Application of Legume Flours in Low-fat Meat Product Formulations for Better Consumer Acceptance

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Abstract—**Research activities focused on the evaluation of consumer preference of legume flours as a meat binder in low-fat (<10% fat) pork bologna. Legume flours (5% w/w), including chickpea, lentil and pea, were incorporated into commercial scale batches, and compared to a non-flour control and one with wheat flour. One hundred and sixty consumers, selected to match the demographics of the adult Canadian population, evaluated samples of the five bolognas using a series of intensity and hedonic scales. Although wheat flour gave the best physicochemical properties, bologna with chickpea and lentil flours were more highly acceptable to panellists. In contrast, pea flour was found the least acceptable among the flour binders mainly due to its undesirable flavour noted in the bologna. Consequently, this work demonstrates a potential application of legume flours in low-fat meat products to achieve positive consumer acceptance.**

Keywords— **Legume flour, Low-fat bologna, Sensory.**

I. INTRODUCTION

In the meat processing industry, the substitution of meat with non-meat ingredients is considered an important strategy for reducing overall production costs [1]. Most countries regulate the upper limits of non-meat protein ingredients in final meat products. In Canada, regulations require a minimal of 9.5% meat protein and at least 11% total protein in cooked sausage, thus adding non-meat protein-rich ingredients is desirable. Nowadays, processors are beginning to re-formulate their products to address consumer health concerns over consuming high-fat meat products in addition to associated economic benefits.

Legume flours/proteins make an attractive alternative to wheat flour as a meat binder (commercial standard), for replacement of a portion of the proteins in low-fat meat products. Legume flours are consumed around the world as a nutritious protein source, whose consumption has been shown to reduce low density lipoprotein (LDL)-cholesterol and the risk of acquiring type-2 diabetes [2].

In adopting new ingredients in food products, consumer acceptance is critical, where showing a strong link between the sensory attributes and physicochemical properties is of upmost importance. In this study, this relationship is explored for commercial scale low-fat pork bologna containing legume flours (chickpea, lentil and pea) as meat binders. Products were then compared to those prepared with wheat flour and without binders.

II. MATERIALS AND METHODS

A. Bologna Preparation

Fresh skinless and boneless pork shoulder and pork back fat were trimmed to remove connective tissues, and then ground through a 3 mm plate, separately. The required quantities of ground pork and back fat (62.75%, lean to fat ratio of 85/15), flours (5%, water in case of control), spices and other additives (2.83%), ice/water (29.42%) were formulated. Meat protein and total fat content were adjusted to a constant level of 11% and 10% in the final product, respectively. Ground meat and back fat were mixed with 1.25% salt, 0.28% cure salt (salt with 6.4% sodium nitrite), 0.5% seasoning, 0.2% sodium tripolyphosphate, 0.1% sodium erythorbate, and half of the ice water in a 30 L bowl silent cutter (Seydelmann, Stuttgart, Germany) and chopped for 2 min. With the addition of other dry ingredients (0.5% dextrose and 5% flours) and the remaining ice/water, the mixture was chopped at high speed under vacuum (-0.8 bar) for another 3 min. The batter was passed through an emulsion mill (Stephan, MC15, Hameln, Germany) with 0.5 mm cutting slit.

The final temperature of the batter was controlled at ~8°C. The total amount of each batch was 20 kg. The mixture was then vacuum stuffed (Handtmann, Model VF80, Waterloo, ON, Canada) into fibrous casings (105 mm diameter) at full vacuum pressure (filling pressure 35 bar). The bologna products were then thermally processed in a smokehouse (Maurer & Söhne, Insel Reichenau, Germany) to a final core temperature of 73°C. The product was then cooled in running water until the core temperature reached 45°C, and then stored at 1°C overnight. The production of the five bologna batches was repeated on a different day.

B. Proximate Composition

Moisture, fat and ash were determined according to AOAC [3]. Crude protein was measured by Kjeldahl method by multiplying total nitrogen of 6.25 and 5.7 for legumes and wheat flour, respectively [3].

C. Instrumental Evaluation

Physicochemical properties: The physicochemical properties of bologna were determined as described by Shand [4]. In brief, cooking yield and expressible moisture were estimated for water binding properties. Texture profile analysis (TPA) was conducted by compressing samples 50% of initial height for 2 cycles.

Torsional gelometry: Bologna sliced 28 mm thick was used for torsion testing. Eight cores (19 mm in diameter) were removed from each slice using a cork borer. The plastic styrene discs were glued on both ends of cores, and the cores were ground into 1 cm dumb-bells using a bench grinder (731VS9021, Bodine Electric Co., Chicago, IL, USA). The dumb-bells were tempered for 1 h at ambient and twisted at 2.5 rpm using a viscometer (5xHBDV-I+, Brookfield Engineering Labs Inc., Stoughton, MA, USA). Shear stress and strain at failure were measured.

D. Consumer Sensory Testing

Sensory evaluation was conducted at the Consumer Product Testing Centre (Edmonton, AB, Canada). The protocol had received approval from the University Research Ethics Board. For the consumer panel test, adult Canadian populations (n=160) consisted of 53% male and 47% female were selected as shown in **Fig. 1**. Sensory properties were evaluated using a series of intensity and hedonic scales (6 point). For intensity of flavour, juiciness, and texture, 1 represented weak, very dry, very soft, and 6 represented very intense, very juicy, very firm, respectively. Consumer acceptance categories ranged from extremely dislike (1) to extremely like (6).

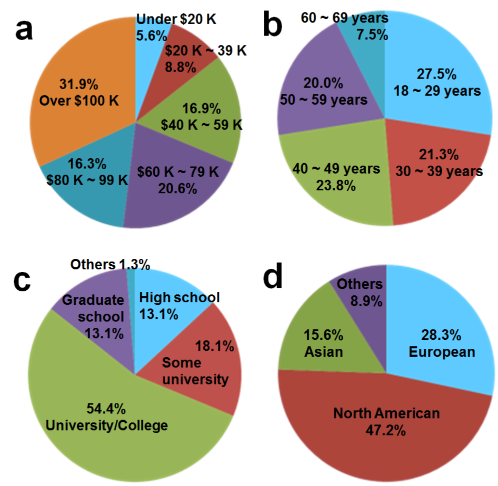

Fig. 1 Panel demographics by (a) income, (b) age, (c) education and (d) ethnic background.

E. Statistical Analysis

A completely randomized design was adopted to analyse this work. Data was analysed by the general linear model procedure using SAS (ver. 9.2). Analysis of variance (ANOVA) was performed and the means were separated by Duncan's multiple range test if the main effect was significant ($p<0.05$).

III. RESULTS AND DISCUSSION

A. Proximate Composition of Flours

The pulse flours (chickpea, lentil and pea) showed 2-fold higher protein content than that of wheat (**Table 1**). The wheat flour had relatively high carbohydrate (starch) content compared to pulses. The proximate compositions of flours were generally in agreement with other literature [5].

Table 1 Proximate composition of flours

	Chickpea	Lentil	Pea	Wheat
Moisture (%)	10.3	8.6	8.2	10.3
Protein (%)	20.4	22.4	19.9	11.9
Fat (%)	6.2	1.5	1.8	1.2
Carbohydrate (%)	60.2	65.0	67.5	75.4
Ash (%)	3.0	2.5	2.6	1.2

B. Instrumental Evaluation

The cooking yields of bologna were not different among treatments and ranged from 94-96% (**Fig. 2**). Expressible moisture (EM) of bologna differed significantly among treatments ($p<0.05$). Control bologna had the highest EM (13%) and bologna with wheat flour the lowest (7%). Although bologna contained lentil and pea showed significantly different expressible moistures ($p<0.05$), the overall EM of the bologna made with legumes was about 10%.

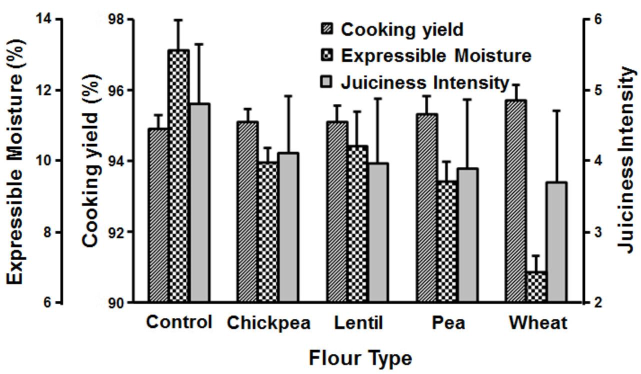

Fig. 2 Effects of various flours on the water-binding properties of low-fat pork bologna. Sensory juiciness (6 pt scale) was compared to analytical determinations.

EM results were in agreement with the consumer panel juiciness intensity scores. The juiciness intensity was significantly higher for the control bologna and lowest for the wheat treatment ($p<0.05$). Although the chickpea treatment was significantly juicier than pea treatment ($p<0.05$), all legume flour bologna treatments showed an intermediate juiciness between the control and wheat treatment.

For texture profiles (**Fig. 3**), the hardness of bologna contained pulse flours was higher than 83.2 N comparing to 61.1 N for the control bologna while the difference was not significant because of high standard deviation between the bologna replications. In addition, no significant difference in cohesiveness nor in springiness was found among bologna made with or without flours.

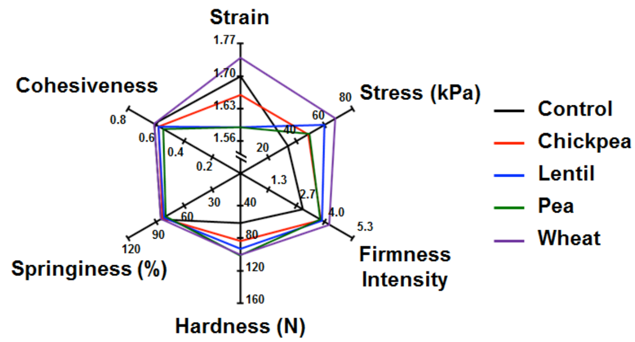

Fig. 3 Effects of various flours on the textural properties of low-fat pork bologna. Sensory firmness was compared to analytical determinations.

The rheological properties of bologna showed different features according to types of flours. The addition of wheat flour increased the shear strain of bologna, while that of bologna with any of the legume flours decreased significantly compared to the control ($p<0.05$). All flours tended to increase the shear stress of bologna, in particular, the stress was significantly higher for bologna made with wheat and lentil flours than the control ($p<0.05$). According to graphical comparison of fracture properties of bologna [6], the addition of wheat flour made the bologna more tough while those made with the legume flours became more brittle.

C. Consumer Panel Results

The chickpea and lentil treatments were highly acceptable for all parameters evaluated compared to the control, followed by the wheat treatment (**Fig. 4**). Despite wide application and high functionality of wheat flour in processed meat formulations, high water-binding properties of wheat treatment appeared to result in drier mouth-feel to panellists compared to legume treatments. Although bologna with wheat flour had instrumental indicators for a tougher texture, consumers scored this treatment better in firmness, texture and overall acceptability than the control. However, wheat flour bologna had less preferred texture than the ones with legume flours. The bologna with pea had the same consumer acceptance level as the control. Pea flour addition (5% w/w) must have generated the characteristic "pea" notes contributing to the low aroma and flavour scores.

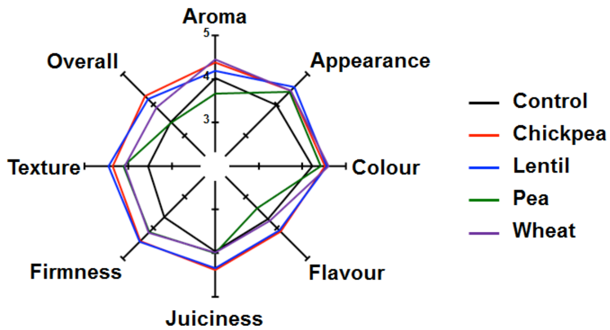

Fig. 4 Sensory preference (degree of liking) of low-fat pork bologna (n=160 panellists).

According to the consumer survey (**Table 2**), price was not the most important factor when selecting meat products and 87% of consumers considered nutritional aspects rather than price. Although most consumers were concerned about fat content in meat products (78%), purchase decision appeared to be strongly affected by flavour.

Table 2 Consumer perception survey

	← Disagree					Agree →
Survey question[a]	1	2	3	4	5	6
Price	7.5	23.1	18.1	25.0	14.4	11.9
Low-fat version	4.4	11.3	15.6	20.0	27.5	21.3
I will opt low-fat	20.6	26.3	19.4	17.5	12.5	3.8
Pork nutritious	1.9	3.1	11.3	18.8	33.1	31.9
Pulse nutritious	0.6	1.3	7.5	9.4	26.3	55.0

[a]Actual questionnaire items: Price is the most important factor I consider when I buy meat products; I prefer to buy the lower-fat version of a food product if it is available; I will opt for the lower-fat version of a food product, even at the expense of lower flavour quality; I believe that pork is a good source of nutrition; I believe that pulses are a good source of nutrition.

Considering that 81% of consumers perceived legumes (pulses) as a good source of nutrition compared to 65% regarding the meat source (**Table 2**), application of legumes in meat products may influence consumer acceptance. A survey looking at the "halo" effect of a nutritious ingredient such as a legume flour on overall acceptability of meat products would help answer this question.

IV. CONCLUSIONS

The bologna containing wheat flours showed better water-binding and rheological properties than those made with legume flours. However, the strong water-binding and tough textural properties of bologna made with wheat flour were less acceptable to a consumer panel comparing to bologna made with lentil or chickpea flours. In addition, flavour of these flours in the bologna was strongly correlated to overall acceptance. Considering the positive consumer perception that legumes are a good source of nutrition, chickpea and lentil have potential to be desirable plant ingredients in low-fat meat production.

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