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Physical and Chemical Properties of Extruded Pea Product

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Abstract. Peas (*Pisum sativum* L.) are a good source of protein, dietary fibre, and certain minerals, thus making them valuable nutrients in human diet. Unfortunately, peas are not commonly used in human diet due to their long cooking time. New products should be manufactured to increase the presence of peas in human diet. In order to make the grey peas easier for people to consume, extrusion cooking was used. Due to varying recipes, different products were obtained. Peas of the variety 'Bruno' with and without the addition of wheat and oat flour and egg powder were used in the experiments. Protein, fat and starch content of these products was analysed chemically but their pH, size, hardness, and volume mass was measured using physical methods. The average pH for all the samples was 7.3 ± 0.5, size differences ranged from 5.4 ± 0.4 mm to 10.3 ± 0.5 mm in length and 6.4 ± 0.2 to 11.7 ± 0.8 mm in width. More fat was found in the sample with onion flavour – up to 9.5 ± 0.5 g 100 g^{-1} – but the least amount of fat was found in the sample without any seasoning – 0.6 ± 0.05 g 100 g^{-1} on average. The average starch content was 23 ± 2 g 100 g^{-1}, while the highest protein content was discovered in the sample where grains and egg powder had not been added – 26.9 ± 0.2 g 100 g^{-1}, and the lowest – 18.6 ± 0.5g 100 g^{-1} – in the sample with the largest grain proportion. The samples with the highest volume mass were the ones with added egg powder – 43 ± 2 N and 387 ± 2 g L^{-1}. The obtained results show that the largest and crispiest sample was acquired using only pea flour, and pea and wheat flour mixed in the proportion 1:1.

Key words: Peas, extrusion-cooking, characteristics.

INTRODUCTION

As peas contain substantial levels of protein, their potential nutritional value is high. Peas also contain rather high levels of starch, although it varies from 33 g 100 g^{-1} to 48 g 100 g^{-1} in dry matter. For winter and spring cultivars the difference is usually less considerable, for example, in winter cultivars of the white pea the reported starch content is 47.5 g 100g^{-1} for dry matter but for spring cultivars it is 50.0 g 100 g^{-1} for dry matter (Gatel & Grosjean, 1990). Potentially, peas are a very valuable foodstuff in terms of their energy-yielding potential. X-ray diffraction studies (French, 1984) show there are crystalline regions within the starch granule that are more resistant to acidic and enzymatic hydrolysis, leading to reduced starch digestibility in raw peas. Trypsin inhibitor activity levels may be reduced by heat processing, and the susceptibility of starch to enzymes can be increased by gelatinisation, or any other process that destroys the granular structure of starch (Holm et al., 1985); heating may also lead to the loss of α-amylase inhibitors (Alonso et al., 2000; Al-Marzooqi & Wiseman, 2009).

Extrusion technology is well-known in the plastics industry but it has also become a widely-used technology in agri-food production where it is referred to as extrusion-cooking. It has been employed for the production of so-called engineered food and special feed. The extrusion-cooking of raw vegetable materials means the extrusion of ground material at baro-thermal conditions. With the help of shear energy exerted by the rotating screw, and the additional heating of the barrel, the foodstuff is heated to its melting or plasticating point (Van Zuilichem, 1992; Moscicki, 2011).

In this changed rheological status the food is conveyed through a die under high pressure. Then the product expands to its final shape. As a result, the physical and chemical properties of the extrudates are very different compared to those of the raw materials. Extrusion-cookers are high-temperature short-time equipment capable of performing cooking tasks under high pressure. This is advantageous for vulnerable food and feed, as exposure to high temperatures for a short time restricts unwanted denaturation effects on, for example, proteins, amino acids, vitamins, starches, and enzymes (Moscicki, 2011).

Unfortunately, peas are not commonly used in human diet due to their extended cooking time. The aim of the study was to develop new products to increase the presence of peas in human diet, and their chemical and physical properties were studied and described.

MATERIALS AND METHODS

In order to create new grey pea products that would be easier to consume, extrusion-cooking was used for treatment. Various recipes were used to acquire different products. Peas of the variety 'Bruno' with and without the addition of wheat and oat flour and egg powder were used in the experiments.

Peas of the variety 'Bruno' from the State Priekuli Plant Breeding Institute were used in the experiments, as well as oat and wheat flour. The extrusion-cooking was carried out at Milzu Ltd. using a twin-screw extruder. Cinnamon, walnut, sugar, cocoa and baking powder were purchased from Gemoss Ltd.

Physical and chemical analyses were carried out at the Latvia University of Agriculture. Protein content (LVS EN ISO 5983-2:2009), volume mass (gravimetrical), size (measurement), pH (ГОСТ 26180-84, met.), fat content (ISO 6492:1999), starch content (LVS EN ISO 10520), hardness (Texture Analyzer, TA.XT.plus, pre-test speed 1.5 mm sec^{-1}; test speed 1 mm sec^{-1}; post-test speed 10 mm sec^{-1}; difference 5 mm; die: P/2 DIA) were measured and analysed. The recipes and abbreviations for the base samples are shown in Table 1.

As in pre-experiments the obtained samples were rather small and hard, so different additives were used to increase product size, aeration, thus lowering volume mass and hardness. Egg powder was added to increase the amino acid content of pea products. Other parameters such as pH were used to ascertain whether there are differences in the products that could be caused by the ingredients and treatment.

Table 1. Used ingredients and abbreviations for samples

Sample No.	Used ingredients (%)											
	A	B	C	D	E	F	G	H	I	J	K	L
1	91	9										
2	89	9		1								
3	78	9	1	1		7	5					
4	72	9	0.2	1	4	9	4					
5	69	9	0.2	1	4	9	4		4			
6	66	8	0.3	1	4	8	4		4		4	0.1
7	66	8	0.2	1	4	8	4		4	4		
8	39	5	0.2					39	8		8	0.2
9	44	6	0.2			44			6			
10	71	8	0.2			8	4		4	4		

A – Grey peas; B – Water; C – Salt; D – Baking powder; E – Egg powder; F – Wheat; G – Oat; H – Maize; I – Sugar; J – Cocoa; K – Walnut; L – Cinnamon.

In addition, salty and sweet seasonings were added to enrich the products. The abbreviations for the seasoned samples are shown in Table 2.

Table 2. Abbreviations for seasoned samples

Base sample	Grill	Onion	Almond	Chocolate
1	1-G	1-O	-	-
2	2-G	2-O	-	-
3	3-G	3-O	-	-
4	4-G	4-O	-	-
5	-	-	5-A	-
7	-	-	-	7-C
9	-	-	9-A	-
10	-	-	-	10-C

Grill and fried onion spices from Bairons LBC were used to make salty products but cocoa and almond flour from Gemoss Ltd. were used to make sweet products.

The mathematical analyses of the data was conducted using ANOVA in MS Excel, and all the chemical parameters were calculated on the basis of dry matter. 95% was used as the level of significance.

RESULTS AND DISCUSSION

The volume mass of peas can be reduced from 667 ± 1 g L^{-1} in non-extruded peas to 127 ± 1 g L^{-1} (Fig. 1) in the extrudes of peas, and in a mixture composed of 50% peas and 50% of wheat flour. No significant differences were observed in the samples in which only pea flour was used compared to the samples with added baking powder, which is used in the food industry to achieve better aeration.

Depending on the additives used in the extrusion mix, samples with different volume mass were obtained. The heaviest samples were the ones with added walnut and egg powder, as these hardened the mixture. The samples where oat flour was added had a slightly bigger volume mass but no significant differences were discovered. That was also true when examining seasoned samples and their sample bases, as the coating layer was thin.

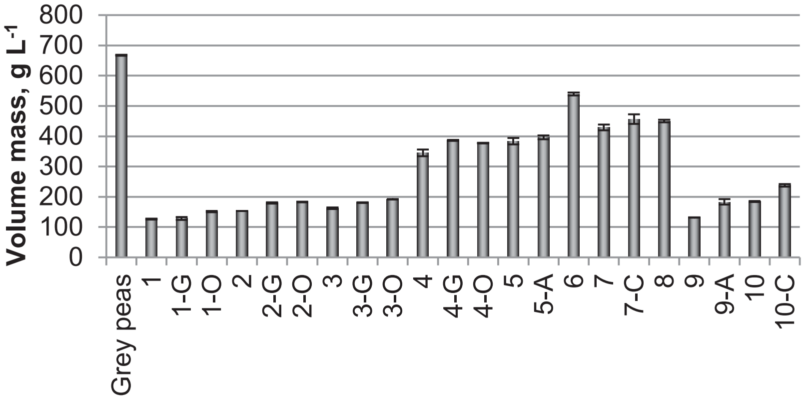

Figure 1. Volume mass of extruded pea (*Pisum sativum* L.) samples.

The samples to which egg powder had been added before extrusion were of significantly smaller size (Fig. 2) compared to those that did not have this additive. However, the samples with wheat and oat flour added to the extrusion mix were not symmetrical in size, as their length and width differed up to 5.6 mm from the samples extruded from pea flour only. The last ones were of similar size to those that had more wheat flour (44%) added to the extrusion mix.

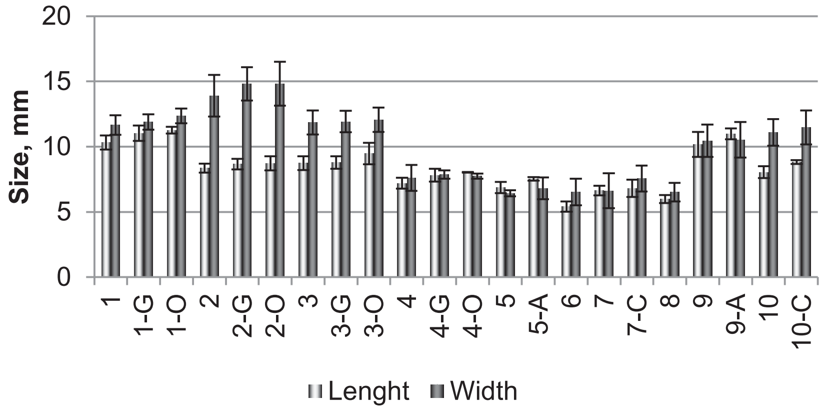

Figure 2. Sizes of extruded pea (*Pisum sativum* L.) samples.

The pellet length of samples without egg powder was 10.3 ± 0.5 mm and width 11.7 ± 0.7 mm but the length of samples with added egg powder was 7.2 ± 0.4 mm and width 7 ± 1 mm.

Significant differences were observed in comparing the size of different samples. For the length $\alpha = 0.05$, $p = 2.5 \cdot 10^{-75}$ but for the width $\alpha = 0.05$, $p = 6 \cdot 10^{-111}$; between samples $\alpha = 0.05$, $p = 3 \cdot 10^{-128}$. However, no significant differences were discovered in comparing base samples and coated ones.

All the coated samples had lower pH compared to the base samples they were made of. The biggest differences were observed in samples where egg powder was used in the extrusion mix. In the samples with grill coating pH was 0.9 units lower but in the samples with onion coating it was 0.7 units lower. Other sample differences did not exceed 0.6 units. Even though there are mathematical differences ($p = 3 \cdot 10^{-26}$ $\alpha = 0.05$), they are most likely caused by the standard error that did not exceed 0.1.

The pH for extruded pea (*Pisum sativum* L.) samples ranged from 6.27 to 7.84. The highest pH was observed in the sample with added egg powder but in the other extrudates pH was lower than 6 (Fig. 3). All the samples were pH neutral and no samples had pH lower than 5.

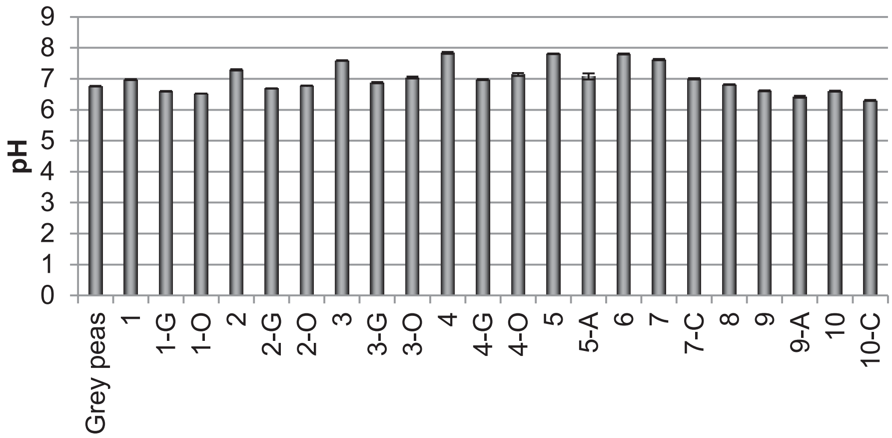

Figure 3. pH of extruded pea (*Pisum sativum* L.) samples.

The hardness of different samples was observed to range from 7.0 ± 1.7 N to 58.9 ± 10.1 N (Fig. 4.). The lowest level of hardness was recorded in the samples that were extruded from pea flour only, without any additional flour and other additives, the hardness being 7.9 ± 0.8 N, and in samples with 44% added wheat flour—7.0 ± 1.7 N.

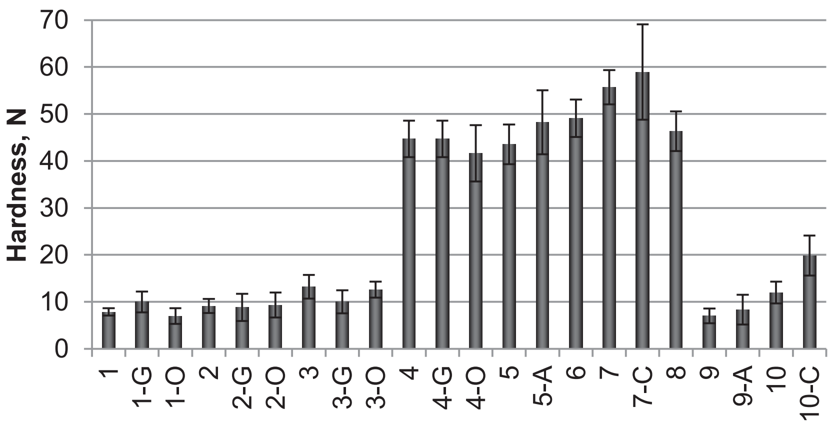

Figure 4. Hardness of extruded pea (*Pisum sativum* L.) samples.

The hardness of samples with added baking powder was 9.1 ± 1.5 N. The hardest samples were the ones with added egg powder, the hardness being 55.7 ± 3.6 N. Significant differences $\alpha = 0.05$; $p = 7.01 \cdot 10^{-9}$ were observed in comparing the samples. Only the sample with chocolate coating was harder by 7.9 N compared to its base, still no significant differences were observed between them.

No significant differences were found in the comparison of non-extruded pea and extruded pea protein content but maize flour decreased the protein content in the samples by more than 30%, as maize had only 8.1 ± 0.2 g 100 g^{-1} protein in dry matter (Fig. 5).

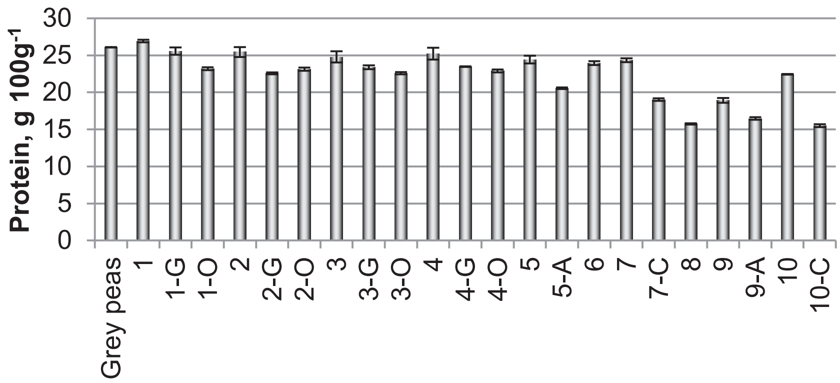

Figure 5. Crude protein content in extruded peas (*Pisum sativum* L.)

The samples with added egg powder had 25.2 ± 0.7 g 100 g^{-1} protein in dry matter, while the sample made from pea flour had 26.9 ± 0.2 g 100 g^{-1} crude protein in dry matter. The average protein content for base samples was 24.7 g 100 g^{-1} in dry matter. Lower protein content was observed in the coated samples. Overall, in the samples with grill seasoning the protein content was higher than in those with onion coating. Only the sample with added baking powder and onion coating had slightly larger protein content than the one with grill flavour. The biggest differences were found in the samples with chocolate coating – the protein content had decreased to 15.5 ± 0.5 g 100g^{-1}, whereas it had originally been 22.5 ± 0.2 g 100 g^{-1}.

However, the fat content in the extruded peas without coating reduced in the extrusion process from 1.06 ± 0.02 g 100 g^{-1} to 0.6 ± 0.1 g 100 g^{-1} (Fig. 6). The samples with added walnuts had the highest fat content – 5.15 ± 0.01 g 100 g^{-1}. The samples with added egg powder had a fat content greater than 1 g 100 g^{-1}. In the samples that had no fat-containing additives the fat content was lower than 1 g 100 g^{-1}.

As oil and syrup were used for coating the samples, the results show that, as expected, the total fat content in the coated samples is higher than in the ones without coating. There was an up to 9.5 ± 0.5 g 100 g^{-1} additional fat content in the samples with onion coating. The lowest fat content observed in the coated samples was in the chocolate sample without egg powder – 2.1 ± 0.2 g 100 g^{-1} fat in dry matter.

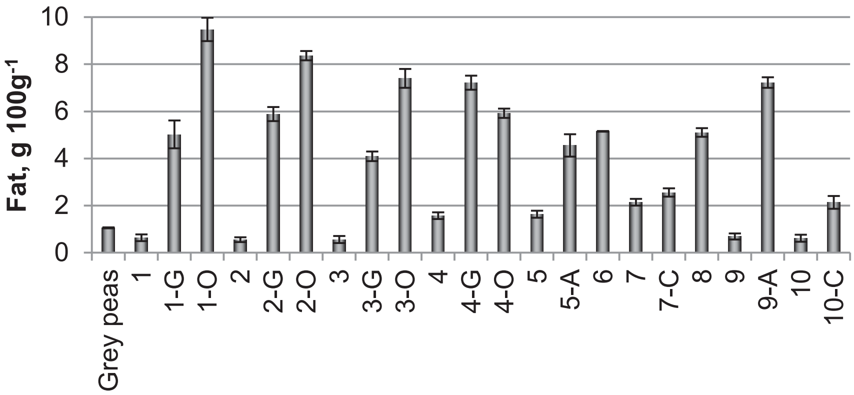

Figure 6. Fat content of extruded pea (*Pisum sativum* L.) samples.

The starch content in the extruded peas ranged from 20.5 ± 0.5 g 100 g^{-1} to 26.1 ± 0.7 g 100g^{-1} (Fig. 7). The highest starch content was found in the samples with added wheat.

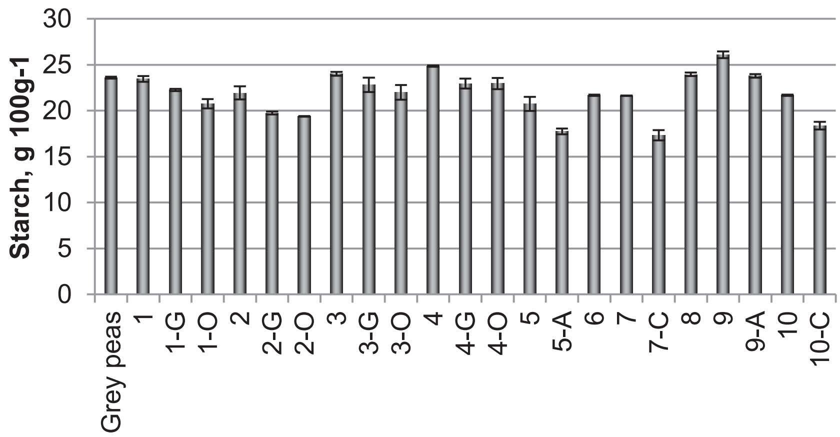

Figure 7. Starch content of extruded pea (*Pisum sativum* L.) samples.

Significant differences α=0.05; p=1.05–10^{-7} were observed in comparing the samples. As expected, the starch content decreased in the coated samples, especially in the sweet samples, as they had more coating than salty ones.

CONCLUSIONS

If the amount of pea flour in the extruded products exceeds 60%, the protein content does not differ significantly from that of non-extruded peas. The coating decreases the protein and starch content in the samples while it increases the total fat content.

The volume mass of peas can be reduced to 127 ± 1 g L^{-1} but significantly smaller samples are obtained with the use of egg powder as well as walnuts. For samples without egg powder, the length was 10.3 ± 0.5 mm and the width was 11.7 ± 0.7 mm but for samples with added egg powder the length was 7.2 ± 0.4 mm and the width was 7 ± 1 mm.

Accordingly, samples made only of peas were 7.9 ± 0.8 N hard, but samples with added egg powder were the hardest – 55.7 ± 3.6 N.

The starch content in the extruded peas ranged from 20.5 ± 0.5 g 100 g^{-1} to 26.1 ± 0.7 g 100g^{-1}. The samples with added egg powder had 25.2 ± 0.7 g 100g^{-1} protein in dry matter, while the sample made of pea flour had 26.9 ± 0.2 g 100 g^{-1} crude protein in dry matter.

The obtained physical characteristics suggest that the best sample was obtained using only pea flour, and pea and wheat flour mixture in the proportion 1:1, whereas adding baking powder did not increase the aeration. No significant increase in protein content was observed with egg powder.

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