Possibilities of Using Phaseolus Vulgaris and Phaseolus Lunatus Beans in Pasta Production

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Abstract

In last decade, in scientific literature, various pulses dominate as raw material of new pasta development. The production of pulse pasta is complex technological process, generally based on extrusion technology. The aim of the study was to produce spaghetti-type pasta from Phaseolus vulgaris (variety unknown) and Phaseolus lunatus (variety Kontra). The recipes made with xanthan gum and corn starch as a binder, the optimal cooking time and water absorption capacity was determined. In the experiment, wheat semolina spaghetti was used as a control sample. Four types of spaghetti were prepared using a single-screw extruder, then dried in a rotary oven and stored until analysis. Pasta cooking properties have been determined. The obtained data were compared using t-test. There were significant differences between obtained spaghetti and control sample. The results confirm that beans can be used in pasta production.

Key words: Beans, pasta, xanthan gum, corn starch, cooking properties

Introduction

Consumers in Europe have indicated that they would like to see more new pasta products in supermarkets (Caproni et al., 2020). Pasta has been evolved since 1980 when focus was on durum wheat semolina to provide “al dente” texture, to pulse pasta since 2020 using beans, peas, chickpeas and lentils as raw material in pasta production (Bresciani et al., 2022). Phaseolus vulgaris and Phaseolus lunatus beans have good potential for new product development in the European market, especially less common are red speckled beans (CBI Ministry of Forreign Affairs, 2022). Beans are good source of protein (15-30%), carbohydrates (55-70%), especially high content of resistant starch (70-83%), which is important for glycemia control (Los et al., 2018; Xu et al., 2022).

Extrusion technology is widely used in pasta and cereal product obtaining, known since 1946 in the form of a single-screw extruder (Pasqualone et al., 2020). This technology cause starch gelatinization, increase protein in vitro digestibility and reduce antinutritional factors in pulses (Pasqualone et al., 2020). Pasta like products made from pulses is trending and new product group with healthier impact on consumers health. One hundred percent pulse pasta obtaining is technologically complex process, there is no natural gluten in raw material, each pulse type has their own compositional features. Scientists reported that increasing bean proportion in recipe from 0 to 100% increased cooking loss and reduced pasta resilience (Laleg et al., 2017). Modifications during extrusion process: screw rotation speed, extrusion temperatures affect the final product quality. Bouaslta studied 3 different screw rotation speeds and concluded that 80 rates per minute

137
rpm) and 30°C are the most suitable conditions for good quality rice-yellow pea pasta obtaining (Bouasla et al., 2016).

According to literature most used binders in gluten-free pastas are xanthan gum, carboximethylcellulose, guar gum, locust bean gum, corn starch (Gao et al., 2018). Typically, xanthan gum is added in the amount of 0.5 to 2.5% in the production of gluten-free pasta (Larrosa et al., 2013; Sanguinetti et al., 2015).

The aim of the study was to test xanthan gum and corn starch as binders in pulse pasta obtaining using Phaseolus Vulgaris and Phaseolus lunatus, and determine their optimal cooking time and water absorption capacity.

Materials and methods

**Materials.** Beans harvest of 2022, Phaseolus lunatus in white colour (var. Kontra) Phaseolus vulgaris in red speckled colour (var. unknown) were grown and purchased from farm Zutiņi (Latvia). Beans have been stored in a refrigerator at 2-6 °C until preparation. Before pasta was prepared the chemical composition of used beans (table 1) was analysed using standard methods: moisture ISO 24557:2009, protein LVS EN ISO 5983-2:2009, lipid ISO 6492:1999, total dietary fibre (TDF) AOAC 985.29, ash ISO 2171:2007, carbohydrates calculated using empirical formula (1;2):

\[
\% \text{ Dry weight}=100-\text{Moisture content (\%)} \quad (1) \\
\% \text{ Carbohydrate}=\% \text{ Dry weight}- (\% \text{ Protein content}+\% \text{ Lipid content}+\% \text{ Ash}) \quad (2)
\]

<table>
<thead>
<tr>
<th>Bean type</th>
<th>Image</th>
<th>Moisture %</th>
<th>Protein %</th>
<th>Lipids %</th>
<th>TDF %</th>
<th>Ash %</th>
<th>Carbohydrates %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phaselous lunatus var. Kontra</td>
<td>![Image]</td>
<td>11.38±0.61</td>
<td>20.86±0.53</td>
<td>1.94±0.04</td>
<td>37.99±0.54</td>
<td>4.96±0.05</td>
<td>60.82±0.61</td>
</tr>
<tr>
<td>Phaselous vulgaris var. unknown</td>
<td>![Image]</td>
<td>16.78±2.25</td>
<td>22.88±0.15</td>
<td>1.09±0.07</td>
<td>13.11±2.55</td>
<td>4.52±0.09</td>
<td>54.67±2.25</td>
</tr>
</tbody>
</table>

For pasta recipes as binders used Xanthan gum (E 415), purchased from SIA “Gemoss”, manufacturer SOSA, Spain. Corn starch, purchased from local supermarket, manufacturer Dr. Oetker, distributor "Dr. Oetker Lietuva", UAB, Lithuania.

**Pasta recipes.** The beans were milled in the laboratory mill Howo’s Muhle 2 (Germany). The development of gluten-free pasta recipes was based on literature findings. In the beginning the proportion was made 2.5% of hydrocolloid and 35.5% of water in 100g bean flour (Larrosa et al., 2013). The raw materials were weighed on electronic scales "Kern" (Kern&Sohn, Germany) and dough was prepared manually. Changes have been made to the recipes during the extrusion process, adjusting water in the dough, extending dough kneading process from 10 to 20 minutes and varying the extrusion temperatures to achieve better results. Four recipes have been prepared (table 2).

<table>
<thead>
<tr>
<th>Bean type</th>
<th>Bean flour g</th>
<th>Xanthan gum g</th>
<th>Corn starch g</th>
<th>Water g</th>
<th>Abbreviations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Var. Kontra</td>
<td>100.00</td>
<td>2.50</td>
<td></td>
<td>49.00</td>
<td>KX</td>
</tr>
<tr>
<td>Var. Kontra</td>
<td>100.00</td>
<td></td>
<td>2.60</td>
<td>53.00</td>
<td>KC</td>
</tr>
<tr>
<td>Red speckled beans</td>
<td>100.00</td>
<td>2.80</td>
<td></td>
<td>60.00</td>
<td>RSBX</td>
</tr>
<tr>
<td>Red speckled beans</td>
<td>100.00</td>
<td></td>
<td>2.18</td>
<td>90.55</td>
<td>RSBC</td>
</tr>
</tbody>
</table>
Pasta obtaining. Extrusion process was performed with single-screw extruder "Extrusiometer L-20" (Götffert, Germany). Screw diameter is 44 mm, the dough was pushed through a matrix with a Ø diameter of 3 mm, obtaining spaghetti-shaped pasta. According to Kalnina, Rakcejeva (2015) during extrusion process used screw rotation speed was 60±2 rpm, compression ratio 3:1, pressure 0.5±0.1 MPa (Kalnina, Rakcejeva, 2015). Extruder has three sections and final temperatures regimes were 90-96-103°C.

According to Biano et al. (2006) pasta was dried in a rotary oven Sveba Dahlen (Sweden) at 70±10°C for 4±1 h, to a moisture content of 10±2% (Baiano et al., 2006). Cooled pasta was stored in an air environment, in polyethylene bags at room temperature for further analysis (Fig. 1. A-with xanthan gum; B-with corn starch). As a control sample wheat semolina spaghetti produced by Dobeles Dzirnavnieks (Latvia) was used.

![Fig. 1. Dried pasta samples A-with xanthan gum; B-with corn starch](image)

Physical parameters of extruded pasta. Optimal cooking time (OCT) determined according to AACC-approved method 66-50, where 5 g of dried spaghetti samples were boiled in 200 mL of distilled water. Every 30 sec. spaghetti is removed from boiling water and pressed between two pieces of petri glass. Spaghetti was considered cooked when the core was no longer visible (Makdoud, Rosentrater, 2017). Water absorption capacity (WAC). Water absorption was determined according to AACC 66-50. Ten grams of dried spaghetti samples were pre-weighed and boiled in 300 ml of water at a predetermined cooking time. The difference in weight before and after cooking was used to calculate water absorption formula (3) (Makdoud, Rosentrater, 2017).

\[ WA(\%) = \left( \frac{CPW - DPW}{DPW} \right) \times 100, \quad (3) \]

Here: CPW= cooked (wet) pasta weight (g); DPW = dried pasta weight (g)

Statistical analysis. The program Microsoft Excel 2016 was used for calculating average value ± standard deviation. The t-test was used for comparison with control sample. All experiments were carried out triplicate in laboratories of Latvia University of Life Sciences and Technologies at Faculty of Agriculture and Food Technology.

Results and discussion

Optimal cooking time. Recent study shows that shorter cooking time is one of the most significant selection motives of consumers pasta choices (Sajdakowska et al., 2021). In our study spaghetti was boiled until core wasn’t visible, but pasta string was still flexible. Control sample was prepared as a manufacturer noted on package. Significant differences were not indicated except for RSBC sample (p<0.05) (Fig. 2.).
Fig. 2. Optimal cooking time of developed pasta samples (KX- white bean pasta made with xanthan gum; RSBX-red speckled bean pasta made with xanthan gum; KC- white bean pasta made with corn starch; RSBC – red speckled bean pasta made with corn starch)

Different letters mean significant differences between pasta samples (p<0.05)

The longest cooking time was for spaghetti made from red speckled beans (RSBC) 14±1 min, but the shortest was for white bean pasta (KC) 9.40±1 min both made from corn starch. This could be explained by differences in recipes. Scientist reported that adding more water to dough makes it less viscose and reduces the mechanical damage of starch caused by extrusion process and makes more solid internal structure (Mitrus et al., 2023). Another study explained that hydrocolloid network can reduce optimal cooking time in pasta samples (Scarton et al., 2022). In contrary optimal cooking time can be influenced by extrusion process at 100°C and drying process at 90°C, developed white kidney bean pastas cooking time was 13.4 ± 0.1 min, but by reducing the temperature twice while maintaining the same drying conditions OCT was reduced till 5.2 ± 0.3 (Hooper et al., 2023). In general, KX and KC required a shorter cooking time than RSBX and RSBC, this could be explained in chemical content differences.

In study where 100% bean (Vicia faba L.), lentil (L. Urvum lens L.) and golden bean (Vigna mungo L.) flour was used in the production of pasta, the cooking time was different 9.5, 9.8 and 6.6 min, these results are explained by the fact that golden bean pasta has more soluble and weakly cross-linked protein network and higher fibre content, especially water-soluble arabinogalactans compared to bean and lentil pasta, could possibly facilitate the penetration of water into the pasta core (Laleg et al., 2016). In our study TDF content in KX and KC samples is almost 3 times higher than in RBSX and RBSC samples, this may also be a factor in why OCT differs between samples. From the nutrition point studies have shown that a longer cooking time allowed more water to be absorbed while reducing the energy density of 100g of cooked pasta (Sobota, Zarzycki, 2013).

Water absorption capacity is expressed as a percentage increase in the weight of cooked pasta compared to the weight of dried pasta (Fig. 3.).

In our study the highest WAC was for control sample – 200%±0.01, the lowest for RSBC-60%±0.02. Obtained results are lower than reported Laleg et al., 2016, study where 100% bean, lentil and golden bean flour was used in pasta, the water absorption capacity was 165%, 154% and 124%.
Water absorptions indicate that extrusion with high moisture content led to the formation of a more hydrophilic structure, which led to higher water absorption, moreover, low water absorption capacity indicates poor quality of cooked pasta as its structure becomes unsatisfactory (Bouasla et al., 2016). Another study explained that the denaturation of legume proteins in hot water during hydration resulted in increased availability of polar amino acid protein groups, which could increase the affinity for water and thus a higher water absorption capacity (Bouasla et al., 2017).

**Conclusions**

The optimal cooking time for spaghetti made with *Phaseolus lunatus* (var. Kontra) was 9 to 10:00 minutes. The water absorption capacity in sample with xanthan gum is 72%, and with corn starch is 140%.

Pasta made with *Phaseolus vulgaris* (var. unknown) OCT was 11 min for sample with xanthan gum and 14 min for sample with corn starch (p<0.05) compared with control sample, WAC was 72% and 60%, respectively.

*Phaseolus lunatus* showed more stable performance and was not significantly different from control sample. *Phaseolus vulgaris* could be a potential material for further experiments, although developed recipes and extrusion technological parameters need to be improved.

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**References**


**Phaseolus vulgaris ir Phaseolus lunatus pupelių naudojimo makaronų gamyboje galimybės**

(Gauta 2024 m. kovo mėn.; atiduota spaudai 2024 m. kovo mėn.; prieiga internete nuo 2024 m. gegužės 10 d.)

**Santrauka**

Šiame straipsnyje mokslinio požiūrio apžvalgijos naujausios makaronų gamybos tendencijos. Vartotojai Europoje nurodo, kad norėtų rinkoje matyti naujų rūšių makaronų. Pastarajį dešimtmetį mokslininkė literatūroje jvairūs
ankštiniai augalai dominuoja kaip žaliava naujems makaronams kurti. Ankštinių makaronų gamyba yra sudėtingas technologinis procesas, kai žaliava neturi glitimo, todėl ją receptūras reikia įtraukti rūšiųjų medžiagų.


OCT analizė parodė reikšmingus skirtumus tarp kontrolinio mėginio ir *Phaseolus vulgaris*, pagaminto su kukurūzų krakmolu (p<0.05), atitinkamai OCT buvo 14 minučių. Trumpiausia OCT nustatyta *Phaseolus lunatus* spagečių, pagamintų su kukurūzų krakmolu – trumpesnė nei 10 minučių, kaip ir kontrolinio mėginio. Sukurtiems makaronų mėginiams WAC buvo nuo 60 % iki 140 %, palyginti, kontrolinio mėginio WAC buvo 200 %. Apskritai rezultatai parodė, kad pupeles gali būti naudojamos makaronų gamybai, tačiau reikia atlikti tolesnius eksperimentus, kad būtų galima koreguoti receptūrą ir technologinius parametrus.