Effects of bacterial cellulose (nata) on the quality of frankfurter

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Abstract—**The quality characteristics of regular frankfurter (27-28% fat) containing bacterial cellulose (nata) were demonstrated. Frankfurters with the addition of 10, 20, and 30% nata were processed, vacuum packaged, and stored for 12 weeks. Quality attributes and physicochemical properties of frankfurters were determined. Raw meat batter of C28 (control with 28% fat) was found to be highest in emulsion stability among all treatments, while N10 (10% nata) had the highest water-holding capacity. In addition, N30 (30% nata) was less susceptible to lipid oxidation expressed by lower thiobarbituric acid-reactive substances (TBARS) value. The ratios of total unsaturated fatty acids to saturated fatty acid were similar for all treatments indicating no apparent effect on fatty acid profiles by the inclusion of nata at varying levels. Results showed decreases in textural hardness and shear force values of nata-added frankfurters with increasing nata levels. In contrast, N30 was the lowest in both hardness and shear values. Juiciness and overall acceptability scores were not different for all treatments, among them C28 and N30 had higher numerical values. Total plate counts of all treatments increased with increasing storage time. In conclusion, incorporation of nata at current levels did not result in significantly adverse effects on regular frankfurters regarding physicochemical, textural, sensory and microbiological properties. Lower levels (10-20%) of nata had reverse effects on textural and sensory traits of frankfurter. Nonetheless, addition of elevated level (30%) of nata produced similar sensory characteristics to control frankfurter. Therefore, manufacture of frankfurter with high-fiber nata appears to be feasible.**

Keywords— **nata, frankfurter, water-holding capacity**

I. INTRODUCTION

Bacterial cellulose (BC), so-called nata, is a product prepared by fermentation of cellulose by Acetobacter xylinum and has a diameter of less than 100 μm making it the most thinnest natural fibre [1,2]. Nata is a ribbon-shaped fibre and composed of glucose units linked by β 1,4 glycosidic bonds. The structure of bacterial cellulose is similar to cellulose and is regarded as an insoluble, noncaloric dietary fibre [1,2,3].

Bacterial cellulose has been reported to display great water-holding capacity capable of absorbing more than 100 times as much water (dry weight) [4]. Bacterial cellulose showed possible application to versatile processed foods through its unique suspending, thickening, water-holding, stabilizing, bulking, and fluid properties [5]. Okiyama et al. [6] found reducing food retention in intestine and increasing bile acid secretion in feces in rats fed with bacterial cellulose. Lowered plasma total cholesterol and triacylglycerol in rats fed with 5% nata in animal feeds also has been reported [7]. Currently, bacterial cellulose is listed as a GRAS (generally regarded as safe) [8]. The objective of this study was to elucidate the quality attributes of frankfurter with the incorporation of so-called functional ingredient bacterial cellulose (nata).

II. MATERIALS AND METHODS

Nata (approximately 1 x 1 x 1 cm cube; purchased from Chia-Meei Food Industrial Corp., Taichung County, Taiwan, ROC.) was originally soaked in acetic acid solution and stored under refrigeration. The total soaking time from manufacture to end-use was approximately 6 months (provided by the manufacturer). Nata was washed off with distilled water until pH 7.0 and drained off excess water for 30 min prior to use.

A. Frankfurter manufacture

Fresh, chilled (~1 °C), vacuum-packaged deboned pork ham meat and frozen pork back fat were purchased from local meat suppliers. Lean tissue was trimmed off heavy connective tissue and then ground through a 0.95-cm plate. Pork back fat was partially thawed in a cooler prior to grinding through a similar plate. Samples of lean and fat were analyzed for percent fat and moisture [9]. Frankfurter formulation was listed in Table 1. Frankfurter manufacture was followed by the procedure of Lin and Huang [10]

B. Analytical methods

Raw meat batters from different treatments were sampled for the determination of emulsion stability. Packages of frankfurter were randomly selected at each storage period for analyses including proximate composition, CIE L*a*b* colour, water-holding capacity (WHC), thiobarbituric acid-reactive substances, TBARS, textural properties, sensory evaluation, and total plate counts.

Table 1. Formulation of nata-containing frankfurter sausage

	Treatment*			
	C28	N10	N20	N30
Ingredients	%Total weight**			
Pork ham	76.4	78.9	76.4	73.8
Pork backfat	23.6	21.1	23.6	26.2
NaCl	1.8	1.8	1.8	1.8
Sugar	1.8	1.8	1.8	1.8
Erythorbate	0.055	0.055	0.055	0.055
$NaNO_2$	0.0156	0.0156	0.0156	0.0156
STPP	0.25	0.25	0.25	0.25
Ice/H_2O	20	0	0	0
Spice mix	0.8	0.8	0.8	0.8
Na caseinate	1.5	1.5	1.5	1.5
Liquid smoke	0.7	0.7	0.7	0.7
White pepper	0.25	0.25	0.25	0.25
Nata	0	10	20	30

* C28= control at 28 % fat; N10 ~ N30= frankfurter sausages containing 10 to 30 % nata, respectively.
** On total meat weight basis.

III. RESULTS AND DISCUSSION

Addition of nata adversely affected the WHC of cooked frankfurter. Highest WHC was found for N10 frankfurter, followed by N20 and N30, and control being the lowest.

Table 2. Differences in WHC of frankfurter before and after cooking

		C28*	N10	N20	N30
WHC (%)	Uncooked	60.01 [a]	58.62 [a]	64.02 [a]	54.21 [a]
	Cooked	57.32 [c]	67.37 [a]	62.95 [b]	57.83 [c]

* C28 = control at 28% fat; N10 − N30 = 28% fat containing 10, 20, and 30% nata, respectively.
[a-c] Means within the same row having unlike letters differ ($p<0.05$).

Frankfurter containing 30% nata (N30) was the lowest in firmness and color scores (Table 3). Although no statistical significance, N30 was high in juiciness and overall acceptability. Increasing the amount of added nata to frankfurters resulted in increasing reduction in color and firmness scores.

Table 3. Sensory evaluation of frankfurter sausages

Treatment**	Color	Firmness	Juiciness	Overall acceptability
C28	5.6 [a]	5.7 [b]	4.9 [a]	5.8 [a]
N10	5.6 [a]	6.7 [a]	4.5 [a]	5.3 [a]
N20	5.3 [a]	6.4 [a]	4.5 [a]	5.3 [a]
N30	4.1 [b]	4.5 [c]	5.1 [a]	5.8 [a]

* On a 9-point hedonic scale. 1 = the least, 9 = the most.
** C28 = control at 28% fat; N10 − N30 = 28% fat containing 10, 20, and 30% nata, respectively.
[a-c] Means within the same column having unlike letters differ ($p<0.05$).

Emulsion stability was expressed by total expressible fluid percentage (TEF%). High TEF refers to low emulsion stability. The TEF% showed increasing tendency in nata-added treatments indicating less stable emulsion (Fig. 1). However, N10 also showed higher percentage released fat (Fat%) in the expressed fluid. On the other hand, no significant difference in TEF% was noted for control and N10 and N20.

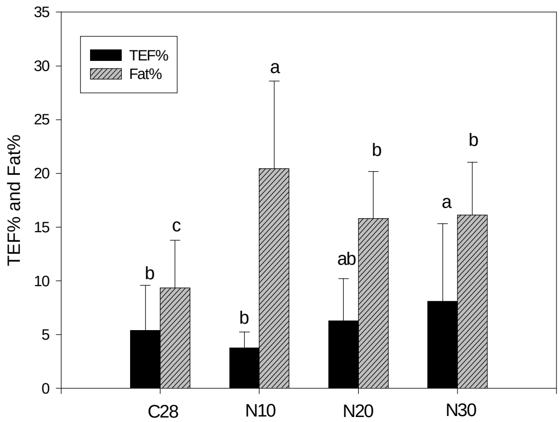

Fig. 1. Changes in emulsion stability TEF% and Fat% of raw frankfurter batter.

[a-c] Means (±standard deviation) within treatments for the same test item having unlike letters differ ($p<0.05$).

Table 4 shows the shear force value of treatments with added nata comparing to regular frankfurter control. N10 (10% nata) had the highest ($p<0.05$) shear value among all treatments at each sampling period. Shear value of nata-added treatments was decreasing with increasing amount of nata. The trends of shear values among treatments at each sampling period were in agreement with those of texture profile analysis (data not shown).

Table 4. Changes in shear value** of frankfurter during refrigerated storage at 4℃

	Storage time (week)				
Treatment*	0	3	6	9	12
C28	3.38^{bAB}	3.29^{bB}	3.44^{aA}	3.45^{aA}	3.41^{bAB}
N10	3.65^{aBC}	3.72^{aB}	3.54^{aC}	3.58^{aBC}	3.90^{aA}
N20	3.23^{cA}	3.02^{cB}	3.37^{aA}	3.29^{bA}	3.41^{bA}
N30	2.77^{dCD}	2.63^{dD}	2.92^{bAB}	2.85^{cBC}	3.01^{cA}

* C28 = control at 28% fat; N10－N30 = 28% fat containing 10, 20, and 30% nata, respectively.

** Expressed in kg.

[a-d] Means within the same column having unlike letters differ ($p<0.05$).

[A-D] Means (±standard deviation) within the same row having unlike letters differ ($p<0.05$).

IV. CONCLUSIONS

Incorporation of nata at current levels did not result in significantly adverse effects on regular frankfurters regarding physicochemical, textural, sensory and microbiological properties. Lower levels (10-20%) of nata had negative impact on textural and sensory traits of frankfurter. Nonetheless, addition of elevated level (30%) of nata produced similar sensory characteristics to control frankfurter. Therefore, manufacture of frankfurter with high-fibre nata appears to be feasible.

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