Optimization of the Formulation of a Gluten-Free Pasta Enriched with Protein Using Pulse Protein Isolates

Kellogg's Honors College Capstone Project

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BACKGROUND:

Pasta is a wheat product eaten all over the world. Much of pasta's properties come from gluten; however, those with Celiac disease have an adverse reaction to its consumption. Pulse proteins, have the possibility of mimicking the gluten network to create gluten-free pasta. The objective of this work was to use various pulse protein isolates to create an enriched protein, gluten-free pasta product. A mixture design of experiments using isolated protein from pea (PPI), lentil (LPI), and fava beans (FPI) to be added into a base formulation consisting of rice flour, tapioca starch, and xanthan gum, was employed to create lasagna type pasta. All formulations were tested for extrusion flow rate, optimal cooking time, cooking loss, swelling index, colour and hardness. After the initial trials, LPI was discarded from the design of experiments due to the difficulty of extrusion, brittleness in the dried product, adverse dark appearance and off flavors. Following the elimination of LPI, a 5-formulation mixture design of PPI:FPI was conducted (100:0, 0:100, 50:50, 25:75 and 75:25 PPI:FPI ratios).

METHODOLOGY:

Extrude Pasta in Mixture Design → Evaluate Properties → Formulate Optimal Formulation → Evaluate Optimal Formulas

Mixture Design of Experiments:
A Mixture design of experiments of PPI and FPI (100% PPI, 100% FPI, 50:50, 25:75 and 75:25 PPI:FPI ratios) was conducted using a base recipe of pulse protein isolate (43%) rice flour (40%) tapioca starch (15%) Xanthan Gum (2%) and water (37% Dry Basis).

Dry ingredients were mixed together water was drizzled in using a KitchenAid benchtop mixer. Samples were mixed for 2 minutes then allowed to hydrate for 30 min in the refrigerator.

Dough was extruded into lasagna type pasta using a La Monferrina P2 single screw cold extruder at 50 rpm, 20:1 Length:Diameter. Samples were dried in a pilot-scale food dehydrator for 6 hours at 165° F.

Physicochemical Properties:
Extrusion Flow Rate (EFR) was determined by the mass of product extruded over a 10 second period.

Colour measurements were taken by Hunter Labs L*A*B* colorimeter in dried and cooked forms.

Hardness of cooked pasta and brittleness of uncooked pasta was determined using a Texture Technologies texture analyzer with a TA-47 pasta analyzing blade

Cooking Properties:
Optimal Cooking Time (CT) was determined by the length of time of cooking pasta until the absence of a white core when cut.

Cooking Loss (CL) was determined by cooking 20g sample to CT+1 then drying in conventional dryer, then determining difference in mass.

Swelling Index (SI) was determined by cooking 20g sample to CT then determining increase in mass

Optimal Formulation :
Optimization of the MDOE was conducted in Minitab statistical software with semolina pasta as the standard

Hedonic Sensory Evaluation of 150-consumer using J.A.R. and 9-point hedonic scale questions was conducted on the two optimal formulations and lab made whole wheat and semolina based pastas.

Microscopy of samples were conducted by Scanning Electron Microscope (SEM) (Fig 11,12)

Approximate Analysis was conducted on the Optimal Formulas and Controls (Fig 10)

RESULTS:

Physicochemical Properties: All samples showed non-significantly different ($p > 0.05$) extrusion flow rates, with those containing a greater amount of FPI having the highest (Fig. 1). FPI also exhibited the greatness brittleness while adding PPI hardened the product (Fig. 2). 100% FPI displayed the brightest yellow colour (Fig. 2).

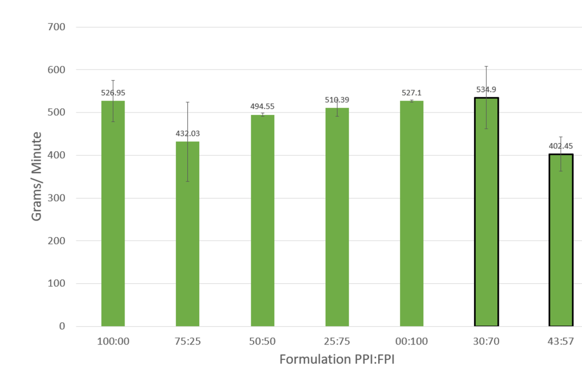

Figure 1: Extrusion Flow Rate

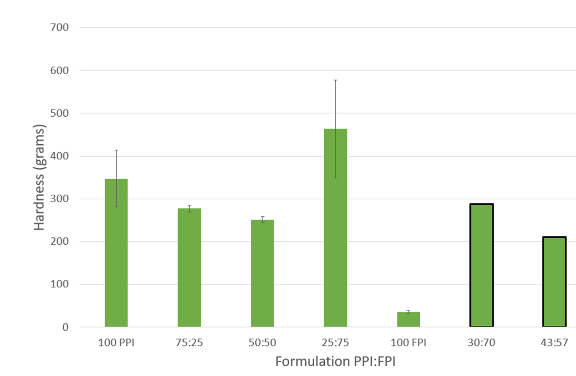

Figure 2: Hardness

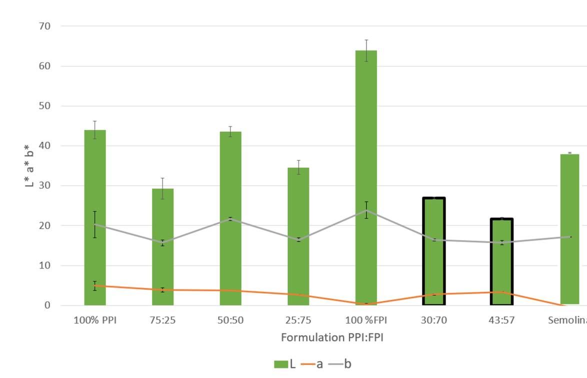

Figure 3: L*A*B* Colour

Cooking Properties: FPI exhibited a significant ($P < 0.05$) greater cooking time than PPI (Fig. 4), while PPI exhibited the greatest cooking loss of all samples unless mixed with FPI (Fig. 5). FPI also exhibited the greatest water uptake in amounts greater that 50% (Fig 6).

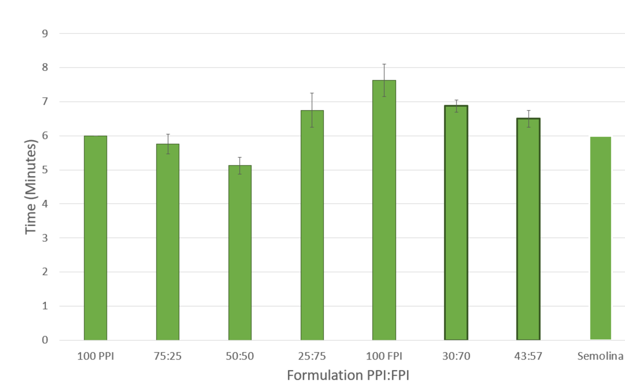

Figure 4: Cooking time

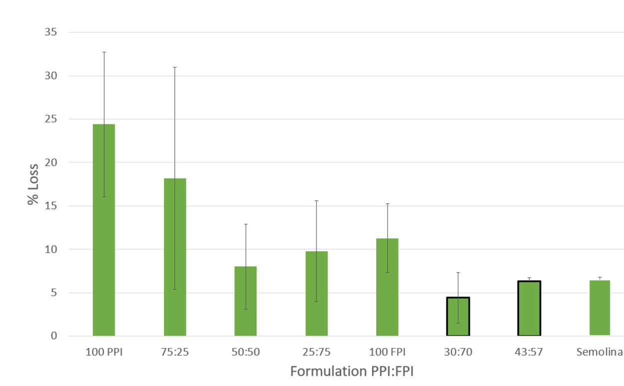

Figure 5: Cooking Loss

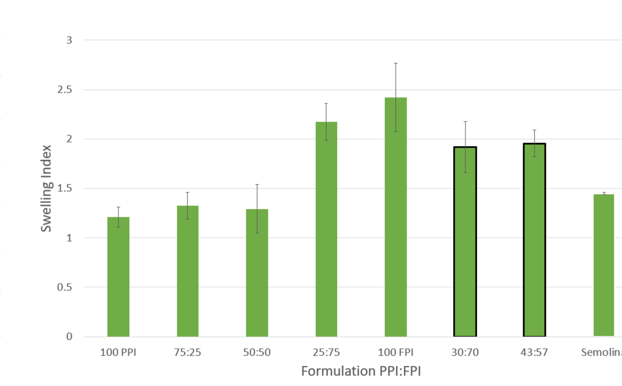

Figure 6: Water Uptake

Optimal Properties: Both Optimal Formulations had a significantly ($P < 0.05$) different Sensory Properties from the gluten samples, but nonsignificant ($p > 0.05$) difference between the two (Fig. 7,8).

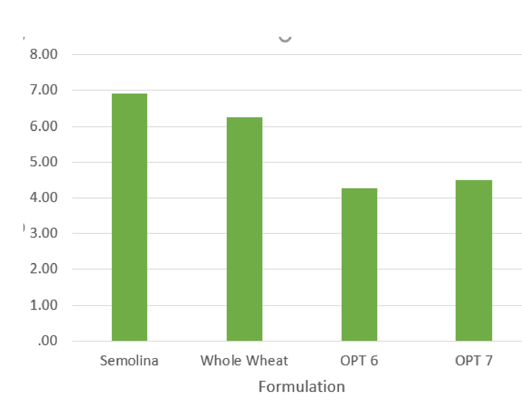

Figure 7: Overall Liking

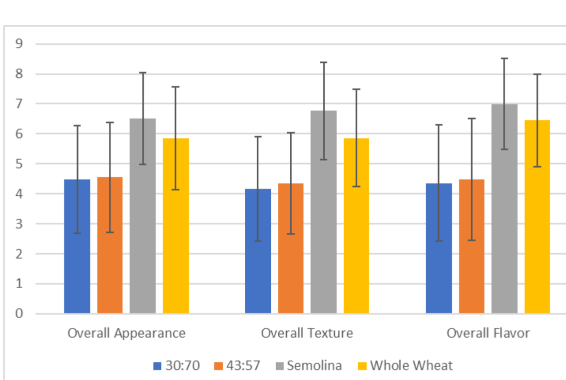

Figure 8: Overall Liking

Figure 9: FPI Pasta

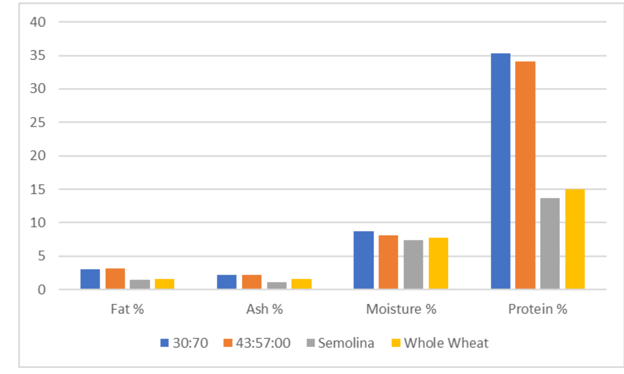

Figure 10: Approximate Analysis

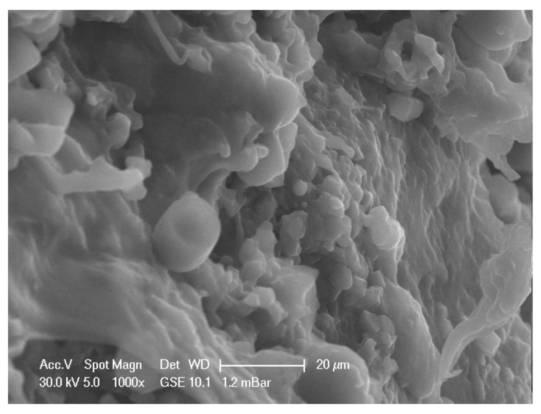

Figure 11: SEM 25:75

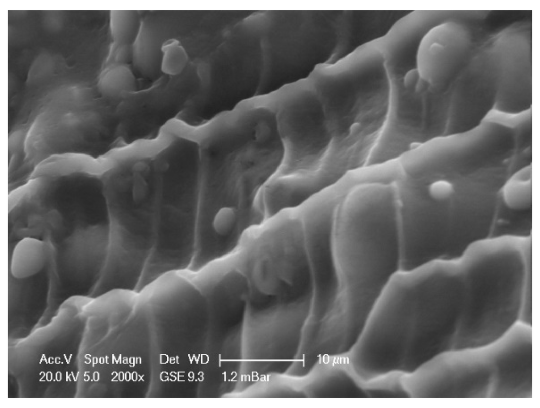

Figure 12: SEM Semolina

CONCLUSIONS:

- LPI exhibits undesirable traits of colour, flavor, extrusion flow, and brittleness.
- FPI exhibits a faster extrusion flow rate but increased brittleness.
- FPI exhibits high water uptake and cooking loss, but is reduced with the addition of PPI.
- Optimal Formulations exhibit a lower consumer acceptability compared to glutenous pastas.
- Optimal Formulations exhibit a slightly lower chewiness and hardness in affective sensory analysis
- SEM shows a form of protein matrix embedded with gelatinized starch granules in formulated product.

A mixture design of experiments may be employed to optimize formulation of pasta with two optimal formulations of 30:70 and 43:57 PPI:FPI being the outcome in this study,

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