# PROPERTIES OF LOW-FAT PORK BOLOGNA WITH ADDED CHICKPEA PROTEIN ISOLATE OR STARCH

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*Abstract*— **Developing ingredients for food processors is vital to bring health beneficial properties of pulses to actual foods and also to increase the use of pulses in regular foods. Similar to any carbohydrate and protein-rich seed, chickpea provides these valuable biopolymers that can deliver various technological functions besides nutritive value. Low-fat pork bologna (<5% fat) were prepared incorporating 1.5% or 3.0% protein isolates and 1.0% or 2.0% starches from Kabuli or Desi chickpea. Controls were prepared without any binder, and formulations with pea or soy protein isolates and pea or native potato starch, respectively, were used as comparisons. Use of chickpea protein isolate (up to 3.0%) and chickpea starch (up to 2%) in bologna did not alter taste properties, but were able to increase cook yield and increase or maintain textural properties. Hence, chickpea could be a successful source for plant protein and starch in emulsified meat products due to the superior technological functions and bland flavour.**

*Index Terms*—**chickpea starch, chickpea protein isolates, low-fat pork bologna.**

## I. INTRODUCTION

Chickpea, the world's third largest pulse crop based on the area grown is widely produced in the provinces of Saskatchewan and Alberta and the leading chickpea exporting countries are India, Australia, Mexico and Canada (FAO, 2007). Chickpea (*Cicer arietinum* L.) is a legume that contains a high level of two main biopolymers; protein and starch in their seeds. Uses of this valuable crop in the human food stream are limited to canned products and salads, especially among Western diet. Therefore a search for new tailored applications of chickpea is necessary. Chickpeas are generally grouped into two phenotypes: Kabuli and Desi. Kabuli chickpeas, also known as garbanzo beans, have a large, cream-coloured seed with a thin seed coat. The Desi phenotype has a small, dark-coloured seed with a thick seed coat.

Plant-derived materials such as flour, protein and starch from wheat, soybeans and potato, respectively, have been used in traditional comminuted meat products (30% fat) as binders, extenders or fillers (Shand, 2000). In our first study, incorporation of chickpea flour in a low-fat pork bologna (LFPB) system was very successful at both 2.5 and 5.0% addition levels (Sanjeewa, Wanasundara, Pietrasik & Shand, 2010). Then we hypothesized that the desirable functionalities in LFPB was due to the protein and starch components of the chickpea flour. Therefore, in order to understand how chickpea fractions behave in a meat system, low-fat (<5%) pork bologna was formulated using different levels of chickpea protein and starch prepared from Kabuli and Desi chickpeas and the instrumental and sensory properties of the resulting products were characterized.

## II. MATERIALS AND METHODS

*Ingredients:* After preliminary physicochemical characterization of six chickpea varieties (Sanjeewa, 2008), the protein isolate and starch fraction from one Desi (*var.* Myles, 70.1% protein) and one Kabuli (*var.* CDC Xena, 74.5% protein) variety were selected for this study. These were prepared as described by Sanjeewa (2008). Commercial pea protein isolate (PPI, Propulse, Nutri-Pea, Portage la Prairie, Canada, 77.7% protein), soy protein isolate (SPI, Supro, Newly Weds Foods, Edmonton, Canada, 86.3% protein), pea starch (Starbrite pea starch, Parrheim Foods, Saskatoon, Canada) and native potato starch (Penford Food Ingredients, Englewood, U.S.A.) were obtained for comparison. For each of three replications per study, fresh (1 to 2 d postmortem) pork buckeye mainly consisting of sirloin (*gluteus medius*) and loin muscle (*longissimus*) were obtained from a local slaughter plant.

*Meat application:* Low-fat pork bologna (LFPB, <5% fat) was prepared by incorporating, 1.0 or 2.0% starch or 1.5 or 3.0% protein isolate (protein basis), in the formulation on a weight basis. Controls (labeled as control in the starch-LFPB study and control-I in the protein-LFPB study) were prepared without any binder and formulations containing potato or pea starch, or soy or pea protein isolate were prepared for comparison. The meat level for all studies was held at 62.6% except for control-II in the protein-LFPB study where it was at 79.5%. The control formulation consisted of 62.6% pork, 34.8% ice water, 1.5% NaCl, 0.30% cure salt (containing 6.4% w/w sodium nitrite), 0.5% dextrose, 0.1% sodium erythrobate and 0.25% seasoning on weight basis.

For the formulations of LFPB/starch, water was substituted (1:1) with 1.0% and 2.0% starch (Kabuli, Desi, pea or potato). In the case of study of LFPB/protein, recipes were standardized on the basis of protein. The total crude protein content of the product was adjusted to 12.6% for the formulations with 1.5% protein level and 14.1% for the formulations with 3.0% protein level. Control I and Control II had a total meat protein level of 11.1 and 14.1%, respectively. Cooked LFPB were evaluated for their textural and sensory attributes as described in Sanjeewa et al. (2010). Three complete replications of each experiment were run, with data then subjected to analysis of variance.

## III. RESULTS AND DISCUSSION

### Colour, cook yield, expressible moisture and purge losses

The cook yield reflects retention of water of the meat matrix during the cooking process. In protein-LFPB, control-I (78.5% moisture content) had lower (P<0.05) cooking yield than all other formulations except bologna with 1.5% Kabuli CPI and 3.0% PPI (Table1). Cook yield of the control-II were similar to LFPB having 3.0% CPI whereas it was significantly (P<0.05) higher than the low fat bologna with 1.5% and 3.0% of SPI and PPI. Cook yields of LFPB were significantly improved (P<0.05) by the addition of the different starches (Table 2) with exception of 1.0% pea starch treatment. Bologna with Kabuli starch and potato starch at 2.0% showed the highest cook yield of 95.5 and 95.9% respectively. Pea and Desi starch at 2.0% were less effective and equivalent to the potato and Kabuli starch used at the 1% level. Shand (2000) reported that cook yield with addition of potato starch in low-fat bologna did not significantly differ from the control.

**Table 1** Effect of different protein binders on cook yield, expressible moisture (EM) and textural properties of cooked bologna

| Treatment | | | Cook yield (%) | EM (%) | Texture Profile Analysis | | |
|---|---|---|---|---|---|---|---|
| Binder | | Level (%) | | | Hardness (N) | Springiness (%) | Chewiness (Nmm) |
| Control | I | 0 | 94.2 $^{f}$ | 17.6 $^{a}$ | 86.7 $^{e}$ | 82.1 | 355.1 $^{e}$ |
| | II | 0 | 96.9 $^{a}$ | 9.4 $^{f}$ | 191.1 $^{a}$ | 82.5 | 920.3 $^{a}$ |
| K-CPI | | 1.5 | 94.6 $^{ef}$ | 14.5 $^{b}$ | 83.2 $^{e}$ | 80.4 | 434.7 $^{d}$ |
| | | 3.0 | 96.5 $^{ab}$ | 11.6 $^{e}$ | 119.7 $^{cb}$ | 79.5 | 451.3 $^{d}$ |
| D-CPI | | 1.5 | 96.1 $^{abc}$ | 13.1 $^{cd}$ | 106.7 $^{d}$ | 80.7 | 453.9 $^{d}$ |
| | | 3.0 | 96.7 $^{ab}$ | 10.2 $^{f}$ | 117.7 $^{c}$ | 80.6 | 463.2 $^{d}$ |
| SPI | | 1.5 | 95.8 $^{bcd}$ | 14.3 $^{bc}$ | 88.2 $^{e}$ | 81.5 | 536.2 $^{c}$ |
| | | 3.0 | 95.2 $^{cde}$ | 13.4 $^{bcd}$ | 127.5 $^{b}$ | 81.4 | 643.2 $^{b}$ |
| PPI | | 1.5 | 95.1 $^{cb}$ | 12.9 $^{d}$ | 91.9 $^{e}$ | 81.4 | 327.4 $^{e}$ |
| | | 3.0 | 95.1 $^{edf}$ | 12.6 $^{de}$ | 102.7 $^{d}$ | 81.0 | 440.7 $^{d}$ |

$^{a-h}$ Means within the same column with the same letter are not significantly different (P > 0.05). Binders: K/D-CPI-Kabuli/Desi chickpea protein isolate, SPI-soy protein isolates, PPI- pea protein isolates. Control I and Control II had a total meat protein level of 11.1 and 14.1%, respectively.

**Table 2** Effect of different starch binders on cook yield, expressible moisture (EM) and textural properties of cooked bologna

| Treatment | | Cook yield (%) | EM (%) | Texture Profile Analysis | | |
|---|---|---|---|---|---|---|
| Binder | Level (%) | | | Hardness (N) | Springiness (%) | Chewiness (Nmm) |
| Control | 0 | 91.63 $^{c}$ | 19.31$^{a}$ | 95.4 $^{e}$ | 75.5 $^{d}$ | 441.4 $^{e}$ |
| Kabuli | 1.0 | 94.35 $^{b}$ | 14.70 $^{d}$ | 121.9 $^{ab}$ | 82.4 $^{ab}$ | 539.7 $^{bcd}$ |
| | 2.0 | 95.51 $^{a}$ | 12.32 $^{f}$ | 131.1 $^{a}$ | 81.4 $^{ab}$ | 605.7 $^{ab}$ |
| Desi | 1.0 | 93.80 $^{b}$ | 15.61 $^{c}$ | 112.0 $^{bcd}$ | 83.5 $^{a}$ | 570.4 $^{abc}$ |
| | 2.0 | 94.45 $^{b}$ | 12.75 $^{ef}$ | 123.4 $^{ab}$ | 80.5 $^{bc}$ | 642.5 $^{a}$ |
| Potato | 1.0 | 93.95 $^{b}$ | 17.05 $^{b}$ | 106.0 $^{cde}$ | 80.9 $^{ab}$ | 481.3 $^{de}$ |
| | 2.0 | 95.85 $^{a}$ | 16.53 $^{b}$ | 113.8 $^{bc}$ | 78.0 $^{cd}$ | 465.2 $^{de}$ |
| Pea | 1.0 | 92.17 $^{c}$ | 16.41 $^{e}$ | 100.2 $^{de}$ | 81.7 $^{ab}$ | 413.1 $^{e}$ |
| | 2.0 | 94.15 $^{b}$ | 14.74 $^{ef}$ | 110.9 $^{bcd}$ | 80.6 $^{bc}$ | 494.8 $^{cde}$ |

$^{a-h}$ Means within the same column with the same letter are not significantly different (P > 0.05).

Expressible moisture (EM) of LFPB was significantly affected by incorporated protein additives (Table 1). Control-I (11.1% total protein), with highest water content and no binders in its formulation, had the highest EM value (17.6%). The lowest values for EM was observed for control-II and bologna with 3.0% Desi CPI indicating that Desi protein was equivalent to extra meat (muscle proteins) in retention of water. Treatments with 3.0% CPI protein showed a decrease in EM (P<0.05) when compared with 1.5% CPI. Nevertheless, no differences (P>0.05) in EM were found among treatments containing either level of added SPI or PPI; however 1.5% PPI had lower EM values than that of the 1.5% SPI. However, in contrast, Shand (2000) observed that EM of ultra low-fat bologna (>1% fat) with 1.0% soy protein concentrate did not significantly (P>0.05) differ from the control.

LFPB with all starches tested had significantly (P<0.05) lower EM losses than the control (Table 2). EM values of LFPB containing 2.0% chickpea starch level were lower than their 1.0% counterparts indicating better water retention with increasing starch level. Further, bologna produced with both chickpea starches had lower EM values than that with commercial potato starch. A similar relationship was also found for purge losses (data not shown). The decrease in EM and purge was probably due to starch gelatinization during the cooking process. Chickpea starch gelatinizes at 64 °C (Sanjeewa et al., 2010).

**Texture profile analysis, torsion analysis and sensory properties**

Addition of protein isolates in LFPB significantly changed the TPA properties (Table 1). Control-II with the most meat protein (14.1% MP) had the highest (P<0.05) hardness and chewiness. These values were more than twice the values that obtained for the control-I containing 11.1% MP. This clearly indicates that addition of more meat had played a vital role in the structure development of the LFPB. None of the tested proteins was able to yield textural properties equivalent to the control II containing 14.1% muscle proteins. Addition of SPI at 3.0% was the most effective of the non-meat proteins and resulted in the second firmest (TPA-hardness) structure among the treatments. TPA-hardness scores for bologna with 1.5% Kabuli CPI, SPI and PPI were same as the control-I whereas bologna with 3.0% Kabuli/Desi CPI, SPI, PPI and 1.5% Desi CPI showed higher values for hardness than that of the control-I. In general, hardness value of bologna with 3.0% protein additives were significantly (P<0.05) higher than with 1.5% of their counterpart. Springiness was not affected (P>0.05) by the type of proteins or even meat protein level. The protein added bologna samples had significantly (P<0.05) higher chewiness scores than that of the control-I except samples containing 1.5% PPI. LFPB samples with SPI seem to be chewier than the LFPB samples with CPI and PPI.

TPA hardness showed significant differences (P<0.05) among starch-LFPB formulations (Table 2). The lowest values for hardness were obtained for the control but these did not significantly differ from the 1.0% potato and pea starch containing samples. The highest TPA hardness values were obtained for the bologna samples with Kabuli starch (at both levels) and 2.0% Desi starch. Bologna with chickpea starch had better texture (hardness) when compared to samples with potato or pea starch. TPA chewiness of the control did not differ from bologna with pea or potato starch at both formulation levels although chickpea starches at 1.0 or 2.0% addition levels showed significantly (P<0.05) higher values than the other treatments.

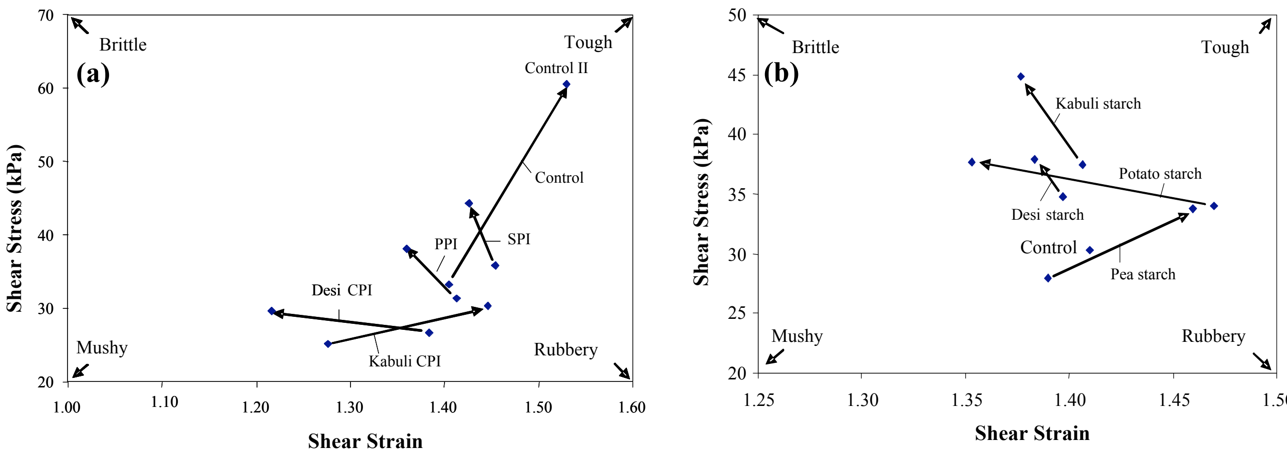


**Figure 1.** Torsion texture map of low-fat bologna containing different (a) protein isolates (b) starches. Arrows point from the low-addition to the corresponding higher addition of substitute plant protein and starch levels.

A texture map, which is a plot of shear stress vs shear strain, provides a graphical representation of product texture (Fig. 2). Due to high meat in the formulation, control-II (14.1% P) gave the "toughest" product (Fig 1a). The second highest shear stress values were obtained for samples containing 3.0% SPI. Except for that formulation, other LFPB containing legume proteins did not significantly differ from the control-I. True shear strain at failure was not affected (P > 0.05) by any treatment factors with the exception of 3.0% Desi CPI. Replacement of water with 1.5 or 3.0% protein from CPI or PPI in LFPB resulted in similar or stronger texture properties than the control-I. SPI generally gave stronger textures than the other two legume counterparts in the LFPB.

However, differences (P<0.05) were found in torsion shear stress and shear strain values in LFPB formulations with various starches (Fig. 1b). The lowest value for shear stress was observed for 1.0% pea starch containing LFPB whereas the highest shear stress was noted for bologna with 2.0% Kabuli starch. Except for the 1.0% pea starch samples, shear stress of all other formulations had higher values than that of the control. There were no significant differences in shear strain among starch added formulations except bologna with 1% potato starch had higher values than the control. Generally, LFPB formulated with 2.0% Kabuli and Desi starch had better texture than those with pea and potato starch.

A 14-member sensory panel evaluated bologna slices from each replication (Fig. 2). For protein-LFPB, there were no differences (P<0.05) between treatments for cohesiveness and overall flavour intensities (Fig. 2a). However, there were differences (P<0.05) among treatments for juiciness, firmness, graininess, flavour desirability and foreign flavour intensities. Perception of initial juiciness was not significantly (P<0.05) affected by addition of 1.5% Kabuli CPI, PPI and Desi CPI (both 1.5 and 3.0%) when compared to the control-I bologna. Bologna with 3.0% CPI and 1.5% SPI addition were slightly less juicy than the control. Bologna with 3.0% CPI and 1.5% SPI exhibited the same scores for firmness as the control-I. However, LFPB having 1.5% CPI and PPI were perceived to be softer than the control-I with no binder. There was only a trivial difference for graininess and saltiness among treatments. Increased level of chickpea proteins in LFPB formulations decreased the perception of flavour desirability significantly (P<0.05). This is may be due to the foreign flavour introduced by the CPI at high level (i.e. 3.0% protein). Overall, flavour properties of CPI containing LFPB were as good as other legumes. For starch-LFPB, it is very clear that addition of starch had few effects on sensory properties (Fig. 2b). Unlike TPA findings, panelists didn't perceive any difference in hardness and cohesiveness between treatments (P>0.05). LFPB containing chickpea or potato or pea starch either at 1.0% or 2.0% was given an acceptable sensory texture and flavour scores which were similar to the control.

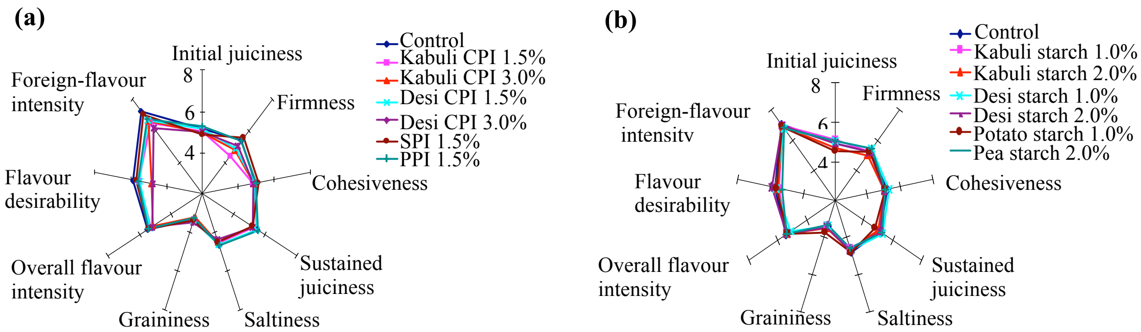


**Figure 2.** Sensory evaluation of LFPB formulated with (a) chickpea, soy or pea protein isolates and (b) chickpea, potato or pea starches as binders.

## IV. CONCLUSION

In general, addition of protein isolates and starch components of chickpea (at levels tested) were not detrimental to the low-fat pork bologna (LFPB) system and showed some positive benefits. Additions of Kabuli and Desi CPI improved meat batter characteristics by increasing water holding properties and decreasing cooking loss. Low-fat bologna containing 3.0% CPI, PPI and SPI were harder than those with their 1.5% counterparts or the control-I (at the same meat protein content). CPI, PPI and SPI at 1.5% addition level in LFPB did not alter flavour properties of the products. Addition of Kabuli and Desi starch at 2.0% improved the water holding of the LFPB hence increasing the cooking yield. These values were similar to the effect of potato starch (2.0% level) and better than the pea starch (2.0%). Generally, LFPB formulated with 2.0% Kabuli and Desi starch had higher instrumental TPA values than those with pea and potato starch. LFPB containing chickpea starch (either 1.0% or 2.0%) were given acceptable sensory texture and flavour scores similar to the control. Therefore, we can conclude in general, protein and starch from chickpea at the tested levels could be used as a binder, extender or filler in low-fat emulsion type meat products without negatively affecting textural and sensory characteristics.

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