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The Effects of Different Amounts of Additional Moisture on the Physical Properties of Cow Pea (*Vigna unguiculata* (L.) Walp.) Extrudates

L. Strauta, S. Muižniece-Brasava

***Abstract*—**Even though legumes possess high nutritional value and have a rather high protein content for plant origin products, they are underutilized mostly due to their lengthy cooking time. To increase the presence of legume-based products in human diet, new extruded products were made of cow peas (*Vigna unguiculata* (L.) Walp.). But as it is known, adding different moisture content to flour before extrusion can change the physical properties of the extruded product. Experiments were carried out to estimate the optimal moisture content for cow pea extrusion. After extrusion, the pH level had dropped from 6.7 to 6.5 and the lowest hardness rate was observed in the samples with additional 9 g $100g^{-1}$ of moisture - 28±4N, but the volume mass of the samples with additional 9 $g100g^{-1}$ of water was 263±3 g L^{-1}; all samples were approximately 7±1mm long.

***Keywords*—**Cow pea, extrusion-cooking, moisture, size.

I. Introduction

THE inclusion of legumes in daily diet has many beneficial physiological effects in controlling and preventing various metabolic diseases such as diabetes mellitus, coronary heart disease, and colon cancer [1]. In addition, legumes belong to the food group that elicits the lowest blood glucose response. The consensus on healthy eating habits favors an increase in the proportion of legume-based carbohydrates, including starch, in the diet. The role of legumes as a therapeutic agent in the diet of people suffering from metabolic disorders has been reported previously [2]-[4].

Cow peas (*Vigna unguiculata* (L.) Walp.) are used worldwide as food. They have also been widely researched [5], particularly as part of recent efforts to investigate underexploited legume species as potential energy and food sources in response to their nutritional value [6]. The cow pea is a relatively inexpensive legume with high protein and carbohydrate contents. Because of their physicochemical and functional attributes, legume starches can be used as nutritional ingredients in the same way as starches from cereals and tubers [7]. Also, when legume starch molecular and/or granular characteristics are modified it increases starch indigestibility, which can be a desirable property [8]. Extruded products are popular, since they are ready-to-eating, they have crispy texture, usually they are nicely shaped and colored. However, they are often regarded as junk food because their composition is mainly based on carbohydrates and added fats. The incorporation of fruit powders into snacks and breakfast cereals can improve their nutritional quality and attractiveness. Fruit powders and extracts contain a high amount of bioactive components such as phenolics and anthocyanins. Besides being a source of antioxidants, their addition also provides an acceptable organoleptic quality [9]-[12].

A number of alternative technologies have been proposed for the use of hard-to-cook beans, such as dry and wet fractionating, soaking in saline solutions, alkaline thermal treatment and extrusion. Extrusion is of particular interest, since it is already widely used to incorporate hard-to-cook seeds into cereals, which are then used to produce precooked flour, baby food, and expanded snacks. These extruded products have advantages in terms of sensory characteristics (texture, flavor, smell, and colour) and nutritional properties (increased protein content and balanced amino acid profile) [13]. The technology for each of them requires an appropriate distribution of temperature, pressure, and moisture content of the material during processing [14]. So, the aim of research was to find the optimal moisture content to add to cow bean flour before extrusion.

II. Materials and Methods

A. Experimental Design

Experiments were carried out in the laboratories of Department of Food Technology and Agronomical Analysis Scientific Laboratory at Latvia University of Agriculture. Cow peas (*Vigna unguiculata* (L.) Walp.) were obtained from Universidade de Trás-os-Montes e Alto Douro (UTAD), Portugal. In order to make pea flour, cow peas were milled at Ltd. “Grauda spēks” with sieve size 1mm, and extruded with a twin screw extruder at Ltd. “Milzu”. The schema for experiments is shown in Fig.1.

Before extrusion, cow pea flour moisture content was analyzed. 5g of flour sample was weighted in container. Before analyses, container was heated at 103 ºC, cooled till room temperature in desiccator. Sample was heated in dryer at 103 ºC temperature for 4 hours. Then, sample was taken out, and cooled in a desiccator in room temperature and weighed, as method requires, with the analytical scale with four significant numbers. This operation was repeated at least two

L. Strauta and S. Muižniece-Brasava are with the Latvia University of Agriculture, Faculty of Food technology, Department of Food technology, Jelgava, Latvia, LV-3001 (e-mail: strauta.liene@gmail.com, sandra.muizniece@llu.lv).

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times, samples are reheated for 1h, cooled and weighted. Final sample weight was recorded when at least two last weights were the same. Moisture content was calculated using (1):

$$w = \frac{m_2 - (m_1 - m_3)}{m_2} \cdot 100 \quad (1)$$

where: w – moisture content of sample, g $100g^{-1}$; m_1 – empty container weight, g; m_2 – sample weight before heating, g; m_3 –sample and container weight after heating, g.

Moisture content for samples were measured after extrusion too with the same principle and calculation.

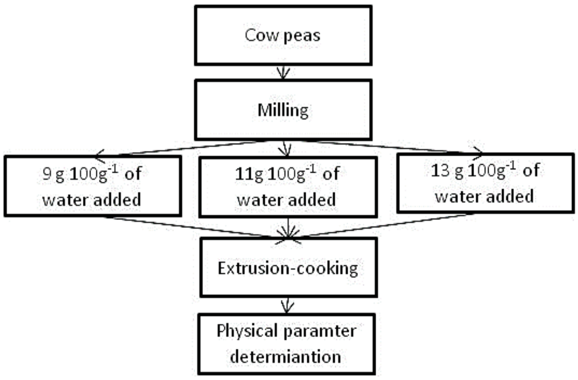

Fig. 1 Experiment scheme

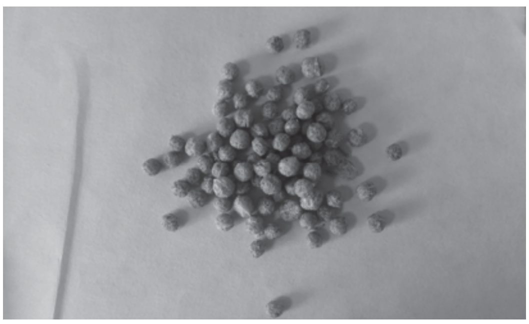

Fig. 2 Obtained cow pea product

Three different amounts of water were added: 9g $100g^{-1}$, 11g $100g^{-1}$ and 13g $100g^{-1}$ respectively. Flours were truthfully mixed with water and extruded with twin screw extruder and dried for 15 min.

One of the obtained cow pea (*Vigna unguiculata* (L.) Walp.) products is shown in Fig. 2. In order to describe the physical properties of the obtained products, their volume mass, size, pH, and hardness were measured.

Volume mass was analyzed using 1L baker with marks and scale ACCULAB L-Series. 1L baker was placed on a scale, tarred and the extruded sample was poured in till the 1L mark. Mass was recorded in three repetitions and average was calculated.

In order to do pH measurements, sample was crushed in mortar until it was homogeneous. Then 10 g of the sample were weighed (rounding the weight to the nearest 0.01 g) in a tarred 150 mL beaker. Water was added till 100mL; sample was thoughtfully mixed, covered with parafilm and left overnight. Next day sample was filtrated and pH was measured in filtrate using pH-meter Jenway 3510.

Sample size was measured using electronic slide gauge. Length and width was measured in ten repetitions and average result was calculated.

Hardness of samples was measured using TA.XT. plus Texture Analyser (Stable Micro Systems Ltd.), using 2mm needle.

B. Statistical Analysis

The results were processed by mathematical and statistical methods using MS Excel 2007 one way ANOVA.

$$S = \sqrt{\frac{\sum_{i=1}^{N}(x_i - x_a)^2}{(n-1)}} \quad (2)$$

where: S – standard deviation; x_i – value for sample i; x_a – average of values; n – number of repetitions.

Standard deviation equation (2) was calculated and used as measure for errors and significance calculations.

III. Results and Discussion

Cow pea (*Vigna unguiculata* (L.) Walp.) moisture content before extrusion was 11.60g $100g^{-1}$. After the cow pea flour had been divided in three samples, each with a different amount of water added to it, the total moisture content in the samples was respectively 20.6g $100g^{-1}$, 22.6 g $100g^{-1}$ and 24.6 g $100g^{-1}$. After extrusion, the sample with 9g $100g^{-1}$ of additional moisture (Fig. 3) contained 8.13 ± 0.03 g $100g^{-1}$ of water. The sample that had had 11g $100g^{-1}$ of water added to it now contained 8.39 ± 0.05 g $100g^{-1}$. Lastly, the sample with 13g $100g^{-1}$ of additional water after extrusion contained 9.27 ± 0.07 g $100g^{-1}$ of moisture. The mathematical analyses of the data show significant differences in this parameter ($p=4\cdot10^{-4}$; $\alpha=0.05$).

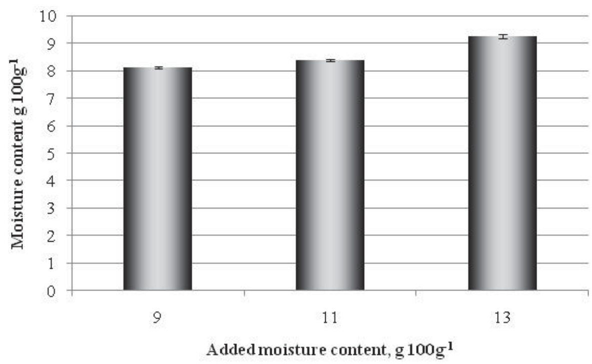

Fig. 3 Moisture content (g $100g^{-1}$) in extruded samples

To determine if any degradable chemical changes had taken place, the pH was measured (Fig. 4). After extrusion, the pH levels had dropped from 6.7 to 6.5-6.6 in the sample with additional 13g $100g^{-1}$ of water. This could be explained by the changed rheological state the samples went through in the extrusion process, and the changes in starch. Though statistical analyses show significant differences between the samples (p=0,01; α=0,05), these changes should not be considered large, as the biggest one was only by 0.2. However, these differences should be explained with methods precision.

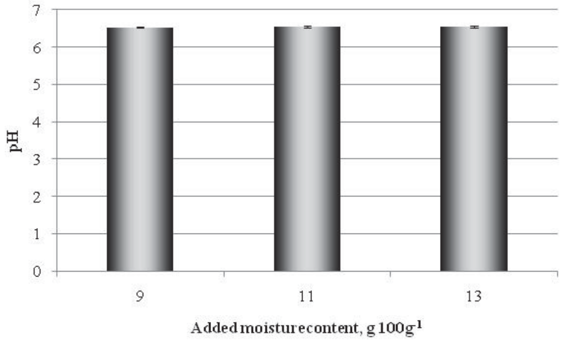

Fig. 4 pH of extruded cow pea samples

Contrary to pH, the sample hardness (Fig. 5) showed no significant differences (p=1; α=0,05), mostly due to the rather large standard deviation, which could be explained by the fact that the texture of the extruded samples contained rather visible air bubbles.

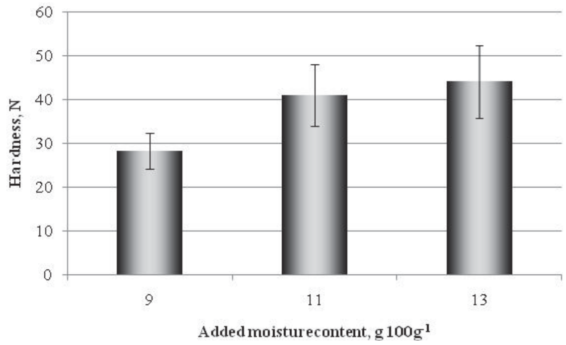

Fig. 5 Hardness (N) of extruded cow pea samples

The lowest sample hardness was for the samples with additional 9 g $100g^{-1}$ moisture content - 28±4N, but the hardest were the samples with 13 g $100g^{-1}$ of water added.

Similar differences occurred in volume mass (Fig. 6), where the lowest volume mass was recorded in the samples with additional 9 $g100g^{-1}$ of water - 263±3 g L^{-1}, but the greatest volume mass was observed in the samples with additional 13 g $100g^{-1}$ of water - 298±7N.

Correlation between volume mass and hardness was observed r=0.999, and volume mass showed significant differences ($p=3\cdot 10^{-5}$; α=0.05).

All samples were approximately 7±1mm long (Fig. 7), but the sample with additional 13 g 100g-1 of water – 8.8±0.7mm was the widest. The other two were 8.6±0.7mm wide.

No significant differences were observed for size parameter (both length and width). As for length p=0.5 and for width p=0.4, when α=0.05.

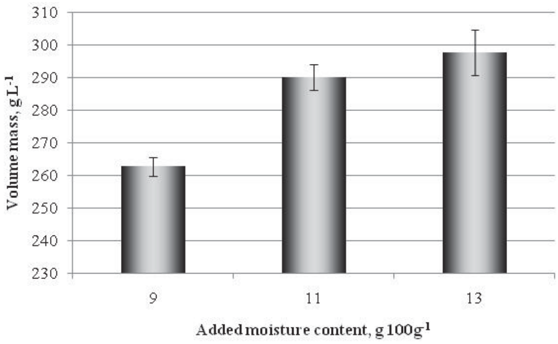

Fig. 6 Volume mass (g L^{-1}) of extruded cow pea samples

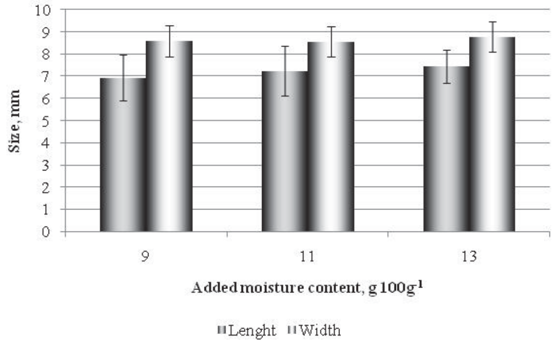

Fig. 7 Size (mm) of extruded cow pea samples

The literature [14] mentions moisture content as one of the main parameters for obtaining samples with different size. As significant differences were found for such parameters as volume mass and hardness, but not for size, further experiments should work to improve size parameters, if possible constitute a bigger sample.

IV. Conclusion

Thus far, the best results were obtained adding 9 g $100g^{-1}$ water to flour before extrusion, as those samples had a lower volume mass and hardness than the samples with additional 11 g $100g^{-1}$ and 13 g $100g^{-1}$ of water. No significant changes in the samples' pH were observed. Still further experiments with extrusion temperatures are needed to try and improve the samples.

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