

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

Elizabete Andersone-Trezina\*, Tatjana Kinca

Faculty of Agriculture and Food Technology, Latvia University of Life Sciences and Technologies  
Liela Str.2, Jelgava, LV-3001, Latvia

email: [elizabete-andersone@inbox.lv](mailto:elizabete-andersone@inbox.lv), telephone +371 22376567

(Received in March, 2024; Accepted in March, 2024; Available Online from 10<sup>th</sup> of May, 2024)

## 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

## Anotacija

Pastarajį dešimtmetį mokslinėje literatūroje įvairūs ankštiniai augalai dominuoja kaip žaliava naujiems makaronams kurti. Ankštinių makaronų gamyba yra sudėtingas technologinis procesas, paprastai pagrįstas ekstruzijos technologija. Tyrimo tikslas - pagaminti spagečių tipo makaronus iš *Phaseolus vulgaris* (veislė nežinoma) ir *Phaseolus lunatus* (veislė Kontra). Pagal receptus pagaminti makaronai su ksantano derva ir kukurūzų krakmolu, kaip rišamąja medžiaga, nustatytas optimalus jų virimo laikas ir vandens sugerties geba. Eksperimente, kaip kontrolinis mėginys, buvo naudojami kviečių manų kruopų spagečiai. Keturių rūšių spagečiai buvo paruošti naudojant vieno sraigto ekstruderį, po to išdžiovinti rotacinėje džiovykloje ir laikomi iki analizės. Nustatytos makaronų kepimo savybės. Gauti duomenys palyginti naudojant t-testą. Nustatyti reikšmingi skirtumai tarp gautų spagečių ir kontrolinio mėginio. Rezultatai patvirtina, kad pupelės gali būti naudojamos makaronų gamyboje.

**Reikšminiai žodžiai:** pupelės, makaronai, ksantano derva, kukurūzų krakmolai, kepimo savybės.

## 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 Foreign 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. Bouasla studied 3 different screw rotation speeds and concluded that 80 rates per minute



(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, carboxymethylcellulose, 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 1.** Chemical composition of raw material 100 g<sup>-1</sup> dry weight

Bean type	Image	Moisture %	Protein %	Lipids %	TDF %	Ash %	Carbohydrates %
<i>Phaseolus lunatus</i> var. Kontra		11.38±0.61	20.86± 0.53	1.94± 0.04	37.99± 0.54	4.96±0.05	60.82± 0.61
<i>Phaseolus vulgaris</i> var. unknown		16.78±2.25	22.88± 0.15	1.09± 0.07	13.11± 2.55	4.52±0.09	54.67± 2.25

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 2.** Pasta recipes

Bean type	Bean flour g	Xanthan gum g	Corn starch g	Water g	Abbreviations
Var. Kontra	100,00	2.50	-----	49.00	KX
Var. Kontra	100,00	-----	2.60	53.00	KC
Red speckled beans	100,00	2.80	-----	60.00	RSBX
Red speckled beans	100,00	-----	2.18	90.55	RSBC
		--			



**Pasta obtaining.** Extrusion process was performed with single-screw extruder "Extrusiometer L-20" (Göttfert, Germany). Screw diameter is 44 mm, the dough was pushed through a matrix with a  $\phi$  diameter of 3 mm, obtaining spaghetti-shaped pasta. According to Kalnina, Rakcejeva (2015) during extrusion process used screw rotation speed was  $60\pm 2$  rpm, compression ratio 3:1, pressure  $0.5\pm 0.1$  MPa (Kalnina, Rakcejeva, 2015). Extruder has three sections and final temperatures regimes were 90-96-103°C.

According to Bianco et al. (2006) pasta was dried in a rotary oven Sveba Dahlen (Sweden) at  $70\pm 10^\circ\text{C}$  for  $4\pm 1$  h, to a moisture content of  $10\pm 2\%$  (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 Dzirnāvnieks (Latvia) was used.



Fig. 1. Dried pasta samples A-with xanthan gum; B-with corn starch

**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 (3) (Makdoud, Rosentrater, 2017).

$$WA(\%) = ((CPW - DPW) / DPW) * 100, \quad (3)$$

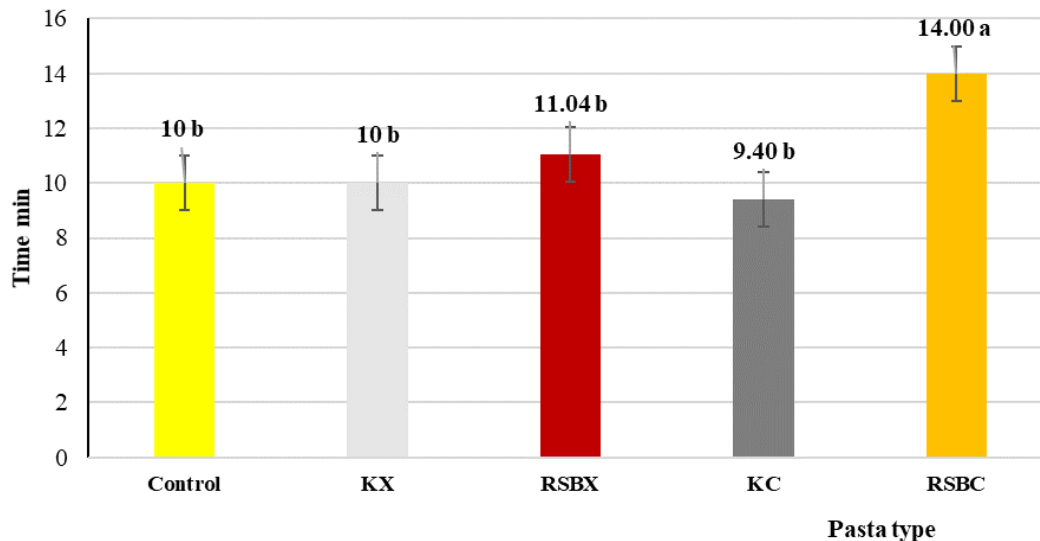
Here: CPW= cooked (wet) pasta weight (g); DPW = dried pasta weight (g)

**Statistical analysis.** The program Microsoft Excel 2016 was used for calculating average value  $\pm$  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 ( $p < 0.05$ )

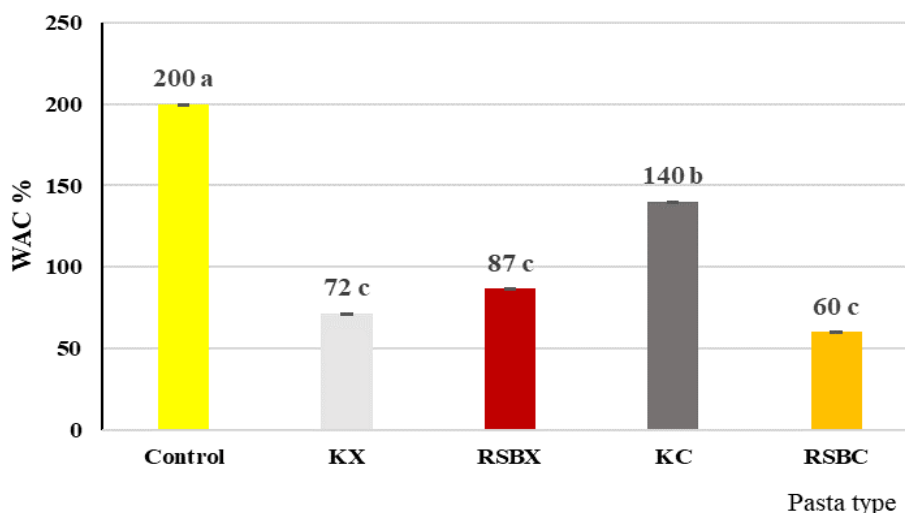
The longest cooking time was for spaghetti made from red speckled beans (RSBC)  $14 \pm 1$  min, but the shortest was for white bean pasta (KC)  $9.40 \pm 1$  min both made from corn starch. This could be explained by differences in recipes. Scientist reported that adding more water to dough makes it less viscous 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  $100^\circ\text{C}$  and drying process at  $90^\circ\text{C}$ , developed white kidney bean pastas cooking time was  $13.4 \pm 0.1$  min, but by reducing the temperature twice while maintaining the same drying conditions OCT was reduced till  $5.2 \pm 0.3$  (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 –  $200\% \pm 0.01$ , the lowest for RSBC-  $60\% \pm 0.02$ . 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%.





**Fig. 3.** Water absorption capacity 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 ( $p < 0.05$ )

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.

**Acknowledgments.** This research was supported by the framework of the project "Legumes as alternative for extruded pasta obtaining" funded and implemented by the program "Strengthening of Scientific Capacity at LBTU".

### References

1. Baiano A., Conte A., Del Nobile M. A. (2006). Influence of drying temperature on the spaghetti cooking quality. *Journal of Food Engineering*, 76 (3), pp. 341–347. DOI: 10.1016/J.JFOODENG.2005.05.030
2. Bouasla A., Wójtowicz A., Zidoune M. N. (2017). Gluten-free precooked rice pasta enriched with legumes flours: Physical properties, texture, sensory attributes and microstructure. *LWT*, 75, pp. 569–577. DOI: 10.1016/J.LWT.2016.10.005
3. Bouasla A., Wójtowicz A., Zidoune M. N., Olech M., Nowak R., Mitrus M., Oniszczuk A. (2016). Gluten-Free Precooked Rice-Yellow Pea Pasta: Effect of Extrusion-Cooking Conditions on Phenolic Acids Composition, Selected Properties and Microstructure. *Journal of Food Science*, 81 (5), pp. C1070–C1079. DOI: 10.1111/1750-3841.13287
4. Bresciani A., Pagani M. A., Marti A. (2022). Pasta-Making Process: A Narrative Review on the Relation



- between Process Variables and Pasta Quality. *Foods* 2022, Vol. 11, Page 256, 11 (3), pp. 256. DOI: 10.3390/FOODS11030256
5. Caproni L., Raggi L., Talsma E. F., Wenzl P., Negri V. (2020). EUROPEAN CONSUMER SURVEY ON PLANT-BASED FOODS Describing the product landscape and uncovering priorities for product development and improvement IMPRINT 'European Consumer Survey on Plant-based Foods-Describing the product landscape and uncovering priorit. *Scientific Reports* 2020 10:1, 10 (1), pp. 1–13. DOI: 10.1038/s41598-020-76417-3
  6. CBI Ministry of Foreign Affairs. (2022). The European market potential for common dry beans | CBI. Available: <https://www.cbi.eu/market-information/grains-pulses-oilseeds/dried-beans/market-potential>
  7. Gao Y., Janes M. E., Chaiya B., Brennan M. A., Brennan C. S., Prinyawiwatkul W. (2018). Gluten-free bakery and pasta products: prevalence and quality improvement. *International Journal of Food Science & Technology*, 53 (1), pp. 19–32. DOI: 10.1111/IJFS.13505
  8. Hooper S. D., Bassett A., Wiesinger J. A., Glahn R. P., Cichy K. A. (2023). Extrusion and drying temperatures enhance sensory profile and iron bioavailability of dry bean pasta. *Food Chemistry Advances*, 3, pp. 100422. DOI: 10.1016/J.FOCHA.2023.100422
  9. ISO 24557:2009 - Pulses — Determination of moisture content — Air-oven method. Available: <https://www.iso.org/standard/42281.html>
  10. Kalnina S., Rakcejeva T. (2015). Investigation of physicochemical, sensory characteristics, cooking and texture properties of whole grain pasta. *Chemical Technology*, 66 (1). DOI: 10.5755/J01.CT.66.1.12364
  11. Laleg K., Barron C., Cordelle S., Schlich P., Walrand S., Micard V. (2017). How the structure, nutritional and sensory attributes of pasta made from legume flour is affected by the proportion of legume protein. *LWT - Food Science and Technology*, 79, pp. 471–478. DOI: 10.1016/j.lwt.2017.01.069
  12. Laleg K., Cassan D., Barron C., Prabhasankar P., Micard V. (2016). Structural, Culinary, Nutritional and Anti-Nutritional Properties of High Protein, Gluten Free, 100% Legume Pasta. *PLOS ONE*, 11 (9), pp. e0160721. DOI: 10.1371/JOURNAL.PONE.0160721
  13. Larrosa V., Lorenzo G., Zaritzky N., Califano A. (2013). Optimization of rheological properties of gluten-free pasta dough using mixture design. *Journal of Cereal Science*, 57 (3), pp. 520–526. DOI: 10.1016/J.JCS.2013.03.003
  14. Los F. G. B., Zielinski A. A. F., Wojeicchowski J. P., Nogueira A., Demiate I. M. (2018). Beans (*Phaseolus vulgaris* L.): whole seeds with complex chemical composition. *Current Opinion in Food Science*, 19, pp. 63–71. DOI: 10.1016/j.cofs.2018.01.010
  15. Makdoud S., Rosentrater K. A. (2017). Development and Testing of Gluten-Free Pasta Based on Rice, Quinoa and Amaranth Flours. *Journal of Food Research*, 6 (4), pp. 91. DOI: 10.5539/JFR.V6N4P91
  16. Mitrus M., Wójtowicz A., Oniszczyk T., Combrzyński M., Bouasla A., Kocira S., ... Szparaga A. (2023). Application of Extrusion-Cooking for Processing of White and Red Bean to Create Specific Functional Properties. *Applied Sciences (Switzerland)*, 13 (3), pp. 1671. DOI: 10.3390/APP13031671/S1
  17. Pasqualone A., Costantini M., Coldea T. E., Summo C. (2020). Use of Legumes in Extrusion Cooking: A Review. *Foods* 2020, Vol. 9, Page 958, 9 (7), pp. 958. DOI: 10.3390/FOODS9070958
  18. Sajdakowska M., Gębski J., Jeżewska-Zychowicz M., Jeznach M., Kosicka-Gębska M. (2021). Consumer Choices in the Pasta Market: The Importance of Fiber in Consumer Decisions. *Nutrients*, 13 (9). DOI: 10.3390/NU13092931
  19. Sanguinetti A. M., Secchi N., Del Caro A., Fadda C., Fenu P. A. M., Catzeddu P., Piga A. (2015). Gluten-free fresh filled pasta: The effects of xanthan and guar gum on changes in quality parameters after pasteurisation and during storage. *LWT - Food Science and Technology*, 64 (2), pp. 678–684. DOI: 10.1016/J.LWT.2015.06.046
  20. Scarton M., Clerici M. T., Pedrosa Silva. (2022). Gluten-free pastas: ingredients and processing for technological and nutritional quality improvement. *Food Science and Technology*, 42, pp. e65622. DOI: 10.1590/FST.65622
  21. Sobota A., Zarzycki P. (2013). Effect of Pasta Cooking Time on the Content and Fractional Composition of Dietary Fiber. *Journal of Food Quality*, 36 (2), pp. 127–132. DOI: 10.1111/JFQ.12023
  22. Xu S., Qin L., Mazhar M., Zhu Y. (2022). Functional components profile and glycemic index of kidney beans. *Frontiers in Nutrition*, 9, pp. 1044427. DOI: 10.3389/FNUT.2022.1044427/BIBTEX

## 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 moksliniu požiūriu apžvelgiamos naujausios makaronų gamybos tendencijos. Vartotojai Europoje nurodo, kad norėtų rinkoje matyti naujų rūšių makaronų. Pastarąjį dešimtmetį mokslinėje literatūroje įvairūs



ankštiniai augalai dominuoja kaip žaliava naujiems makaronams kurti. Ankštinių makaronų gamyba yra sudėtingas technologinis procesas, kai žaliava neturi glitimo, todėl į receptūras reikia įtraukti rišamųjų medžiagų.

Tyrimo tikslas – patikrinti ksantano dervos ir kukurūzų krakmolo panaudojimo galimybes makaronų gamyboje, naudojant Latvijoje užaugintas *Phaseolus vulgaris* (veislė nežinoma) ir *Phaseolus lunatus* (veislė Contra) pupeles. Spagečiai buvo gaminami taikant ekstruzijos technologiją. Kaip kontrolinis mėginys buvo naudojami kviečių manų kruopų spagečiai. Prieš gaminant makaronus buvo nustatyta pupelių cheminė sudėtis. Nustatytos gaminimo savybės, tokios kaip optimalus gaminimo laikas (OCT) ir vandens absorbcijos geba (WAC).

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. Sukuriami makaronų mėginiai WAC buvo nuo 60 % iki 140 %, palyginti, kontrolinio mėginio WAC buvo 200 %. Apskritai rezultatai parodė, kad pupelės gali būti naudojamos makaronų gamybai, tačiau reikia atlikti tolesnius eksperimentus, kad būtų galima koreguoti receptūrą ir technologinius parametrus.

