Effect of pregelatinized corn starch on the technological and quality properties of pea dough and snacks

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Keywords:

Pea flour
Corn
Starch
Dough
Snack
Strength
Viscosity

Article history:

Received 29.01.2025
Received in revised form 01.06.2025
Accepted 30.06.2025

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DOI:
10.24263/2310-1008-2025-13-1-7

Abstract

Introduction. The aim of the work was to study the effect of pregelatinized corn starch on the technological and quality properties of pea dough and snacks.

Materials and methods. Pea flour was used as the main raw material, and corn starch was used as the structure-forming agent. Structural and mechanical properties of the dough and snacks were determined by the elasticity, adhesion strength, dough viscosity, and snack strength. Sensory quality indicators were determined with the involvement of tasters using a 5-point scale, taking into account the importance of each indicator.

Results and discussion. It was shown that the addition of up to 20% pregelatinized corn starch to the formulation of pea-based snacks positively influenced dough structure formation. Specifically, elasticity increased to 37 g, which was by 25.6% higher compared to the control sample containing 5% native corn starch, while viscosity increased to 171 cP.

A further increase in the dosage of pregelatinized corn starch, however, resulted in a decline in these quality indicators. A similar trend was observed in the final product: as the starch dosage increased, snack firmness decreased, making them easier to chew. However, when the starch content exceeded 15%, the finished product became excessively thin, negatively affecting its structural integrity. This will negatively affect the quality of the snacks during transportation due to the possibility of a large number of scraps.

The analysis of the effect of pregelatinized corn starch dosage on sensory characteristics showed a positive impact on product appearance, as it contributed to the formation of thinner snacks. No noticeable changes in taste were observed. Nutritional value calculations indicated a slight decrease: with a 15% starch addition, protein content was reduced by 5.2%, and fat content by 5.3%, compared to the control sample containing 5% native corn starch. Meanwhile, the carbohydrate content increased by only 10.9%.

Conclusion. The use of pregelatinized corn starch allowed to ensure high structural and mechanical properties of both dough and snacks based on pea flour. It is recommended to incorporate pregelatinized corn starch into the formulation of pea snacks at a level not exceeding 15%.

Introduction

Snack products are one of the most popular in the global market (Chehtman, 2022). Since such products are thermally processed, which facilitates digestion by the human body, dehydrated, therefore they have a low mass, ready for consumption, which is important in the conditions of urbanization of life (Rubanka et al., 2022). However, most of these products are made on the basis of cereals (wheat, rice, barley) a lot of sugar is added as a structure-forming agent, or deep-frying is used during thermal processing, which are undesirable in the case of a healthy diet. Pea flour is naturally gluten-free and considered safe for individuals with celiac disease or other gluten-related disorders.

To combine the demand for ready-to-eat products with the need to consume highly nutritious products, it is necessary to use ingredients with high biological value for their production (Ivanov et al., 2021; Tsykhanovska et al., 2023). Legumes are sources of proteins and essential amino acids. The total essential amino acid content of legume proteins is 38–45 g/100 g (Shevkani, 2023). Peas are a low-cost source of protein and energy that combines technological functionality and nutritional value (Farshi et al., 2024).

It was proven that with an increase in the extrusion temperature of 135°C, the swelling coefficient of the extruded snacks in which corn or rice flour was partially or completely replaced increased to 40% (Maskus et al., 2015). It was also proven that the presence of peas in the snack composition at an extrusion temperature (159–164°C) and a screw rotation speed (165–214 rpm) made it possible to produce high-quality snacks (Félix-Medina et al., 2020).

The use of pea and oat flours and pea isolate in cracker technology allowed the development of snacks with a high protein content (24.66 g/100 g) and a low lipid content (9.07 g/100 g). In terms of its structural properties, the snack had lower hardness (19.04 N) and stickiness (4.07 N), but higher cohesion (0.35), elasticity (0.45 mm) and chewiness (0.35) compared to commercial crackers (Morales-Polanco et al., 2017), which also confirms the feasibility of using pea flour in snack production. The snacks exhibited a higher polyphenolic content—ranging from 0.33 to 0.62 mg gallic acid equivalents (GAE) per gram of sample—along with increased antioxidant activity (up to 8.7%) and a softer texture (Wani et al., 2018).

However, the production of snacks, based on peas can be complicated. Pea proteins are characterized by high water and fat binding capacity, which led to the formation of a gel, and subsequently a hard texture of products after their thermal treatment. This property has positive potential in the case of the production of meat substitutes (Serdaroglu et al., 2005), but is undesirable in the production of snacks from pea flour, as it will give a dense structure to the finished product (Venkatachalam et al., 2025).

Therefore, to adjust the structural and mechanical properties of snacks and their sensory indicators, it is necessary to use ingredients that will provide the structure of the dough and the finished product. One of such ingredients is starch. It has a high water-binding capacity, and the nature of starch, which is determined by the structure of starch grains, affects the characteristics of the dough and the finished product (Yifei et al., 2020).

Starch is widely utilized in the food industry for a variety of purposes, including the production of bakery products (Fonseca et al., 2021), stabilization of emulsions in soft drinks (Lyu et al., 2024), encapsulation of flavorings, formulation of dairy products (Naseer et al., 2021), preparation of fruit semi-finished products (Agudelo et al., 2023), as well as in instant soups and sauces (Fonseca et al., 2021), and in the mayonnaises and salad dressings (Block et al., 2023). It is also used in meat products (Marynin et al., 2023), including the use of electrochemically activated water for the preparation of starch suspensions (Marynin et al., 2022), giving them the desired physicochemical, functional, and digestible characteristics (Agama-Acevedo et al., 2019; Magallanes-Cruz et al., 2017).

The aim of the present work was to investigate the effect of pregelatinized corn starch on the technological and quality properties of dough and snacks made from pea flour.

Materials and methods

Materials and dough preparation

Pea flour (LLC "Prodenergo" Ukraine), native corn starch (PJSC "Dniprovsky Starch Molasses Combine", Ukraine), salt, (LLC "Foreign trade resource" Ukraine), mixture of spices (ground black pepper, dried granulated garlic, ground coriander) (PJSC "Ukroptbakaliya" Ukraine), pregelatinized corn starch Interstarch CWS30.50 (PJSC "Dniprovsky Starch Molasses Combine", Ukraine) were used for snack preparation.

The recipe of the control dough sample included pea flour in the amount of 92.5%, native corn starch, 5%, salt, 2%, mixture of spices, 0.5%, and water. The dough was prepared by kneading with a moisture content of 48.0%. Dough samples under study were prepared, replacing native corn starch and the corresponding part of the flour with pregelatinized corn starch in the amount of 5, 10, 15, 20 and 25%. The finished dough was deposited in an amount of 25 g and baked using a MAGIO MG-397 waffle iron (China) at a temperature of 160 ° C for 2.5 min.

Determination of structural and mechanical properties of dough and snacks

To analyze the structural and mechanical properties of the dough and finished products, a Brookfield CT3 texture analyzer was used. The elasticity of the dough and its adhesion strength were determined using a TA4/1000 nozzle (38.1 mm Diameter cylinder probe) Clear Acrylic 26 g, 20 mm Long Rad 35-43 mm. The study was carried out with the following parameters: nozzle movement speed 1 mm/s, depth of its immersion in the dough sample 10 mm. The research error was ±0.05. The viscosity of the dough was determined on a Brookfield Viscometr DV2T viscometer at a temperature of 21.8°C with a nozzle rotation speed (cylinder) of 100 rpm, torque – 30.3–69.8%.

When analyzing the strength of ready-made snacks on the Brookfield CT3 texture analyzer, a TA7 (knife edge) Clear Acrylic 8 g, 60 mm Wide nozzle was used. Research conditions: nozzle movement speed 2 mm/s, depth of its immersion in the sample 10 mm (Sobczyk et al., 2017).

Determination of sensory quality indicators of pea snacks

Sensory assessment of the quality of ready-made snacks was carried out using a complex indicator (Galenko et al., 2022). The analysis was carried out using a 5-point scale. The tasting commission consisted of 10 experts of different age categories, who established the weighting indicators for each indicator (appearance, consistency, taste, aroma) and evaluated this indicators. Based on the results of the research, quality profilograpms were constructed and a complex indicator (K_0) was calculated using the formula:

$$K_0 = M_1 \frac{P_1}{P_1^b} + M_2 \frac{P_2}{P_2^b} + M_3 \frac{P_3}{P_3^b} + M_4 \frac{P_4}{P_4^b} ,$$

where P_1, P_2, P_3, P_4 are arithmetic mean score for appearance, consistency, aroma, and taste, respectively;

P_1^b, P_2^b, P_3^b, P_4^b are basic score (standard) for appearance, consistency, aroma and taste, respectively (for all indicators a score of 5 was accepted);

M_1, M_2, M_3, M_4 are weighting indicators for appearance, consistency, taste and aroma, respectively.

Calculation of nutritional and energy values of pea snacks

To study the beneficial properties, including the degree of ensuring the physiological needs for basic nutrients and energy, the nutritional and energy value, the content of water-soluble vitamins and minerals of the developed products were calculated. When making calculations, the "Norms of physiological needs of the population of Ukraine for basic nutrients and energy" approved by the Ministry of Health of Ukraine for women aged 18-29 years of the 1st labor intensity group were used.

Statistical analysis

All measurements were carried out as independent experiments and triplicated accordingly.

Results and discussion

Effect of pregelatinized corn starch on the structural and mechanical properties of pea-based dough

Pregelatinized corn starch was made from waxy corn, for the modification of which physical methods were used. Such starches are rich with amylopectin, where the amylose content does not exceed 5% (according to the product specification declared by the manufacturer), which in turn will affect the structural and mechanical properties of the dough and as a consequence the process of kneading the dough and settling the dough pieces. Therefore, it was considered appropriate to investigate the influence of pregelatinized corn starch on the structural and mechanical properties of the dough. The results of studies of dough elasticity and its adhesive properties are presented in Figure 1.

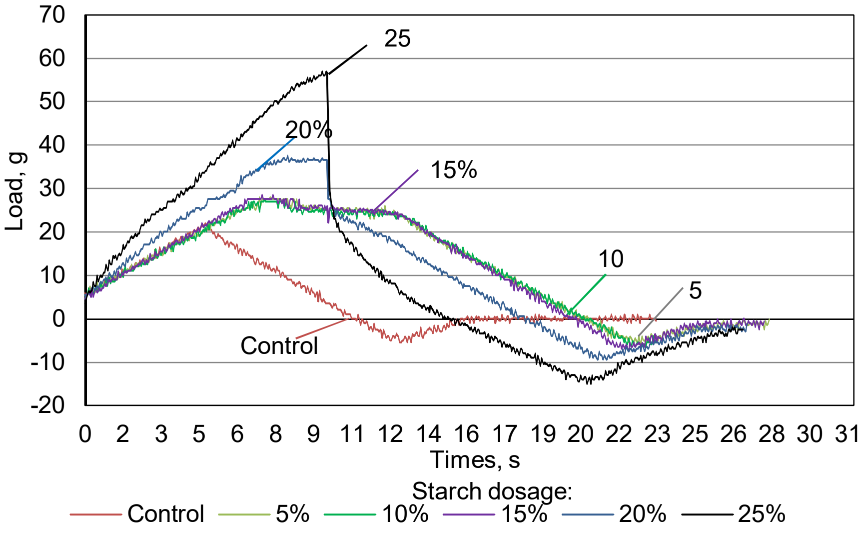

Figure 1. Changes in dough elasticity and adhesion strength depending on the dosage of pregelatinized corn starch

It was found that the introduction of pregelatinized corn starch in an amount of 5 to 15% caused a softer consistency compared to the control, due to the fact that it is cold-swelling – pregelatinized (Sugiura et al., 2017), which positively affected the elastic properties of the dough. Increasing the dosage of pregelatinized corn starch above 15% led to an increase in the amount of moisture that binded to the starch. Therefore, the dough acquired the characteristics of a soft paste, not a hard gel. Thus, its viscosity increased, which reduced the immersion time of the texture analyzer nozzle in the sample and increased the strength of the dough, which is visible in the graph. Thus, amylopectin starch from waxy corn, which contains no more than 5% amylose, forms a gel and if the starch dosage is increased, the gel turns into a paste (Varghese et al., 2022). The addition of 5, 10 and 15% of pregelatinized corn starch to the pea snack recipe moderately increased the dough elasticity to 27 g for all three samples, which was 25.6% more compared to the control sample. At the same time, the immersion time of the nozzle in the test sample was gradually increased to 10 mm. The addition of 20 and 25% of pregelatinized corn starch significantly increased the dough elasticity, namely to 37 and 57 g, respectively, which was 72.1 and 165% more compared to the control sample. During similar studies by a group of scientists from South Korea and India, they proved that in pregelatinized starches there was a hydrophilic tendency of starch and explained this by the hydrothermal treatment of starches (Singh et al., 2009). Similar results were reported by Morales-Polanco et al. (2017), in which gluten-free cracker dough had higher dough elasticity compared to commercial crackers. These results were consistent with those reported by Crocket et al. (2011), who added pea protein to gluten-free products to increase dough elasticity and improve the palatability of the finished product.

During the removal of the load from the studied samples, a decrease in stress occured, which is called relaxation, which was accompanied by the restoration of the dough shape. At the same time adhesive separation occured along the product layer (cohesive type). Thus, samples with the addition of 5, 10 and 15% of pregelatinized corn starch were characterized by gradual adhesion after 7.05, 6.7 and 6.5 s, respectively, and continued up to 12.5 s. While in samples with the addition of 20 and 25% of pregelatinized corn starch, a sharp decrease in adhesion was observed and the higher the dosage, the stronger the separation, which is possibly explained by the increase in dough viscosity and the transition from the gel to the paste state.

The results obtained are confirmed by the studies of Yousif at al. (2012), who analyzed in detail the pregelatinized corn starch pastes and found that this property was desirable and widely used for the production of many food products, while native starch paste had a non-cohesive texture, which limited its application. Morales-Polanco et al. (2017) proved that the cohesiveness of pea dough was 0.35 mm, which was higher than for commercial crackers. These results are consistent with the results reported by Crocket et al. (2011), who added pea protein to gluten-free products to increase the elastic modulus of the dough and improve the palatability of the finished product. To confirm the obtained results, the viscosity of the dough was investigated, the results are shown in Figure 2.

The addition of 5–25% of pregelatinized corn starch increased the viscosity of the dough 1.2, 1.8, 8, 11 and 17 times. The obtained research results confirm the previous ones. It was known that pregelatinized starch contained broken intermolecular bonds of starch molecules, therefore the granular structure was split (Fonseca et al., 2021), the dough absorbed more amount if water, therefore the viscosity of the dough increased, which was characteristic of the studied dough.

In addition, Oliver et al. (1995) argued that the use of pregelatinized starch was intended for thickening gluten-free dough mixtures to prevent the settling of starch granules during the dough mixing phase. This in turn allowed to thicken gluten-free dough. However, increasing the dosage of pregelatinized corn starch by more than 20% is not advisable, since the external characteristics of such dough had a structure that was characterized as pasty. Such a dough structure complicated the process of forming dough pieces, namely the settling of the dough. Therefore, to find the optimal dosage of pregelatinized corn starch to the recipe of pea snacks, additional studies of the effect of this additive on the quality of the finished product are necessary.

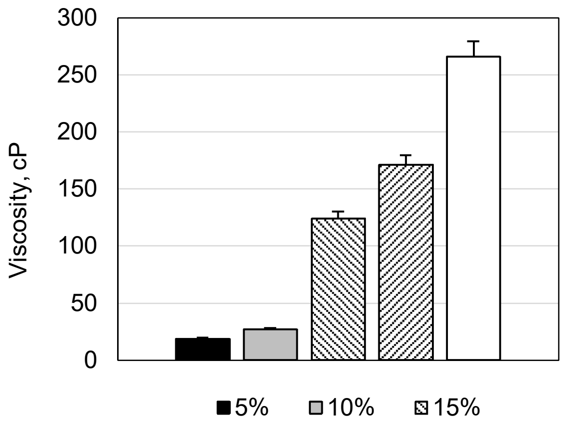

Figure 2. Effect of pregelatinized corn starch dosage on the viscosity of pea dough

Effect of pregelatinized corn starch on the strength of pea snacks

It has been demonstrated that pregelatinized starches can be used in snack technology to give them a “crispy” texture (Christaki et al., 2017; Fustier et al., 1998; Wang et al., 2019). (Christaki et al., 2017; Fustier et al., 1998; Wang et al., 2019). However, both manufacturers and researchers have reported that the incorporation of pregelatinized starch into dough formulations results in a finer but drier texture of the final product, as well as starch retrogradation during storage (Wang et al., 2019). This reduced the time of maintaining the required softness of the finished products. Therefore, the effect of the dosage of pregelatinized corn starch on the strength of pea snacks was investigated. The results of the studies are presented in Figure 3.

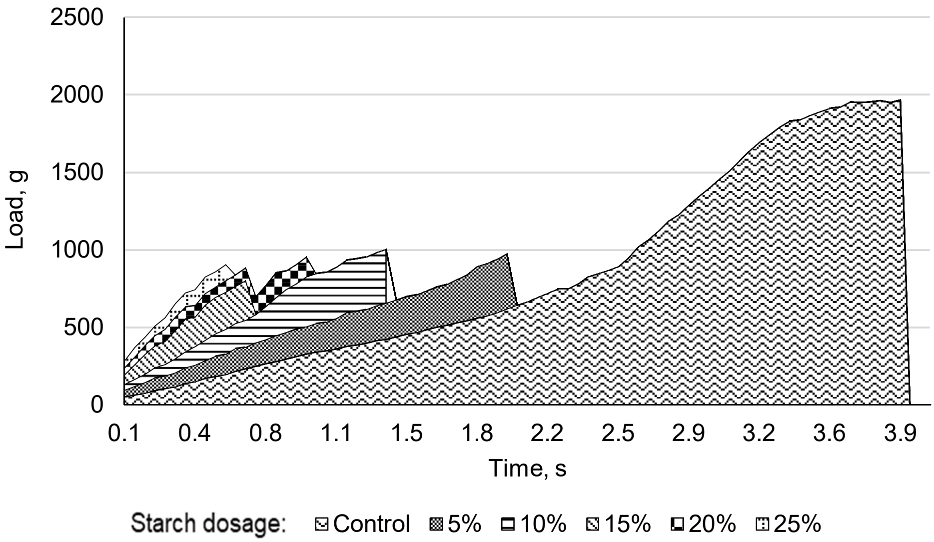

Figure 3. Effect of dosage of pregelatinized corn starch addition on pea snack strength

When 5% pregelatinized starch was added to pea snacks, the strength of the finished products decreased 5.5 times compared to the control sample. Further addition of starch in the amount of 10-25% reduced the strength of the snacks 5.7 times, 7.7 times, 15.1 times and 18.5 times compared to the control sample. Numerous studies have shown that increasing the amount of pregelatinized starch added contributes to greater water absorption in the dough, which in turn leads to an increase in its volume (Chillo et al., 2007; Christaki et al., 2017; Wang et al., 2019). Yousif et al. (2012) found that the water binding and fat binding capacity of pregelatinized corn starch increased to 1.49 and 2.35 g/g, respectively, compared to native starch, for which the water-binding capacity was 1.2 g/g, the fat-binding capacity was 1.6 g/g. The use of such starch in the production of noodles contributed to an increase in the volume of the finished product by up to 10%. The replacement of wheat flour with 5%, 10% and 15% pregelatinized corn starch did not cause any negative effects on the sensory properties of noodles.

During the heat treatment of dough pieces, moisture was removed and the finished product was loosened. Thus, the strength of pea snacks was reduced, which affected the sensory characteristics of the finished product. It was found that the addition of 20% and 25% pregelatinized corn starch resulted in obtaining snacks with a very soft structure, with a strength of only 130 g and 106 g, respectively. Such snacks broke with minimal force, and therefore, their packaging and transportation may be complicated, during which a lot of waste such as scrap and crumbs may be formed. This, in turn, may lead to additional costs for product production and a decrease in their sensory quality in terms of appearance.

Influence of pregelatinized corn starch on the sensory characteristics of pea snacks

As it is known (Meiselman, 2013; Torrico et al., 2023) sensory indicators such as appearance, color, consistency, taste and aroma primarily affect consumer choice. Therefore, the sensory characteristics of snacks made with the addition of different concentrations of starch were evaluated. The quality profile of the finished snacks is presented in Figure 4.

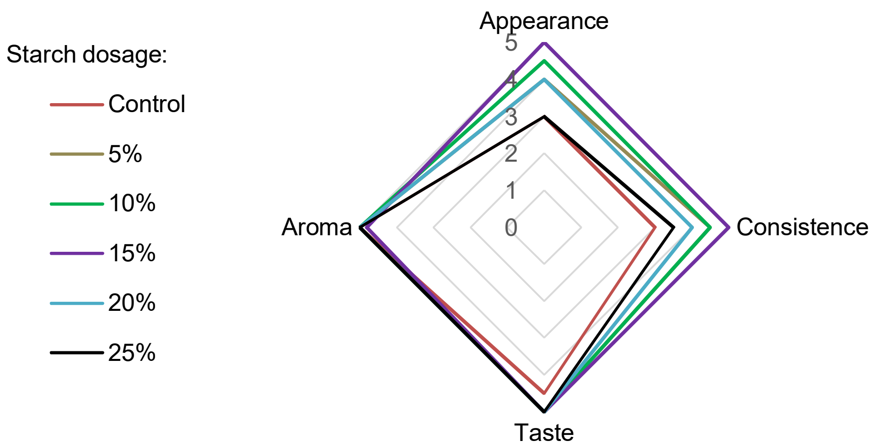

Figure 4. Profilogram of sensory quality assessment of pea snacks made with the addition of pregelatinized corn starch

The introduction of pregelatinized corn starch into the recipe of pea snacks improved the appearance and consistency of the finished products. The more starch was added, the thinner the snacks were obtained, which became more crispy and tender in consistency. However, the introduction of 20 and 25% of pregelatinized corn starch led to a too thin structure. Thus, the snacks became tenderer but dry, easily broke and a lot of crumbs were formed. Pregelatinized corn starch did not affect the taste and aroma. All samples had a pleasant aroma and a clear pea flavor, the color was from light yellow to cream. When comparing snacks made with pregelatinized corn starch and the control sample, even a dosage of 5% pregelatinized corn starch promoted obtaining snacks more crispy in consistency, which confirmed the results of the analysis of the strength of the finished snacks shown on Figure 4.

The results were also confirmed by calculation of a complex sensory quality assessment index for pea snacks with different dosages of pregelatinized corn starch (Figure 5).

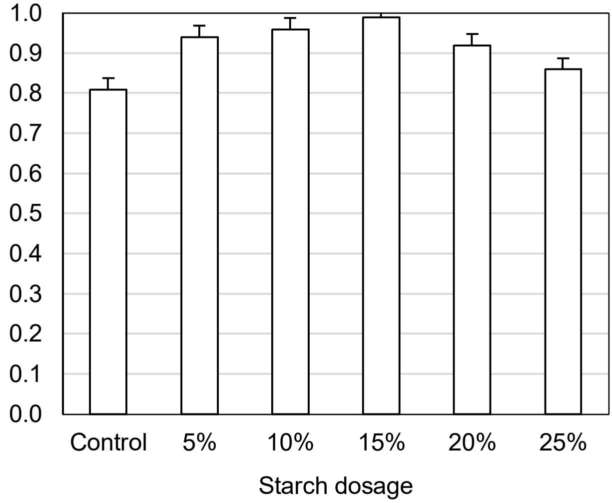

Figure 5. Complex sensory quality assessment index for pea snacks with different dosage of pregelatinized corn starch

Replacing native starch with pregelatinized corn starch with a subsequent increase in dosage to 15% contributed to an increase in complex indicator of sensory quality assessment which was closer to 1. The best result was obtained with a sample containing 15% of pregelatinized corn starch, the complex indicator of which was 0.99. Further increase in starch dosage reduced the complex indicator to 0.92 and 0.86 for 20 and 25 %, respectively.

The obtained data confirmed the results of studies by scientists (Chillo et al., 2007; Christaki et al., 2017; Fustier et al., 1998; Wang et al., 2019), who claimed that pregelatinized starches contributed to the structure formation of the dough by thickening it and increasing the adhesive (gluing) properties for thin wafers, crispy coating for nuts, molded chips, cookies, crackers, galettes, provided that its dosage was strictly controlled. Thus, based on the structural and mechanical properties of the dough, ready-made snacks based on pea flour and their sensory evaluation, it was recommend adding 15% of pregelatinized corn starch, which was the most optimal for achieving high quality of the finished product. In order to establish the quality of the finished product, nutritional and energy value of snacks made with the addition of 15% pregelatinized corn starch, the following indicators were calculated, which are presented in Table 2.

Table 2

Nutritional and energy value of pea snacks

Ingredient	Daily requirement	Control		Snacks with 15% pregelatinized corn starch	
		Content per 100 g of snack	Integral score, %	Contentper 100 g of snack	Integral score, %
Proteins, g	55–57	19.4	35.3	18.4	33.5
Fats, g	56–58	1.9	3.4	1.8	3.2
Carbohydrates, g	320–325	49.5	15.5	54.9	17.2
Energy value, kcal	2450–2500	280.3	-	295.0	-

The replacement of part of the pea flour with 15% pregelatinized corn starch led to a decrease in the protein content, the value of the integral score of which was reduced by only 6%, and for fat – by 5.3%. The carbohydrate content increased by 11%. And this, in turn, led to an increase in the energy value of snacks by 5%. Thus, the introduction of 15% starch reduced the nutritional value, increased the energy value, but these losses overlapped the effect on the structural and mechanical indicators of the finished snacks and their sensory characteristics.

Conclusions

The use of pregelatinized corn starch had a positive effect on the structure of gluten-free dough made from pea flour. Pregelatinized corn starch coused structural characteristics of a gel in pea dough, it became more elastic (the elasticity increased to a maximum of 37 g), and the viscosity increased (up to 171 cP). However, this pattern was observed when adding pregelatinized corn starch in an amount of up to 20%, and a further increase in the dosage of this ingredient led to a deterioration in the consistency of the dough. In addition, since increasing the dosage of the additive reduced the strength of finished products, they became more tender, crispy, but in the amount of 20 and 25% starch, the products had such a low strength (namely 130.5 g and 106 g, respectively) that they became thin and overdried.

The starch used had no taste and did not affect the flavor or aroma of the snacks, while improving their consistency (crispness) up to the addition limit of 15% pregelatinized corn starch.

It is recommended to add pregelatinized corn starch to pea snack formulations in amounts not exceeding 15%. This level ensures the production of gluten-free dough and finished snacks with favorable structural, mechanical, and textural properties. Furthermore, nutritional value assessments support the feasibility of incorporating starch at this level, as the reductions in protein and fat content were relatively minor – 5.2% and 5.3%, respectively – while the carbohydrate content increased by only 10.9%.

References

Agama-Acevedo E., Flores-Silva P. C., Bello-Perez L. A. (2019), Cereal starch production for food applications In: M. Clerici, M. Schmiele (Eds.), *Starches for Food Application*, pp.

71–102, Academic Press, USA, https://doi.org/10.1016/B978-0-12-809440-2.00003-4

Agudelo A., Varela P., Sanz T., Fiszman S. M. (2014), Native tapioca starch as a potential thickener for fruit fillings. Evaluation of mixed models containing low-methoxyl pectin, *Food Hydrocolloids*, 35, pp. 297–304, https://doi.org/10.1016/j.foodhyd.2013.06.004

Block A.E., Bolhuis D.P., Arnaudov L.N., Velikov K.P., Stieger M. (2023), Influence of thickeners (microfibrillated cellulose, starch, xanthan gum) on rheological, tribological and sensory properties of low-fat mayonnaises, *Food Hydrocolloids*, 136(2), 108242, https://doi.org/10.1016/j.foodhyd.2022.108242

Chehtman A. (2022), Top six trends shaping the global snacks industry, *Euromonitor International*, Available at: https://www.euromonitor.com/article/top-six-trends-shaping-the-global-snacks-industry

Chillo S., Laverse J., Falcone P.M., Del Nobile M.A. (2007), Effect of carboxymethylcellulose and pregelatinized corn starch on the quality of amaranthus spaghetti, *Journal of Food Engineering*, 83(4), pp. 492–500, https://doi.org/10.1016/j.jfoodeng.2007.03.037

Christaki M., Verboven P., Van Dyck T., Nicolai B., Goos P., Claes J. (2017), The predictive power of batter rheological properties on cake quality – The effect of pregelatinized flour, leavening acid type and mixing time, *Journal of Cereal Science*, 77, pp. 219–227, https://doi.org/10.1016/j.jcs.2017.07.001

Crocket R., Le P., Vodovotz Y. (2011), Effect of soy protein isolate and egg wite solids on the physicochemical properties of gluten-free bread, *Food Chemistry*, 129, pp. 84-91, https://doi.org/10.1016/j.foodchem.2011.04.030

Félix-Medina J.V., Montes-Ávila J., Reyes-Moreno C., Perales-Sánchez J.X.K., Gómez-Favela M.A., Aguilar-Palazuelos E., Gutiérrez-Dorad R. (2020), Second-generation snacks with high nutritional and antioxidant value produced by an optimized extrusion process from corn/common bean flours mixtures, *Lebensmittel- Wissenschaft & Technologie,* 124, 109172, https://doi.org/10.1016/j.lwt.2020.109172

Fonseca L.M., Halal S.L.M.E., Dias A.R.G., Zavareze E.D.R. (2021), Physical modification of starch by heat-moisture treatment and annealing and their applications: A review, *Carbohydrate Polymers*, 274, 118665, https://doi.org/10.1016/j.carbpol.2021.118665

Fustier P., Gélinas P. (1998), Combining flour heating and chlorination to improve cake texture, *Cereal Chemistry*, 75(4), pp. 568–570, http://dx.doi.org/10.1094/CCHEM.1998.75.4.568

Galenko O., Shevchenko A., Ceccanti C., Mignani C., Litvynchuk S. (2024), Transformative shifts in dough and bread structure with pumpkin seed protein concentrate enrichment, *European Food Research and Technology*, 250, 1177–1188, https://doi.org/10.1007/s00217-023-04454-z

Ivanov V., Shevchenko O., Marynin A., Stabnikov V., Gubenia O., Stabnikova O., Shevchenko A., Gavva O., Saliuk A. (2021), Trends and expected benefits of the breaking edge food technologies in 2021–2030, *Ukrainian Food Journal*, 10(1), pp. 7-36, https://doi.org/10.24263/2304-974X-2021-10-1-3

Lyu Z., Sala G., Scholten E. (2024), Texture of emulsion-filled pea protein-potato starch gels: Effect of processing conditions and composition, *International Journal of Biological Macromolecules*, 277(2), 133889, https://doi.org/10.1016/j.ijbiomac.2024.133889

Magallanes-Cruz P.A., Flores-Silva P.C., Bello-Perez L.A. (2017), Starch structure influences its digestibility: A review, *Journal of Food Science,* 82, pp. 2016–2023, https://doi.org/10.1111/1750-3841.13809

Marynin A., Shpak V. (2022), Influence of electrochemically activated water on the rheological indicators of starch suspensions, *Ukrainian Journal of Food Science*, 10(2), pp. 149-160, https://doi.org/10.24263/2310-1008-2022-10-2-5

Marynin A., Shpak V., Pasichnyi V., Svyatnenko R., Shubina Y. (2023), Physico-chemical and rheological properties of meat pates with corn starch suspensions prepared on electrochemically activated water, *Ukrainian Food Journal*, 12(2), pp. 207-226, https://doi.org/10.24263/2304-974X-2023-12-2-5

Maskus H., Arntfield S. (2015), Extrusion processing and evaluation of an expanded, puffed pea snack product, *Journal of Nutrition & Food Sciences, 5*(4), 1000378, https://doi.org/10.4172/2155-9600.1000378

Meiselman H.L. (2013), The future in sensory/consumer research: evolving to a better science, *Food Qual Prefer*, 27(2), pp. 208-214, https://doi.org/10.1016/j.foodqual.2012.03.002

Morales-Polanco E., Campos-Vega R., Gaytán-Martínez M., Enriquez L.G., Loarca-Piña G. (2017), Functional and textural properties of a dehulled oat (*Avena sativa* L) and pea (*Pisum sativum*) protein isolate cracker, *LWT – Food Science and Technology,* 86, pp. 418-423, https://doi.org/10.1016/j.lwt.2017.08.015

Naseer B., Naik H.R., Hussain S.Z., Bhat T., Nazir N. (2021), Development of instant *phirni* mix (a traditional dairy dessert) from high amylose rice, skim milk powder and carboxymethyl cellulose-resistant starch, predicted glycemic index and stability during storage, *Food Bioscience*, 42, 101213, https://doi.org/10.1016/j.fbio.2021.101213

Oliver G., Sahi S.S. (1995), Wafer batters: A rheological study, *Journal of Science Food Agriculture*, 67, pp. 221–227, https://doi.org/10.1002/jsfa.2740670212

Farshi P., Mirmohammadali S.N., Rajpurohit B., Smith J.S., Li Y. (2024), Pea protein and starch: Functional properties and applications in edible films, *Journal of Agriculture and Food Research*, 15, 100927, https://doi.org/10.1016/j.jafr.2023.100927

Rubanka K., Shevchenko O. (2022), Application of potato pulp in technology of snacks, *Scientific Works of National University of Food Technologies,* 28(2), pp. 132–141, https://doi.org/10.24263/2225-2924-2022-28-2-12

Shevkani K. (2023), Protein from land—legumes and pulses Author links open overlay panel. In: B.K. Tiwari., L.E. Healy (Eds.), *Future Proteins Sources, Processing, Applications and the Bioeconomy*, pp. 35-68, Academic Press, USA, https://doi.org/10.1016/B978-0-323-91739-1.00003-9

Singh G.D., Bawa A.S., Riar C.S., Saxena D.C. (2009), Influence of heat-moisture treatment and acid modifications on physicochemical, rheological, thermal and morphological characteristics of Indian water chest nut (*Trapa natans*) starch and its application in biodegradable films, *Starch,* 61, pp. 503–513, https://doi.org/10.1002/star.200900129

Sobczyk A., Pycia K., Stankowski S., Jaworska G., Kuźniar P. (2017), Evaluation of the rheological properties of dough and quality of bread made with the flour obtained from old cultivars and modern breeding lines of spelt (*Triticum aestivum* ssp. spelta), *Journal of Cereal Science*, 77, pp. 35-41, https://doi.org/10.1016/j.jcs.2017.07.013

Sugiura F., Ito S., Arai E., (2017), Effect of pregelatinized starch paste on the ease of swallowing high-moisture content bread, *Journal of Food Engineering*, 214, pp. 209-217, https://doi.org/10.1016/j.jfoodeng.2017.06.021

Tsykhanovska I., Lazarieva T., Stabnikova O., Kupriyanov O., Litvin O., Yevlash V. (2023), Potential benefits of functional antianemic energy bars, *Ukrainian Food Journal*, 12(4), pp. 578-598, https://doi.org/10.24263/2304-974X-2023-12-4-7

Torrico D., Mehta A., Borssato A.B. (2023), New methods to assess sensory responses: a brief review of innovative techniques in sensory evaluation, *Current Opinion in Food Science*, 49, 100978, https://doi.org/10.1016/j.cofs.2022.100978

Varghese S., Awana M., Mondal D., Rubiya M.H., Melethil K., Singh A., Krishnan V., Thomas B. (2022), Amylose–amylopectin ratio. In: S. Thomas, A. Ar, C.J. Chirayil, B. Thomas (Eds.), *Handbook of Biopolymer*, pp. 1305–1334, Springer, Singapore, https://doi.org/10.1007/978-981-16-6603-2_48-1

Venkatachalam A., Wilms P.F.C., Tian B., Bakker E.J., Schutyser M.A.I., Zhang L. (2025), Customizing fracture properties of pea-based snacks using 3D printing by varying composition and processing parameters, *Food Research International*, 202, 115715, https://doi.org/10.1016/j.foodres.2025.115715

Wang H., Xiao N., Wang X., Zhao X., Zhang H. (2019), Effect of pregelatinized starch on the characteristics, microstructures, and quality attributes of glutinous rice flour and dumplings, *Food Chemistry*, 283(4), pp. 248-256, https://doi.org/10.1016/j.foodchem.2019.01.047

Wani S.A., Kumar P. (2018), Influence on the antioxidant, structural and pasting properties of snacks with fenugreek, oats and green pea, *Journal of the Saudi Society of Agricultural Sciences*, 18, pp. 389–395, https://doi.org/10.1016/j.jssas.2018.01.001

Yifei F., Francesco P. (2020), Modification of starch: A review on the application of «green» solvents and controlled functionalization, *Carbohydrate Polymers,* 241, 116350, https://doi.org/10.1016/j.carbpol.2020.116350

Yousif E.I., Gadallah M.G.E., Sorour A.M. (2012), Physico-chemical and rheological properties of modified corn starches and its effect on noodle quality, *Annals of Agricultural Science*, 57(1), pp. 19-27, https://doi.org/10.1016/j.aoas.2012.03.008

Cite:

UFJ Style

Rubanka K., Pysarets O., Levkivska T., Samoilik O., Shpak V. (2025), Effect of pregelatinized corn starch on the technological and quality properties of pea dough and snacks, *Ukrainian Journal of Food Science*, 13(1), pp. 55–66, https://doi.org/10.24263/2310-1008-2025-13-1-7

APA Style

Rubanka, K., Pysarets, O., Levkivska, T., Samoilik, O., & Shpak, V. (2025). Effect of pregelatinized corn starch on the technological and quality properties of pea dough and snacks. *Ukrainian Journal of Food Science, 13*(1), 55–66. https://doi.org/10.24263/2310-1008-2025-13-1-7