Int. Agrophysics, 1994, 8,671-680

THE INVESTIGATIONS OF THE TEXTURE OF EXTRUDED PLANT MATERIALS

Z. Rzedzicki, L. Mościcki

Food Process Engineering Department, University of Agriculture, Doświadczalna 44, 20-236 Lublin, Poland

A b s t r a c t. The widely available on the market extruded snacks are produced mainly on the basis of starch raw materials, mostly corn semolina. This raw material as well as the product it yields have got an unbalanced composition of amino acids. The excess of metionine and deficiency of lizyne significantly decrease the feeding value of these products. So the investigations were carried out on the improvement of the raw materials composition, resulting in inventing the technology of snack production based on the mixture of corn semolina and seeds of native pulses: peas, beans and lentils. The analyses particularly concerned the influence of the moisture content in the raw material, the barrel temperature, compression ratio, die diameter, screw r.p.m. and of the raw materials meal composition on the course of the extrusion-cooking process and the properties of the extrudate. In particular, the properties significant for the crisps quality were tested: the expantion ratio, specific density, extruders yield, WAI and the texture. Also, the organoleptic test was carried out. The analysis of the results of the investigations showed that the extrusion of the mixture of corn semolina and pulse raw materials allows to yield the product of very good quality, as good as the corn crisps, containing up to 20 % pulses meal and with the texture similar to that of the corn crisps. Results of the investigations were statisticaly analysed.

K e y w o r d s: extruded plant materials, corn semolina, corn crips, pulses

INTRODUCTION

The technique of extrusion-cooking, widely applied in the west countries, for the last few years has also become present in the native food processing industry. The numerous advantages of this method make it extremely attractive in the production of a variety of snacks, crisps, fancy breakfast articles etc. Corn semolina is the main raw material used for the production of these articles. Its wide application is due to both technological and technical reasons. From these reasons corn crisps are now the most popular extruded product offered in a variety of shapes, colours and tastes. They are mainly starch products with low protein level and an unbalanced composition of amino acids. They are characterized by an excess of metionine and a significant deficiency of lysine. So, the investigations were carried out on the modification of the technology and improvement of the composition of amino acids in the extruded snacks. Meals of the native pulses seeds were added as the improving factors. The seeds contain a lot of lysine and little of metionine and thus they suit very well the task of balancing the composition of the corn protein. The simultaneous application in the extruders barrel of tempereture, moisture, pressure and shear stress destroys most anti-nutritional factors in the seeds of pulses and thus allows to yield the product of high value.

MATERIALS AND METHODS

Corn semolina from PZZ Włocławek and the seeds of pulses: peas, beans and lentils, quality of sowing material, were used for the experiments, and their fraction composition is presented in Table 1. The pulses raw materials were added in the qantity of 0, 5, 10, 15, 20, 25 and 30 %. The mixtures were moistened up to the moisture content

Table 1. Characteristics of raw materials

		Corn semolina	Peas	Beans	Lentils
			(%)		
Fraction	(mm)				
>1,6		-	3.48	5.92	16.16
1.6-1.0		7.54	24.60	30.96	41.32
1.0-0.5		66.96	35.04	32.28	25.32
0.5-0.4		13.12	8.60	9.32	4.28
0.4-0.265		8.70	7.76	16.16	3.84
<0.265		3.68	20.36	6.72	9.08
Bulk density	(kg/m^3)	610.9	685.5	682.1	616.2

of 14 %, mixed in the drum mixer and conditioned for 24 h. For the testing of the influence of the raw materials degree of fineness on the product quality, the mixture of peas and corn semolina were applied. The fraction composition of these raw materials is presented in Table 2.

Table 2. Characteristics of peas meal

Fraction (mm)	Mix. A	Mix. B	Mix. C
		(%)	
>1.6	6	1.5	0
1.6-1.2	17	8	1.5
1.2-1.0	14	9	6
1.0-0.5	31	32	37.5
0.5-0.315	9	11	12.5
0.315-0.1	9	12.5	13
<0.1	14	26	29.5

The samples were extruded on the extrusion-cooker S-45 type using the following parameters: temperature 413/438/383K, screw rpm 90, compression ratio 3:1, die diameter 3.5, 4, and 5 mm. The above parameters were chosen on the basis of some earlier pilot tests. The samples were taken for the testing of expantion ratio, specific density, WAI, crispiness and organoleptic test. The expantion ratio was measured in 50 replications and calculated from the dependence as the ratio of the extrudate cross-section area to the cross-section area of the die. The organoleptic test was calculated as the mean of 20 evaluations made by workers and students. For the evaluation of the texture of the product a new method and new tester were developed. They were described by Rzedzicki [6]. The texture evaluations was conducted for the test samples with moisture content 8 % (test a) and 10 % (test b).

RESULTS AND DISCUSSION

The extrusion process of the pulses-corn mixtures runs correctly for a wide range of parameters. The best results are obtained when using: temperature 413/438/383 K, die diameter 3.5 and 4 mm, compression ratio 3:1, rpm. 90, and moisture content of the meal 14 %. The obtained yields range from 23 to 27 kg/h (Fig. 1). A significant rise in the extruders yield is observed along with the rise of the pulses ratio in the mixture. For the pulses ratio of about 20 %, again the yields fall is observed. This regularity is valid for each of the investigated pulses. This phenomenon may probably result from the change in the viscosity of the processed mixture when a definite protein content has been obtained. It should be stressed that the yields obtained from mixtures were always higher than those obtained from corn semolina.

The change in the raw material composition has a significant influence on changes in the extrudates basic physical properties. Along with the rise of the pulses content, the expantion ratio was falling for each raw material (Fig. 2). A higher expantion ratio can be noticed for test samples extruded on the 3.5 mm die, the lower one for those extruded on the 5 mm die. Of course, this concerns radial expansion. It should be mentioned that there is also a longitudinal expansion, very difficult to measure. So that, in order to define the products expansion in a possibly correct way, the measurement of the specific density were also taken (Fig. 3). The specific density rises along with the rise of the pulses content in the mixture and ranges from 75 to 120 kg/mm^3. All the kinds

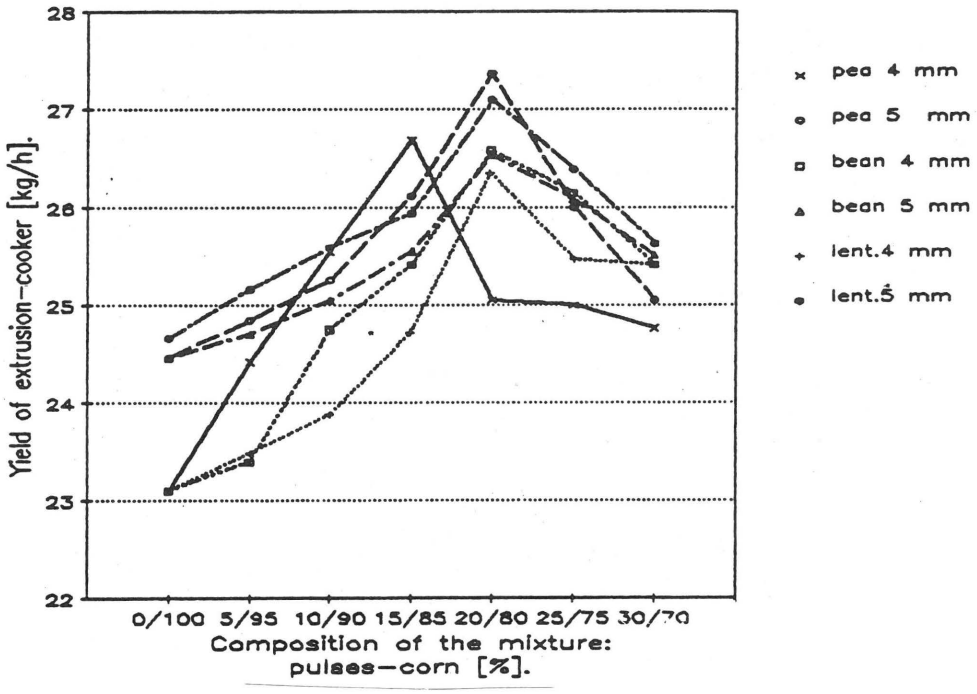

Fig. 1. The influence of the composition of the mixture on the yield of extrusion-cooker.

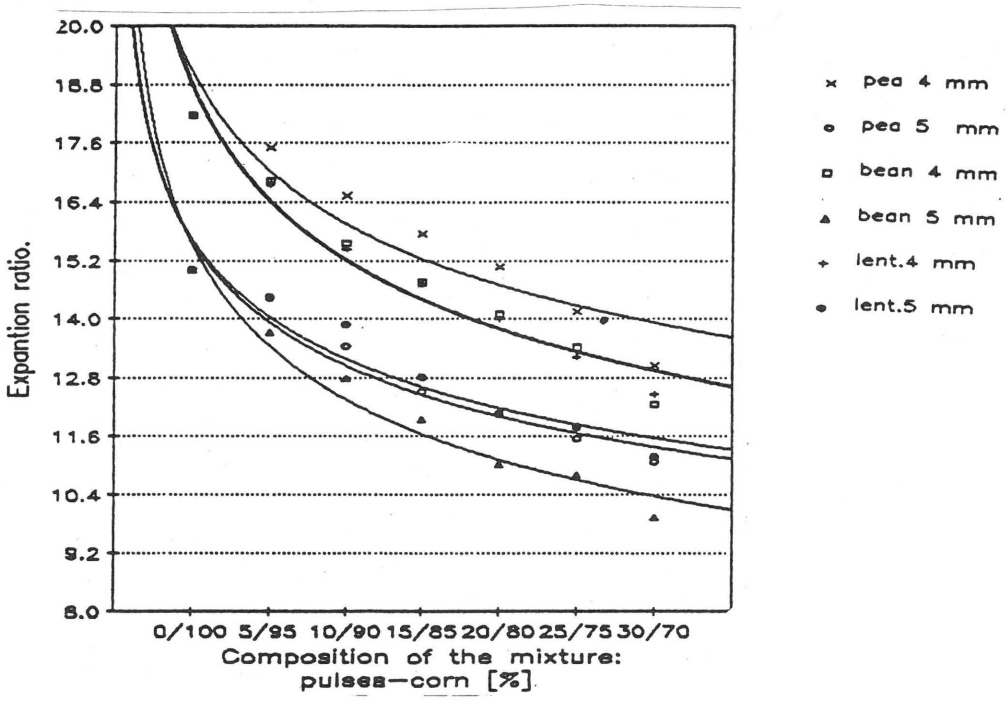

Fig. 2. The influence of the composition of the mixture on the expansion ratio.

of mixtures yielded products with similar density patterns.

The influence of the mixture composition on the extrudates WAI was also investigated (Fig. 4).

The test samples were also subjected to organoleptic test. They were evaluated using a scale from 0 to 5 points. First the look, taste and crispiness were evaluated and then the final mark was given. The results of the final evaluation are presented in Fig. 5. The highest marks, very similar ones, were given to the test samples with peas and lentils, extruded on the 3.5 and 4 mm dies; definitely worse marks were given to the test samples containing beans and the samples extruded on the 5 mm die. It should be especially stressed that even the test samples with 20 % peas and lentils content received marks above 4 points. So, it is a very good product of high consumable value. Extrudate containing beans is fair in colour but rather hard. When the beans content rises above 15 %, the taste of beans already appears. For possible production only test samples containing not more than 10 % of beans can be recommended.

Extrudates containing peas are darker in colour, they are crispy and tasty. The peas taste appears only in samples containing not less than 25 % of peas. The samples extruded with the use of 3.5 mm die can be recommended for practical application in production.

The test samples containing lentils received very similar marks to those containing peas. This mixture deserves special attention as lentils is our most valuable native pulse. Lentil products are very tasty and healthy. Extrudates containing lentils are darker than corn crisps. Even at the lentils rate of 30 % the characteristic pulse taste does not appear in the extrudate.

Corn extrudates containing lentils should be especially recommended for practical application inproduction. They will surely sell well to vegetarians and people limiting their meat consumption as lentils has got very valuable amino acid composition. The extrusion technique can also be used for the production of vegetarian dishes containing even up to 90 % of lentils. Without any addition of corn extrusion process of pulses on a single screw extrusion-cooker runs very poorly; this concerns as well peas, beans and lentils.

Another very important snack property is its texture. The influence of the process parameters on the texture quality was also examined. For most of the tested samples the addition of the pulses meal did not show any bad effect on their texture. One can even observe a slight loss of crushing energy value along with the rise in pulses content (Fig. 6).

When the die is diminished and thus the expantion ratio raised, the texture also improves and the product crushing energy value lowers (Fig. 7). The grinding ratio of the pulse raw material also has a significant effect on the texture quality. A finer raw material gives a more crispy product with lower crushing energy (Fig. 8). Extremely valid for the texture quality is also the moisture content of the product and hence the conditions and period of storage (Fig. 9). The rise of the product moisture content from 8 % (in test a) to 10 % (in test b) significantly impairs the texture and raises the crushing energy by over 20 %.

CONCLUSIONS

1. Corn-pulses mixture is a very valuable raw material for snack production.

2. The recommended bean content in the mixture is 10 %, peas content up to 20 % and lentils content even up to 25 %.

3. The highest organoleptic evaluation was received by the tested samples containing peas and lentils extruded on the die 3.5 mm.

4. It is necessary to keep within the above mentioned temperature, rpm., and moisture content as it leads to the browning of the product.

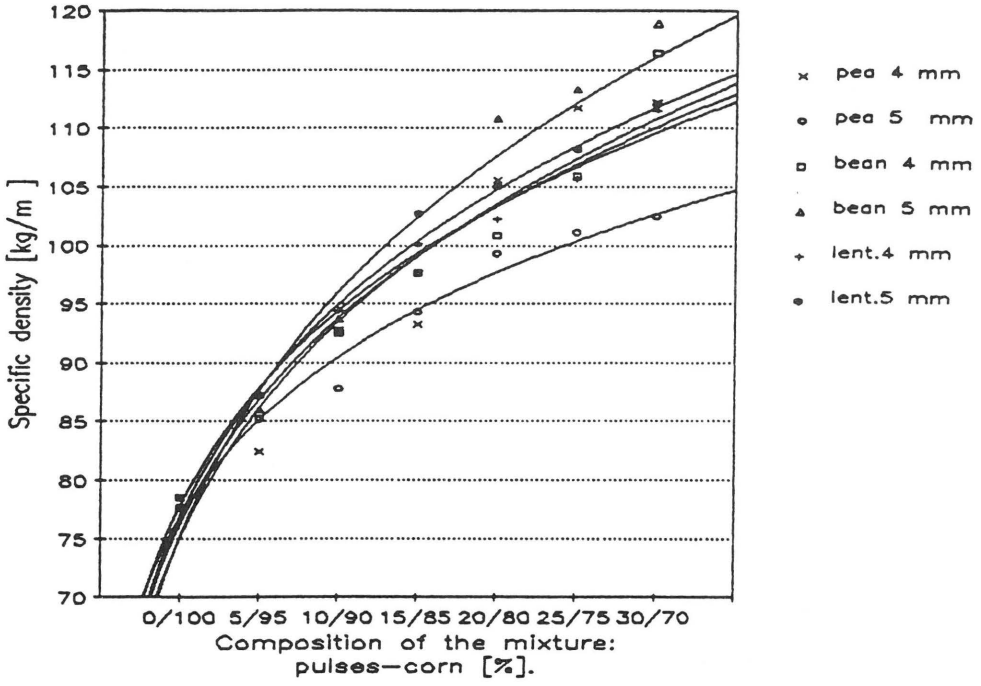

Fig. 3. The influence of the composition of the mixture on the specific density.

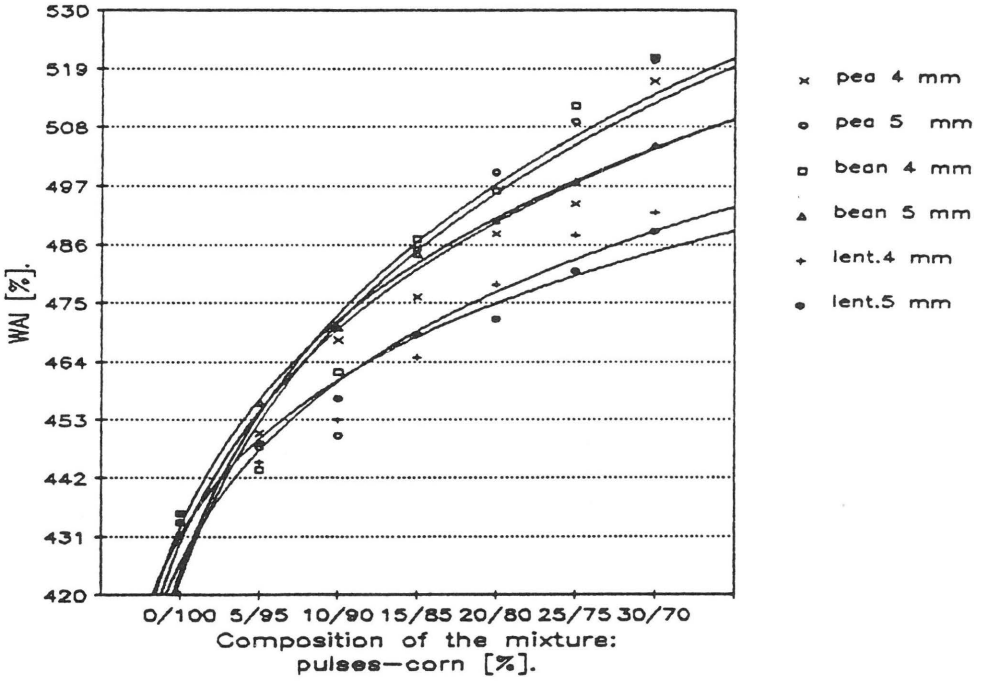

Fig. 4. The influence of the composition of the mixture on the WAI.

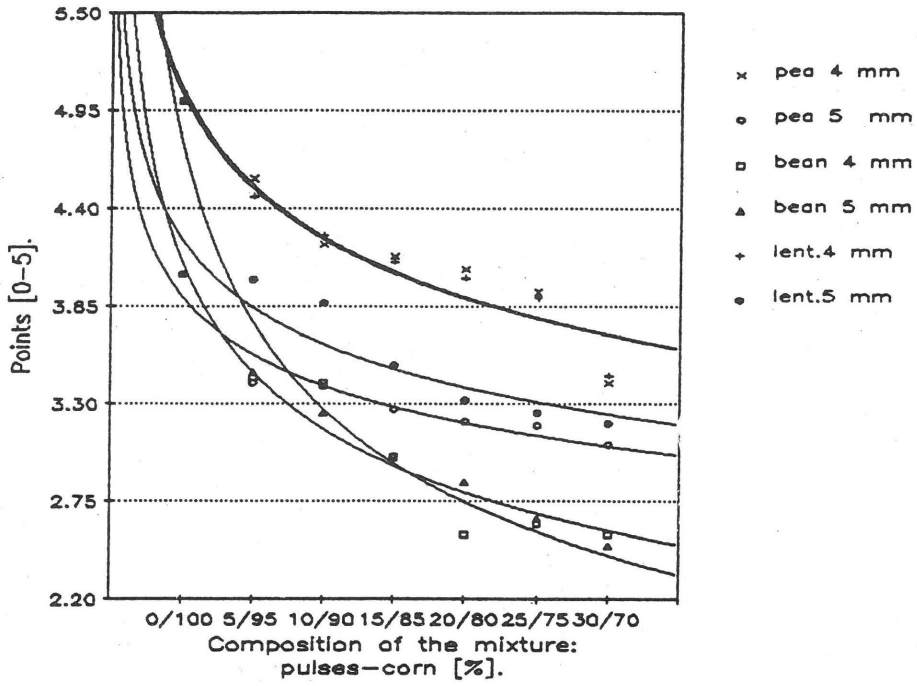

Fig. 5. The organoleptic test of the corn-pulses extrudate.

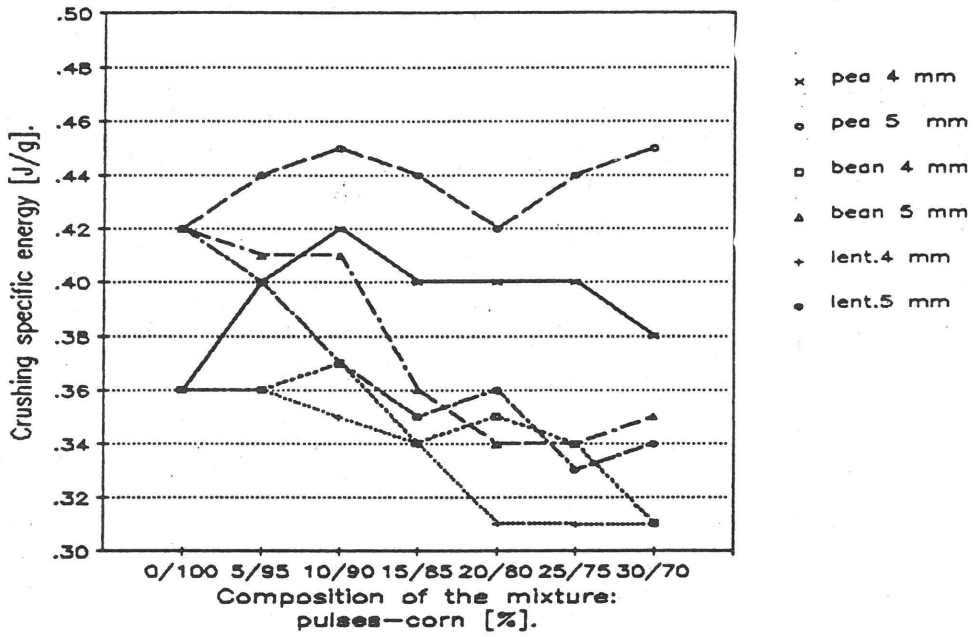

Fig. 6. The influence of the species of the pulses on the specific crushing energy.

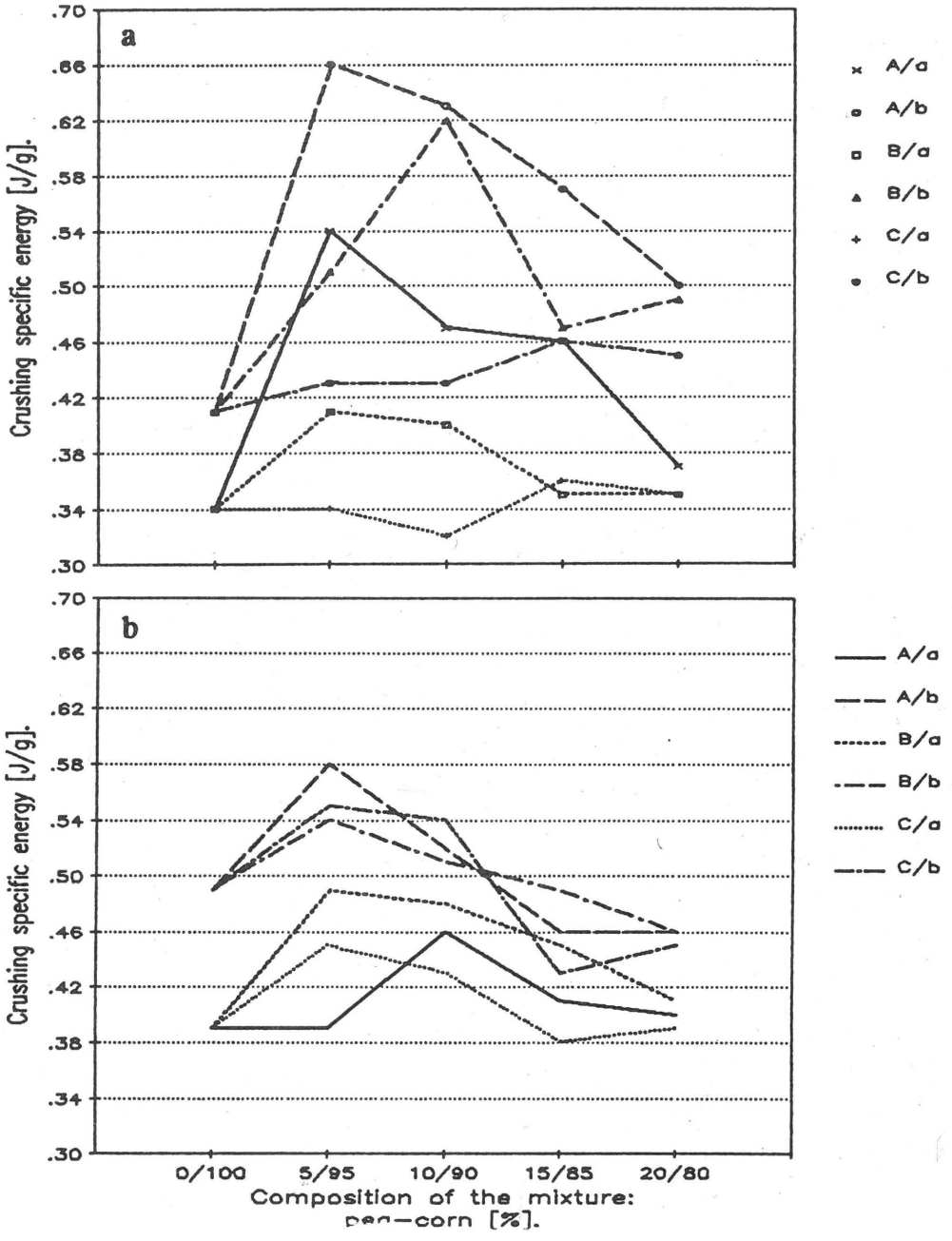

Fig. 7. The influence of the composition of the mixture on the specific crushing energy. Die 3.5 mm (a). Die 4 mm (b).

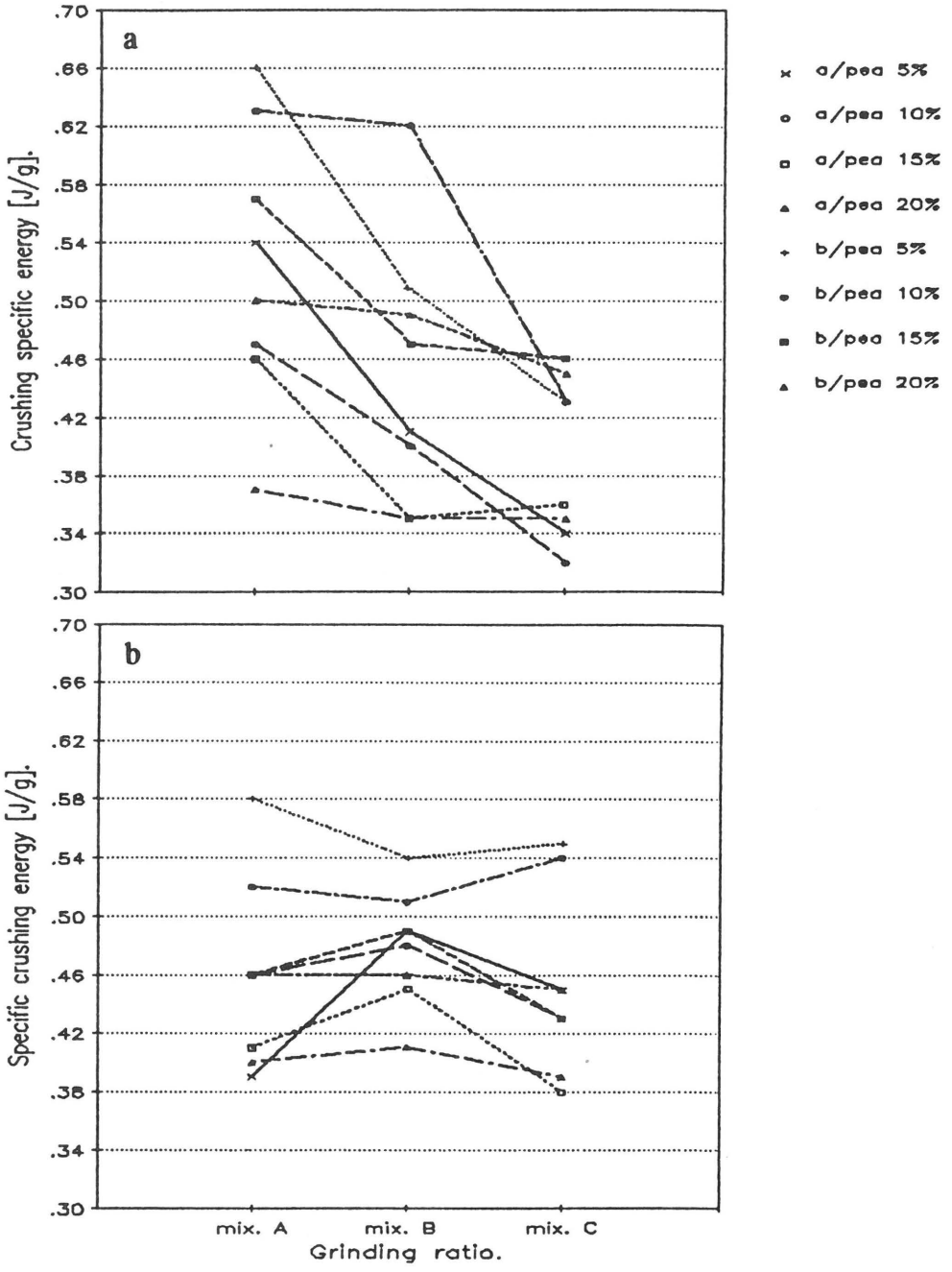

Fig. 8. The influence of the grinding ratio on the specific crushing energy. Die 3.5 mm (a). Die 4 mm (b). Knife table 3 mm.

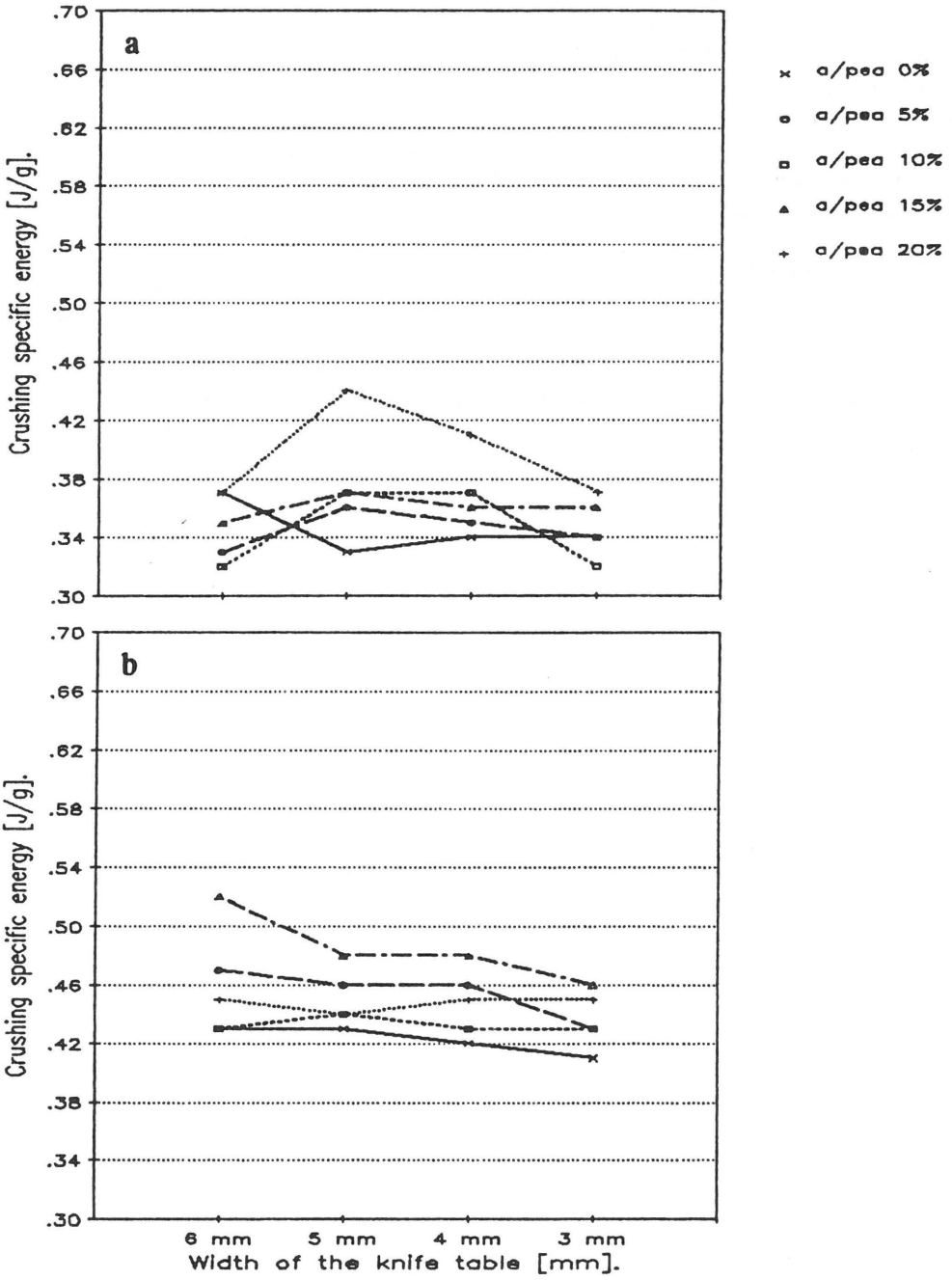

Fig. 9. The influence of the moisture content of the extrudate on the specific crushing energy. Die 3.5 mm. Mixture C/a (a). Mixture C/b (b).

5. The extrusion technique can also be used in the production of vegetarian dishes containing even up to 90 % of lentils.

6. The addition of the pulses raw material does not show any bad effect on the products texture.

7. Greater fineness of the pulses meal has a positive effect on the products texture quality.

8. Texture quality is extremely valid for lowering the moisture rise in the product.

REFERENCES

1. **Aguilera J.M., Crisafuli E.R., Lusas A.W., Uebersax M.A., Zabik M.**: Air classification and extrusion on navy bean fractions. J. Food Sci., 49, 543-546, 1984.
2. **Chauhan G.S., Bains G.S.**: Effect of defatted soy flour on the physico-chemical characteristics of extruded rice products. J. Food Techn., 22, 2, 1985.
3. **Peri C.**: Physical, chemical and nutritional quality of extruded corn germ flour and milk protein blends. J. Food Techn., 18, 3-52, 1983.
4. **Pham C.B.**: Studies on the development of texturised vegetable products by the extrusion process, I. Effect of processing variables on protein properties. J. Food Techn., 19, 535-547, 1984.
5. **Pham C.B.**: Studies on the development of texturized vegetable products by the extrusion process, II. Effects of extrusion variables on the available lysine, total and reducing sugars. J. Food Techn., 19, 549-559, 1984.
6. **Rzedzicki Z.**: New method of texture measurement of crispy food and feed. Int. Agropysics, 8, 661-670, 1994.