the positive control. No significant differences were observed for gumminess and chewiness. TBARS were not significantly different ($P > 0.05$) between treatments, with values never exceeding 0.2 mg malondialdehyde/kg product throughout the 98-day duration of the study, indicating citrus fiber did not promote lipid oxidation. Sensory evaluation did not detect any difference ($P < 0.05$) across treatment or day for bologna aroma, off-flavor, or color (light to dark), but did detect higher moistness and bologna flavor on day 14 ($P < 0.05$), although not for the remainder of the study.

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Table 1. Means for proximate composition (%) and treatment effect on pH, emulsion stability (%) and total (cook/chill) yield (%) of alternatively cured bologna.

	Moisture	Fat	Protein	pH	Emulsion Stability	Total Yield
STPP	56.54^{a}	26.11^{a}	12.62^{a}	6.38^{a}	99.13^{b}	95.6^{a}
No STPP	56.87^{a}	25.79^{ab}	12.55^{a}	6.19^{ab}	98.47^{ab}	94.9^{a}
0.50% CF	57.38^{a}	25.37^{ab}	12.45^{a}	5.83^{b}	96.70^{a}	95.4^{a}
0.75% CF	57.01^{a}	24.86^{ab}	12.49^{a}	6.06^{ab}	98.12^{ab}	95.7^{a}
1.00% CF	57.59^{a}	24.36^{b}	12.57^{a}	6.00^{ab}	96.53^{a}	95.6^{a}
SEM	0.32	0.38	0.08	0.10	0.43	<0.1

$^{a\text{-}c}$ Different superscripts within columns indicate significant differences ($P < 0.05$)

Table 2. Means for effect of treatment (across all days) on CIE color values of alternatively-cured bologna stored under retail display lights or in the dark.

	Dark			Retail Display		
	L	a	b	L	a	b
STPP	72.14^{ab}	7.16^{a}	13.45^{c}	73.03^{a}	7.29^{a}	13.30^{b}
No STPP	72.63^{a}	6.99^{a}	13.40^{c}	73.72^{a}	7.19^{a}	13.36^{b}
0.50% CF	71.69^{b}	7.09^{a}	13.69^{b}	72.83^{a}	7.34^{a}	13.81^{a}
0.75% CF	72.21^{ab}	6.95^{a}	13.75^{ab}	73.11^{a}	7.22^{a}	13.84^{a}
1.00% CF	71.83^{ab}	7.02^{a}	13.90^{a}	72.93^{a}	7.03^{a}	14.13^{a}
SEM	0.22	0.06	0.04	0.29	0.09	0.09

$^{a\text{-}c}$ Different superscripts within columns indicate significant differences ($P < 0.05$)

Table 3. Means for effect of treatment on TPA parameters of alternatively-cured bologna.

Lipid type	Hardness (g)	Resilience (%)	Cohesiveness (%)	Chewiness	Springiness (%)
PF	4182^{b}	38.91^{a}	0.72^{a}	2639^{b}	86.66^{a}
SBO	4234^{b}	35.20^{ab}	0.65^{ab}	2380^{a}	84.99^{ab}
2.5 RBW	4780^{ab}	33.47^{b}	0.62^{b}	2472^{ab}	83.98^{b}
10 RBW	4520^{ab}	34.06^{b}	0.67^{ab}	2581^{a}	85.17^{ab}
RBW/LS	5336^{a}	34.27^{b}	0.64^{b}	2928^{a}	84.67^{ab}
SEM	224	1.02	0.27	109	0.17

$^{a\text{-}c}$ Different superscripts within columns indicate significant differences ($P < 0.05$)