ISSN 1313 - 8820
Volume 8, Number 2
June 2016

AGRICULTURAL SCIENCE AND TECHNOLOGY

2016

An International Journal Published by Faculty of Agriculture,
Trakia University, Stara Zagora, Bulgaria

Scope and policy of the journal

Agricultural Science and Technology /AST/ – an International Scientific Journal of Agricultural and Technology Sciences is published in English in one volume of 4 issues per year, as a printed journal and in electronic form. The policy of the journal is to publish original papers, reviews and short communications covering the aspects of agriculture related with life sciences and modern technologies. It will offer opportunities to address the global needs relating to food and environment, health, exploit the technology to provide innovative products and sustainable development. Papers will be considered in aspects of both fundamental and applied science in the areas of Genetics and Breeding, Nutrition and Physiology, Production Systems, Agriculture and Environment and Product Quality and Safety. Other categories closely related to the above topics could be considered by the editors. The detailed information of the journal is available at the website. Proceedings of scientific meetings and conference reports will be considered for special issues.

Submission of Manuscripts

All manuscripts written in English should be submitted as MS-Word file attachments via e-mail to editoffice@agriscitech.eu. Manuscripts must be prepared strictly in accordance with the detailed instructions for authors at the website www.agriscitech.eu and the instructions on the last page of the journal. For each manuscript the signatures of all authors are needed confirming their consent to publish it and to nominate on author for correspondence.

They have to be presented by a submission letter signed by all authors. The form of the submission letter is available upon from request from the Technical Assistance or could be downloaded from the website of the journal. Manuscripts submitted to this journal are considered if they have submitted only to it, they have not been published already, nor are they under consideration for publication in press elsewhere. All manuscripts are subject to editorial review and the editors reserve the right to improve style and return the paper for rewriting to the authors, if necessary. The editorial board reserves rights to reject manuscripts based on priorities and space availability in the journal.

The journal is committed to respect high standards of ethics in the editing and reviewing process and malpractice statement. Commitments of authors related to authorship are also very important for a high standard of ethics and publishing. We follow closely the Committee on Publication Ethics (COPE), http://publicationethics.org/resources/guidelines

The articles appearing in this journal are indexed and abstracted in: DOI, EBSCO Publishing Inc. and AGRIS (FAO).

The journal is accepted to be indexed with the support of a project № BG051PO001-3.3.05-0001 "Science and business" financed by Operational Programme "Human Resources Development" of EU.

The title has been suggested to be included in SCOPUS (Elsevier) and Electronic Journals Submission Form (Thomson Reuters).

Address of Editorial office:
Agricultural Science and Technology
Faculty of Agriculture, Trakia University
Student's campus, 6000 Stara Zagora
Bulgaria
Telephone.: +359 42 699330
+359 42 699446
www.agriscitech.eu

Technical Assistance:
Nely Tsvetanova
Telephone.: +359 42 699446
E-mail: editoffice@agriscitech.eu

ISSN 1313 - 8820

Volume 8, Number 2
June 2016

AGRICULTURAL SCIENCE AND TECHNOLOGY

2016

An International Journal Published by Faculty of Agriculture,
Trakia University, Stara Zagora, Bulgaria

AGRICULTURAL SCIENCE AND TECHNOLOGY, VOL. 8, No 2, pp 111 - 116, 2016
DOI: 10.15547/ast.2016.02.019

Nutrition and Physiology

Optimization of formulations with balanced biochemical composition and possibilities for their extrusion

M. Ruskova[1]*, T. Petrova[1], I. Bakalov[1], N. Penov[2], A. Simitchiev[2]

[1]Food Research and Development Institute, 154 V. Aprilov, 4000 Plovdiv, Bulgaria
[2]Department of Canning and Refrigeration Technology, Technological Faculty, University of Food Technologies, 26 Maritza, 4000 Plovdiv, Bulgaria

(Manuscript received 10 June 2015; accepted for publication 9 May 2016)

Abstract. *Combinations of different raw materials (beans, einkorn wheat, and buckwheat) for obtaining formulations with high protein content and balanced amino acid composition were studied using simplex centroid design. The target functions for optimization were content of protein, sulfur-containing amino acid methionine and cysteine, lysine, and tryptophan. The optimal area of combinations of raw materials in the food formulas with balanced biochemical composition was obtained. Optimized ternary mixture consisting of 50% bean, 40% einkorn wheat, and 10% buckwheat with different moisture content (16, 22, and 28%) has been extruded in a laboratory single screw extruder (Brabender 20 DN, Germany). Extrusion parameters were as follows: feed screw speed 50 rpm, die diameter 3 mm, screw compression ratio 2:1, temperature profile 100/140/160ºC, screw speed 160 rpm. The three extrudates with different initial moisture were evaluated by sectional expansion index, water absorption index, water solubility index, and density, with the aim of choosing the best treatment. The results demonstrated that the 22% initial moisture content yielded an extrudate with good physicochemical characteristics overall but an optimization study is needed to confirm this.*

Keywords: beans, einkorn wheat, buckwheat, protein, amino acids, extrusion

Introduction

It is known that proteins of legume seeds are largely balanced in terms of essential amino acids (Comai et al., 2007; Iqbal et al., 2006). They are rich in lysine, arginine and leucine. The sulphur-containing amino acids (methionine and cysteine) are determinative amino acids (Montoya et al., 2008; Shekib et al., 1986; Wang and Daun, 2006). The content of lysine and tryptophan are determinative in the wheat (Abdel-Aal et al., 1995). That's why the shortage of incoming essential amino acids in legumes can be compensated by combining them with cereals.

Extrusion processing is a modern, highly efficient method, with proven technical and economic advantages for processing raw materials. It is used in seeds of legumes, because of the understanding that they are not expanded well with extrusion. In recent years, the expanding of the raw material base and the assortment of extruded food product increasess, their consumption also increases (Penov and Petrova, 2014). The expansion index is an important parameter determining the extrusion process. It characterizes the structural-mechanical changes which occur as a result of the extrusion processing of the material and can be controlled by changing the type and origin of the components, and by varying the process conditions in the extruder.

Recovery and raised interest in legumes has been recently observed, which on the one hand is due to their nutritional value, and on the other – the unused opportunities to create new products with them. The increasing popularity of buckwheat will result in a greater variety of products thereof. One possible solution is to extrude buckwheat (Edwardson, 1996), yielding new, ready-to-eat products such as extruded chips and many others (Petrova, 2012; Petrova and Desev, 2012). To obtain extrudates with balanced biochemical composition proper selection of the raw materials and the ratio between them is required. New in the study is the combination of legumes with other crops of plant origin, which is an expedient approach for obtaining raw material with very good functional characteristics. The main hypothesis of the research is absence of data in the literature on extrusion processing of ternary mixture from legumes, einkorn wheat and buckwheat.

The aim of the study is optimization of formulations with balanced biochemical composition and investigation of the possibility for their extrusion processing.

Material and methods

Representative samples of commercial raw materials einkorn wheat (*Triticum monococcum*) and buckwheat (*Fagopyrum*) were provided and delivered from the Experimental station, village of Lomets, municipality of Troyan, Bulgaria. Bean seeds (*Phaseolus coccineus* L.), cultivar "Bivolare", were grown and supplied from the Experiment station in the Rhodope Mountains. The proximate composition and amino acid profile for each of the raw materials were provided by suppliers or sourced from the literature as shown in Table 1.

Einkorn wheat, buckwheat, and bean seeds were ground using a hammer mill (SWH 20, Glen Creston LTD, UK) and passed through standard sieves. The prepared particle size of einkorn wheat, buckwheat, and bean grits was in the range of 0.4 – 0.5 mm. The

* e-mail: mmruskova@gmail.com; m.ruskova@canri.org

Table 1. The information of the components used for formulation

Composition, %	Raw material		
	Bean	Buckwheat	Einkorn wheat
Protein	24.8	13.25	16.7
Methionine	1.1	0.19	1.75
Lysine	6.5	0.67	2.60
Cysteine	1.1	0.23	2.86
Tryptophan	1.3	0.19	2.59

bean, einkorn wheat, and buckwheat grits were mixed in the ratio of 50:40:10. Water was added slowly to the samples to obtain various moisture contents (16, 22 and 28%). The wet materials were placed and kept in sealed plastic bags for 12 h in a refrigerator at 5ºC. The samples were tempered for 2 h at room temperature prior to extrusion. They were extruded in a laboratory single screw extruder (Brabender 20 DN, Germany). The extruder barrel (476.5 mm in length and 20 mm in diameter) contained three sections and independently controlled die assembly electric heaters. Extrusion parameters were as follows: feed screw speed 50 rpm, die diameter 3 mm, screw compression ratio 2:1, temperature profile 100/140/160ºC, screw speed 160 rpm. The obtained extrudates were air-dried at ambient temperature for about a week. Sectional expansion index (*SEI*) was measured as the ratio of the diameter of the extrudate to that of the die. The diameter of extrudate was determined as the mean of 10 random measurements using a Vernier caliper. *SEI* is dimensionless.

Density (ρ, g/cm^3) of the extrudates was determined by measuring the weight and the diameter of the same amount of extrudates (10 pieces) of the same length at each point of the experiment. The sample was weighed using a balance while its diameter and length were measured using a Vernier caliper. Ten replications were done for each sample. The volume of each extrudate was calculated by assuming that its shape approximates cylindrical. The density was calculated by the formula:

$$\rho = \frac{M\left(1-\frac{W}{100}\right)}{V-M\frac{W}{100}} \qquad (1)$$

where *M* is the weight of the sample (g), *V* is the volume of the sample (cm^3), and *W* is moisture content of the sample (%). The moisture contents of the extrudates were determined as described by (AOAC, 1984). Triplicate determinations were carried out and the result averaged. Variation in the product density of the product is largely dependent on the proportion of voids or bubbles that were trapped in the extruded products as they solidified from the extruder. The product density is expected to be correlated with the void fraction of the products, hardness and general consumer acceptability of the product.

To determine water absorption and solubility indices, the extrudates were finely ground using a laboratory hammer mill and sieved through a 500 µm sieve. A 0.2 g sample was placed in a tared centrifuge tube and 5 ml distilled water added. After standing for 30 min at 30ºC (with intermittent shaking every 5 min), the sample was centrifuged at 3000 rpm for 20 min using a centrifuge CH 90-2A. The supernatant was decanted into a tared aluminium pan and weight gain in the gel was noted. The supernatant was evaporated to dryness at 105ºC until constant weight.

Water absorption index (*WAI*, g/g) and water solubility index (*WSI*, %) were calculated as:

$$WAI = \frac{m_g}{m_o} \qquad (2)$$

$$WSI = \frac{m_{ds}}{m_o}.100 \qquad (3)$$

where m_g is the weight gain of the gel (g), m_o is the weight of the dry sample (g), m_{ds} is the weight of the dried supernatant (g). Triplicate determinations were carried out and the result averaged.

A three-component, constrained simplex centroid mixture design was used for the development of formulations with a balanced biochemical composition (high protein content and markedly good participation of essential amino acids). The mixture components consisted of bean grit (X_1), buckwheat grit (X_2), and einkorn wheat grit (X_3). Component proportions were expressed as fractions of the mixture with a sum ($X_1 + X_2 + X_3$) of one (Table 2). The

Table 2. Mixtures composition in formulations with a balanced biochemical composition in a three-component constrained simplex centroid design

Formulation[a]	Ingredients proportion		
	X_1 (Bean)	X_2 (Buckwheat)	X_3 (Einkorn wheat)
1	1	0	0
2	0	1	0
3	0	0	1
4	0.5	0.5	0
5	0.5	0	0.5
6	0	0.5	0.5
7	0.33	0.33	0.33

[a] Formulation numbers correspond to Figure 1

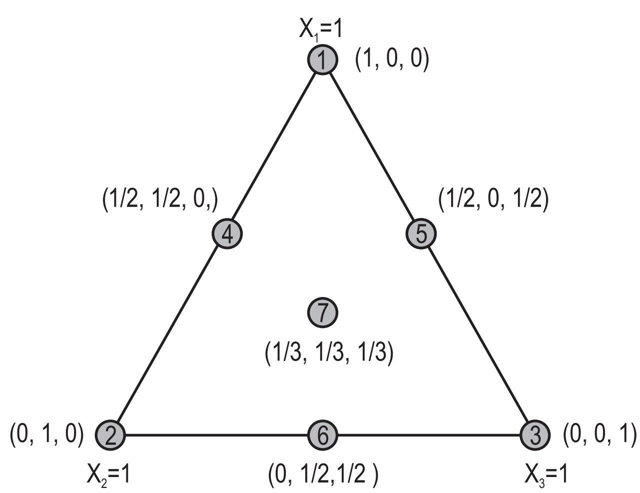

Figure 1. Seven point simplex-centroid design for the interaction of bean (X_1), buckwheat (X_2), and einkorn wheat (X_3) grit in formulations with a balanced biochemical composition

seven points were three single components, three two-component mixtures and one three-component mixture (Figure 1).

Scheffe's canonical special cubic equation for three components was fitted to data collected at each experimental point using backward stepwise multiple regression analysis as described by Cornell (1980). This canonical model differs from full polynomial models in that it does not contain a constant term (intercept equal to zero). Variables in the regression models, which represent two-ingredient or three-ingredient interaction terms, were referred to as "non-linear" terms. The postulated canonical special cubic equation was:

$$Y = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_{12} X_1 X_2 + \beta_{13} X_1 X_3 + \beta_{23} X_2 X_3 + \beta_{123} X_1 X_2 X_3 \quad (4)$$

where *Y* is a predictive dependent variable (protein, sulfur-containing amino acids methionine and cysteine, lysine, tryptophan content), β_1, β_2, β_3, β_{12}, β_{13}, β_{23}, and β_{123} are the corresponding parameter estimates for each linear and cross-product term produced for the prediction models for bean, buckwheat, and einkorn wheat grit, respectively. An analysis of variance was performed on the data and response surfaces were generated for each response using predictive models. The fitted model for protein, methionine and cysteine, lysine, and tryptophan content was used to optimize the formulations with balanced biochemical composition.

The terms in the canonical mixture polynomial have simple interpretations which can be found in specialized texts (Myers and Montgomery, 2002). The usual way to summarize mixture proportions is via triangular (ternary) graphs. One can add a fourth dimension to the triangle, perpendicular to the first three, to plot the value for the dependent variable or it can be indicated, as is more usual, in a two-dimensional plot where the contour of constant height is graphed on a triangle.

Results and discussion

Using the simplex method and procedures of modeling related to it and optimization after treatment of the results equations for protein, sulfur-containing amino acids methionine and cysteine (Met + Cys), lysine (Lys) and tryptophan (Trp) content have been obtained, as follows:

Protein = $24.8X_1 + 16.7X_2 + 13.25X_3 + 0.02X_1X_3 + 0.02X_2X_3 - 0.12X_1X_2X_3$, % (5)

Met + Cys = $2.2X_1 + 4.61X_2 + 0.42X_3 + 0.02X_1X_2 + 0.04X_1X_3 + 0.02X_2X_3 - 0.24X_1X_2X_3$, % (6)

Lys = $6.5X_1 + 2.6X_2 + 0.67X_3 + 0.02X_1X_3 + 0.02X_2X_3 - 0.03X_1X_2X_3$, % (7)

Trp = $1.3X_1 + 2.59X_2 + 0.19X_3 + 0.02X_1X_2 + 0.02X_1X_3 - 0.12X_1X_2X_3$, % (8)

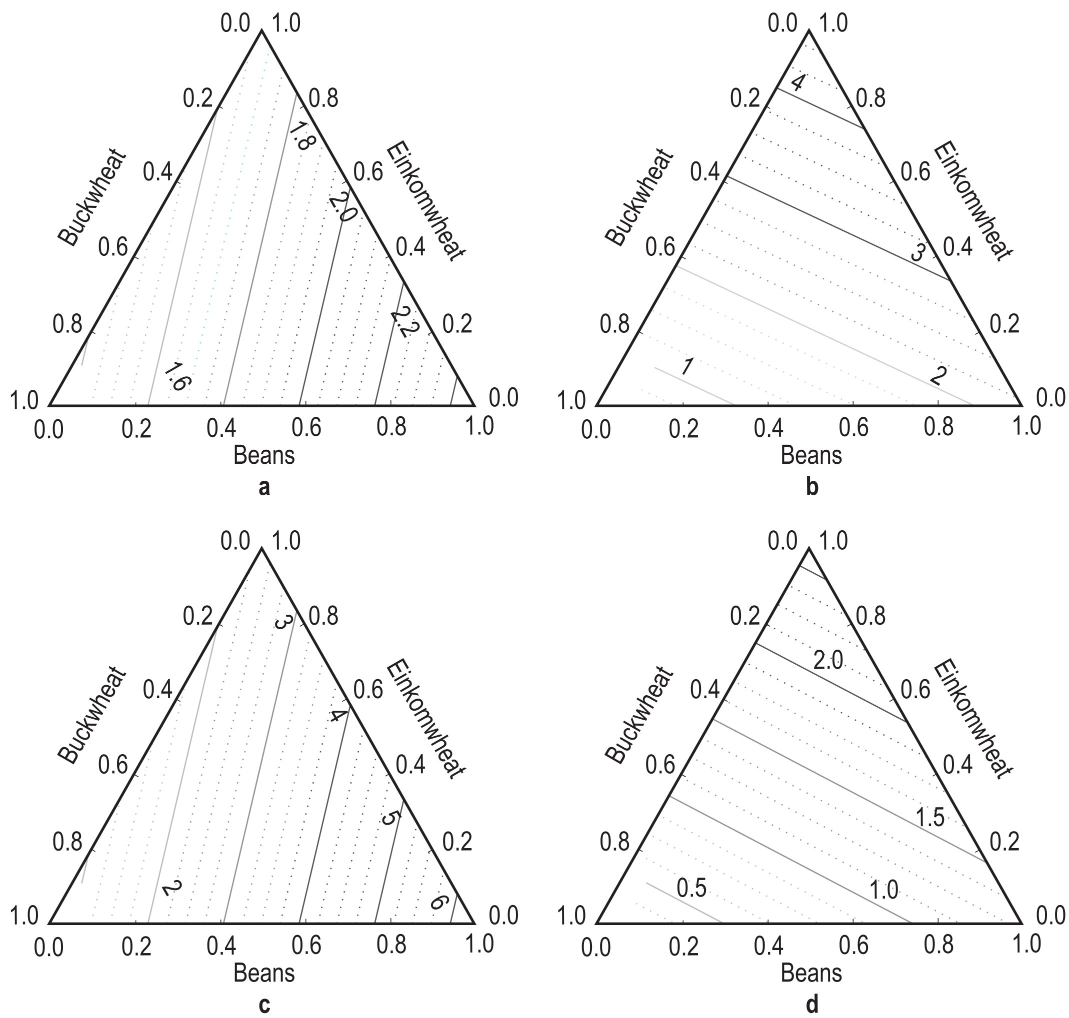

Figure 2. Two-dimensional triangular coordinate system showing the protein content (a), Met+Cys (b), Lys (c) and Trp (d)

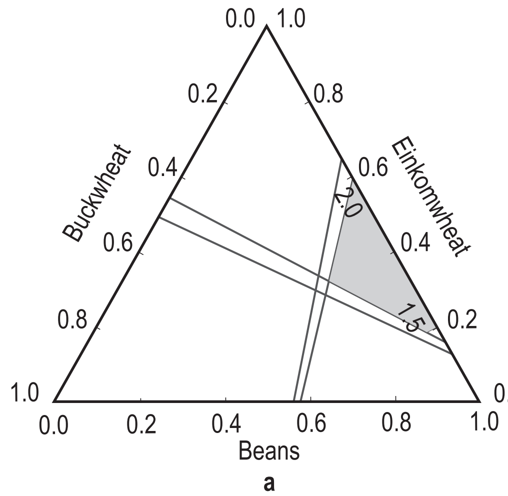

Figure 3. Graphical optimization of the ingredients in the mixture of formulations with balanced biochemical composition

The resulting equations with high accuracy describe the change of the contents of the dependent variable (R^2 > 0.9). The two-dimensional contour plots are shown in Figure 2.

For optimization of the ternary mixture obtained from beans, einkorn wheat, and buckwheat the following limited conditions have been accepted: protein content > 20%, methionine and cysteine content > 2.5%, lysine content > 4%, and tryptophan content > 1.5%. Optimization has been carried out by the superposition of the contour plots for predicted protein, methionine and cysteine, lysine, and tryptophan content of the formulations with a balanced biochemical composition. The optimum area for the ingredients in the mixture of the formulations is presented on Figure 3 (the darkened area). To each point of this area correspond ingredients in the mixture whose values with respect to the content for protein, sulfur-containing amino acids methionine and cysteine, lysine and tryptophan are optimized.

Based on the definite optimal area and a result of the obtained mathematical models the following composition of a ternary mixture of bean, einkorn wheat and buckwheat is selected: protein (20.40), methionine and cysteine (2.99), lysine (4.36), tryptophan (1.71).

Optimized ternary mixture obtained from bean, einkorn wheat, and buckwheat with different moisture content (16, 22, and 28%) has been extruded in a laboratory single screw extruder. The three extrudates with different initial moisture were evaluated by sectional expansion index (*SEI*), water absorption index (*WAI*), water solubility index (*WSI*), and density (*ρ*), with the aim of choosing the best treatment. The results of this evaluation are presented in Table 3.

Expansion, as measured by expansion index and density, is used to express product characteristics after extrusion. The values of the expansion index and density are dependent on the feed moisture, screw speed, and temperature of extrusion (Balandran-Quintana et al., 1998; Dogan and Karwe, 2003; Gujska and Khan, 1990). These values are also dependent on all ingredients contained in the extruded foods, such as starch, protein, fat, sugar, fibers, and so on. All these ingredients have different effects on extrudate expansion (Mercier and Feillet, 1975; Faubion and Hoseney, 1982; Launay and Lisch, 1983). The extrudates from beans have different appearance from the extrudates from cereals. Overall, the extrudates from beans have significantly lower expansion indices compared to corn flour (Gujska and Khan, 1990). A high expansion ratio at low feed moisture content for extruded products is typical for cereals and their expansion depends on the degree of gelatinization of starch (Repo-Carrasco-Valencia et al., 2009). Faubion et al. (1982) reported a decrease in expanded volumes of cereals with increasing amounts of protein, and Linko et al. (1981) with increasing amounts of lipids. Table 3 shows that the sectional expansion index of extrudates increased with the feed moisture content before it reached a critical level (22%) after which *SEI* declined. *SEI* exhibited the highest value when extrusion was carried out at moisture content 22%. These changes in product characteristics are a result of modification of the starch and protein components under high temperature and pressure in the extruder barrel. An increase in *SEI* when moisture content went from 16 to 22% may be due to a reduction in viscosity, which resulted in less mechanical damage to starch, thus enabling dough to expand more and faster (Harper, 1986; Colonna et al., 1989). Similar finding has also been reported by others (Balandran-Quintana et al., 1998; Gujska and Khan, 1991). Balandran-Quintana et al. (1998) have extruded pinto bean flours at three different die temperatures (140, 160, and 180ºC), feed moisture content (18, 20, and 22%), and screw speeds (150, 200, and 250 rpm). They have reported that the expansion index increased with increasing the feed moisture from 18 to 20%. At 180ºC and 22% moisture, the expansion index decreased, probably because at high temperatures starch dextrinization occurred.

Table 3. Functional properties of an extruded mixture of bean, einkorn wheat, and buckwheat with different moisture content

Parameter	Moisture content, %		
	16	22	28
SEI	1.51 ± 0.07	1.74 ± 0.09	1.54 ± 0.11
ρ, g/cm^3	0.739 ± 0.05	0.571 ± 0.04	0.721 ± 0.07
WAI, g/g	7.615 ± 0.09	7.822 ± 0.16	10.11 ± 0.11
WSI, %	14.53 ± 0.12	14.33 ± 0.09	11.75 ± 0.19

*SEI sectional expansion index, ρ density, WAI water absorption index, WSI water solubility index

The density has been linked with the expansion ratio in describing the degree of puffing in extrudates (Asare et al., 2004) and the high density is associated with a low expansion index. The density of the extrudate decreased with increasing moisture content from 16 to 22%, then it increased. This could be due to starch degradation at high temperatures resulting in less expansion (Kokini et al., 1992). Similar results were shown by Balandran-Quintana et al. (1998) for extruded whole pinto bean meal.

Water absorption index depends on the availability of hydrophilic groups and on the gel formation capacity of the macromolecules (Gomez and Aguilera, 1983). It is a measure of damaged starch together with protein denaturation and new macromolecular complex formations (Dogan and Karwe, 2003). The water absorption index increased when the initial moisture increased. Our results show that *WAI* of the extruded mixture of bean, einkorn wheat, and buckwheat increases from 7.62 to 10.11 g/g with raising the moisture content from 16 to 28%. Similar results have been observed by Doğan and Karwe (2003) and Repo-Carrasco-Valencia et al. (2009).

The water solubility index decreased with increasing moisture content. Similar results have been observed by Repo-Carrasco-Valencia et al. (2009). This fact can be explained by the greater rupture of starch granules at the lower initial humidity. Low moisture content in the raw material in extrusion enhances the friction and the energy dissipation to the product, causing the dextrinization of the starch and, at the same time, improving the *WSI* (Repo-Carrasco-Valencia et al., 2009). According to Gutkoski and El-Dash (1999) *WSI* is a parameter that indicates the degradation of starch granules.

Regarding the sectional expansion index, water absorption index, water solubility index, and density, the results demonstrated that the 22% initial moisture content yielded an extrudate with good physicochemical characteristics overall but an optimization study is needed to confirm this.

Conclusion

The determination of functional characteristics such as bulk density, sectional expansion index, water absorption index and the water solubility index allow to do optimization as regards the content of protein, sulfur-containing amino acids methionine and cysteine, lysine and tryptophan. An optimized ternary mixture consists of 50% bean, 40% einkorn wheat, and 10% buckwheat with different moisture content (16, 22, and 28%). Formulations with high protein and balanced amino acid composition have been obtained. The possibility for single screw extrusion of the optimized ternary mixture has been investigated and the parameters bulk density, sectional expansion index, water absorption index and the water solubility index have been determined. There is inverse relationship between the bulk density and the sectional expansion index and the correlation is a linear one ($R = 0.98$, $p < 0.05$).

The most important consequences for the science and practice resulting from the conducted research are that the resulting extrudates after grinding can be successfully used for the preparation of an instant product with balanced biochemical composition and good characteristics, such as bulk density, sectional expansion index, water absorption index and water solubility index.

References

Abdel-Aal E, Hucl P and Sosulski F, 1995. Compositional and nutritional characteristics of spring einkorn and spelt wheats. Cereal Chemistry, 72, 621-624.

AOAC, 1984. Official method of Analysis, 14th ed. Association of Official Analytical Chemists Washington D.C.

Asare E, Sefa-Dedeh S, Sakyi-Dawson E and Afoakwa E, 2004. Application of response surface methodology for studing the product characteristics of extruded rice-cowpea-groundnut blends. International Journal of Food Sciences and Nutrition, 55, 431-439.

Balandran-Quintana R, Barbosa-Canovas G, Zazueta-Morales J, Anzaldua-Morales A and Quintero-Ramos A, 1998. Functional and nutritional properties of extruded whole pinto bean meal (*Phaseolus Vulgaris* L.). Journal of Food Science, 63, 113-116.

Comai S, Bertazzo A, Bailoni L, Zancato M, Costa C and Allegri G, 2007. Protein and Non-protein (Free and Protein-bound) Tryptophan in Legume Seeds. Food Chemistry, 103, 657-661.

Cornell J, 1980. Experiments with mixtures: Design models, and the analysis of mixture data. New York: John Wiley & Sons (pp. 2-63).

Ding Q, Ainsworth P, Tucker G and Marson H, 2005. The effect of extrusion conditions on the physicochemical properties and sensory characteristics of rice-based expanded snacks. Journal of Food Engineering, 66, 283-289.

Ding Q, Ainsworth P, Plunkett A, Tucker G and Marson H, 2006. The effect of extrusion conditions on the functional and physical properties of wheat-based expanded snacks. Journal of Food Engineering, 73, 142-148.

Dogan H and Karwe M, 2003. Physicochemical properties of quinoa extrudates. Food Science and Technology International, 9, 101-114.

Edwardson S, 1996. Buckwheat: Pseudocereal and nutraceutical. in: Progress in New Crops (ed. J. Janick). ASHS Press, Alexandria, VA., pp. 195-207.

Faubion J and Hoseney R, 1982. High-temperature short-time extrusion cooking of wheat starch and flour. II. Effect of protein and lipid on extrudate properties. Cereal Chemistry, 59, 533-537.

Faubion J, Hoseney R and Seib P, 1982. Functionality of grain components in extrusion. Cereal Foods World, 27, 212-216.

Gomez M and Aguilera J, 1983. Changes in the starch fraction during extrusion cooling of corn. Journal of Food Science, 48, 378-381.

Gutkoski L and El-Dash A, 1999. Effect of extrusion process variables on physical and chemical properties of extruded oat products. Plant Foods for Human Nutrition, 54, 315-325.

Gujska E and Khan K, 1990. Effect of Temperature on Properties of Extrudates from High Starch Fractions of Navy, Pinto and Garbanzo Beans. Journal of Food Science, 55, 466-469.

Gujska E and Khan K, 1991. Feed Moisture Effects on Functional Properties, Trypsin Inhibitor and Hemagglutinating Activities of Extruded Bean High Starch Fractions. Journal of Food Science, 56, 443-447.

Iqbal A, Khalil I, Ateeq N and Khan M, 2006. Nutritional Quality of Important Food Legumes. Food Chemistry, 97, 331-335.

Kokini J, Lai L and Chedid L, 1992. Effect of starch structure on starch rheological properties. Food Technology, 46, 124-139.

Launay B and Lisch L, 1983. Twin-screw extrusion cooking of starches: Flow behaviour of starch pastes, expansion and mechanical properties of extrudates. Journal of Food Engineering, 52, 1746-1747.

Linko P, Colonna P and Mercier C, 1981. High temperature short-time extrusion cooking. p. 145 In “Advances in Cereal Science and Technology”, IV, Y. Pomeranz (Ed.). American Association of cereal chemists, St. Paul, MN.

Mercier C and Feillet P, 1975. Modification of carbohydrate components by extrusion-cooking of cereal products. Cereal Chemistry, 52, 283-297.

Montoya C, Gomez A, Lallès J, Souffrant W, Beebe S and Leterme P, 2008. In vitro and in vivo protein hydrolysis of beans (*Phaseolus vulgaris*) genetically modified to express different phaseolin types. Food Chemistry, 106, 1225-1233.

Myers R and Montgomery D, 2002. Response surface methodology (2nd ed.). New York: John Wiley & Sons, Inc.

Nyombaire G, 2008. Extrusion Cooking to Produce Nutritious Bean Products. UMI Microform edition, ProQuest Information and Learning Company, United States.

Penov N and Petrova T, 2014. Extrusion – Modern and Efficient Technology for Food Production. University of Food Technologies, Plovdiv, ISBN 978-954-24-0255-8 (Bg).

Petrova I, 2012. Possibilities of use of buckwheat in food. Thesis for PhD, University of Food Technologies, Plovdiv (Bg).

Petrova I and Desev Tz, 2012. Studies on Dispersity of Dispersed System Emulsion Type with Buckwheat. International Scientific-Practical Conference "Food, Technologies & Health". Proceedings Book, ISBN 978-954-24-0204-6, 39-42 (Bg).

Repo-Carrasco-Valencia R, de La Cruz A, Alvarez J and Kallio H, 2009. Chemical and Functional Characterization of Kañiwa (*Chenopodium pallidicaule*) Grain, Extrudate and Bran. Plant Foods

for Human Nutrition, 64, 94-101.
Shekib L, Zoueil M, Youssef M and Mohamed M, 1986. Amino Acid Composition and In vitro Digestibility of Lentil and Rice Proteins and Their Mixture (Koshary). Food Chemistry, 20, 61-67.
Toshkov N, 2011. Study of extrusion process for the preparation of food for carp (*Cyprinus carpio* L.). Thesis for PhD, University of Food Technologies, Plovdiv (Bg).
Toshkov N and Lambrev A, 2010. Effects of Several Extrusion Parameters on Important Physical Properties of Aquafeeds. Food Industry, 1, 41-46 (Bg).
Vuchkov I, Kozarev N, Stoyanev S and Tzochev V, 2002. Laboratory experiments on statistical methods. New knowledge, Sofia (Bg).
Wang N and Daun J, 2006. Effects of Variety and Crude Protein Content on Nutrients and Anti-nutrients in Lentils (*Lens culinaris*). Food Chemistry, 95, 493-502.

CONTENTS

CONTENTS

Instruction for authors

Preparation of papers

Papers shall be submitted at the editorial office typed on standard typing pages (A4, 30 lines per page, 62 characters per line). The editors recommend up to 15 pages for full research paper (including abstract references, tables, figures and other appendices)

The manuscript should be structured as follows: Title, Names of authors and affiliation address, Abstract, List of keywords, Introduction, Material and methods,Results, Discussion, Conclusion, Acknowledgements (if any), References, Tables, Figures.

The title needs to be as concise and informative about the nature of research. It should be written with small letter /bold, 14/ without any abbreviations.

Names and affiliation of authors The names of the authors should be presented from the initials of first names followed by the family names. The complete address and name of the institution should be stated next. The affiliation of authors are designated by different signs. For the author who is going to be corresponding by the editorial board and readers, an E-mail address and telephone number should be presented as footnote on the first page. Corresponding author is indicated with *.

Abstract should be not more than 350 words. It should be clearly stated what new findings have been made in the course of research. Abbreviations and references to authors are inadmissible in the summary. It should be understandable without having read the paper and should be in one paragraph.

Keywords: Up to maximum of 5 keywords should be selected not repeating the title but giving the essence of study.

The introduction must answer the following questions: What is known and what is new on the studied issue? What necessitated the research problem, described in the paper? What is your hypothesis and goal ?

Material and methods: The objects of research, organization of experiments, chemical analyses, statistical and other methods and conditions applied for the experiments should be described in detail. A criterion of sufficient information is to be possible for others to repeat the experiment in order to verify results.

Results are presented in understandable tables and figures, accompanied by the statistical parameters needed for the evaluation. Data from tables and figures should not be repeated in the text.

Tables should be as simple and as few as possible. Each table should have its own explanatory title and to be typed on a separate page. They should be outside the main body of the text and an indication should be given where it should be inserted.

Figures should be sharp with good contrast and rendition. Graphic materials should be preferred. Photographs to be appropriate for printing. Illustrations are supplied in colour as an exception after special agreement with the editorial board and possible payment of extra costs. The figures are to be each in a single file and their location should be given within the text.

Discussion: The objective of this section is to indicate the scientific significance of the study. By comparing the results and conclusions of other scientists the contribution of the study for expanding or modifying existing knowledge is pointed out clearly and convincingly to the reader.

Conclusion: The most important consequences for the science and practice resulting from the conducted research should be summarized in a few sentences. The conclusions shouldn't be numbered and no new paragraphs be used. Contributions are the core of conclusions.

References:

In the text, references should be cited as follows: single author: Sandberg (2002); two authors: Andersson and Georges (2004); more than two authors: Andersson et al.(2003). When several references are cited simultaneously, they should be ranked by chronological order e.g.: (Sandberg, 2002; Andersson et al., 2003; Andersson and Georges, 2004).

References are arranged alphabetically by the name of the first author. If an author is cited more than once, first his individual publications are given ranked by year, then come publications with one co-author, two co-authors, etc. The names of authors, article and journal titles in the Cyrillic or alphabet different from Latin, should be transliterated into Latin and article titles should be translated into English. The original language of articles and books translated into English is indicated in parenthesis after the bibliographic reference (Bulgarian = Bg, Russian = Ru, Serbian = Sr, if in the Cyrillic, Mongolian = Mo, Greek = Gr, Georgian = Geor., Japanese = Ja, Chinese = Ch, Arabic = Ar, etc.)

The following order in the reference list is recommended:

Journal articles: Author(s) surname and initials, year. Title. Full title of the journal, volume, pages. Example:

Simm G, Lewis RM, Grundy B and Dingwall WS, 2002. Responses to selection for lean growth in sheep. Animal Science, 74, 39-50

Books: Author(s) surname and initials, year. Title. Edition, name of publisher, place of publication. Example:

Oldenbroek JK, 1999. Genebanks and the conservation of farm animal genetic resources, Second edition. DLO Institute for Animal Science and Health, Netherlands.

Book chapter or conference proceedings: Author(s) surname and initials, year. Title. In: Title of the book or of the proceedings followed by the editor(s), volume, pages. Name of publisher, place of publication. Example:

Mauff G, Pulverer G, Operkuch W, Hummel K and Hidden C, 1995. C3-variants and diverse phenotypes of unconverted and converted C3. In: Provides of the Biological Fluids (ed. H. Peters), vol. 22, 143-165, Pergamon Press. Oxford, UK.

Todorov N and Mitev J, 1995. Effect of level of feeding during dry period, and body condition score on reproductive performance in dairy cows,IXth International Conference on Production Diseases in Farm Animals, September 11–14, Berlin, Germany.

Thesis:

Hristova D, 2013. Investigation on genetic diversity in local sheep breeds using DNA markers. Thesis for PhD, Trakia University, Stara Zagora, Bulgaria, (Bg).

The Editorial Board of the Journal is not responsible for incorrect quotes of reference sources and the relevant violations of copyrights.

Animal welfare

Studies performed on experimental animals should be carried out according to internationally recognized guidelines for animal welfare. That should be clearly described in the respective section “Material and methods”.

AGRICULTURAL SCIENCE AND TECHNOLOGY

Volume 8, Number 2
June 2016

Journal web site:
www.agriscitech.eu

Publisher:
www.alfamarket.biz