Int. Agrophysics, 1994, 8, 661-670

NEW METHOD OF TEXTURE MEASUREMENT OF CRISP FOOD AND FEED

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A b s t r a c t. Wide application of extrusion-cooking in food and feed processing resulted in the creation of a completely new generation of products. Most of this are crispy products, the texture being their most important property. Thus, a simple and convenient method is needed for the evaluation of the internal microstructure of crispy products. That is why investigations were started in order to work out a new method of texture evaluation and a measuring device. As a texture measure unit the quantity of energy was adopted needed to crush a mass unit of the product (J/g). It was named the specific crushing energy. The principle of the new method is following: the tested sample of the product, placed on a special knife table, is hit by a knife pendulum and ground. The energy used by the pendulum to crush the sample is the texture measure.

The main design parameters of the knife table and knife pendulum were also examined. In particular the constructive shapes of the knives of the table and the pendulum were analysed. The best tested solutions were applied to the tester construction and subjected to verification in laboratory tests. The new tester and the new method were accepted as research method for the evaluating the texture of crispy products.

K e y w o r d s: extrusion, crisp food, texture measurement

INTRODUCTION

The internal microstructure and consistency of crispy articles produced by food and feed processing industries is often their most important property determining their taste and consumable value. These properties are also extremely valid for the ability of absorbing the digestive juices, hence also for the feeding value of food stuffs and fodders. The quality of cellar microstructure of these articles is also crucial as they are often used as carriers of other valuable components, e.g., premixes, dyes, flavourings, etc. It is necessary than, to work out a method for the evaluation of the texture of these products and a device for the measurement of this parameter. Once a reliable method for texture measurement is worked out, it will allow to define precisely which factors in particular technologies of production have got a significant effect on texture quality and to model the technological process so that the most suitable texture is secured for a given article.

There are many other methods for the evaluation of the texture and internal structure of food articles. The most popular ones are: Cramer Shear Press, Ottava Texture Ceel, Warner-Bratzler Shear Press, The Universal Crispiness Tester. However, they serve well for the static measurement, when we measure the power needed to destroy the tested sample. They found application in the evaluation of the parameters in pasty and elastic articles like pastries, gels, meat, meat-like articles, etc. Through the slow pressure of measuring elements they find the characteristics of the internal structure, stickiness and to some extent of the shear resistance. Warner-Bratzler Shear Press shears the sample only in one plane. Thus it measures the sample resistance to shearing and can be applied for the evaluation of hard articles, e.g., extrudates imitating bones for dogs. The above mentioned methods need a very expensive apparatus as INSTRON, which ensures continuous motion of measuring elements and records the measuring parameters. Some authors try to use Charpie's Hammer for texture evaluation. However, this is a device for the me-asurement of impact strength. The hit sample breaks at the weakest point and energy used does not tell anything of the internal microstructure of the tested sample. With the heterogeneous internal structure characteristics of organic materials, this method is quite useless.

MATERIALS AND METHODS

The test samples of the raw material moistened to the required moisture content and conditioned for the period of 24 h were extruded on the single screw extrusion-cooker S-45. From each test sample of the extrudate specimens were taken for the examination of physical properties. The texture was tested on the testing stand worked out according to the assumptions of the new method. Its essence consists in giving up the static measurement and adopting the technique in which the tested specimen is dynamically affected by the measuring elements. In the proposed method the energy E is measured, which must be used in order to crush the tested specimen and its internal structure and the specific crushing energy (J/g) is determined.

The working principle of the new proposed method of texture measurement and the working principle of the proposed measuring tester are presented in Fig. 1. On the base *1*, levelled by means of the regulating screws *10*, two supports *2* and *3* are placed. To the support *2* bracket *4* is fixed, on which the pendulum *5* with shearing knives *6* is placed on the axle with bearing. The pendulum *5* is kept in the upper position by means of the catch *12*. To the supports *2* and *3* the bracket of the shearing table *9* is attached with the shearing knives of the table *7*. The shearing table *9* is attached in a movable position both horizontally and vertically so that it is possible to place the geometric centre of the specimen 8 at the point of the passing of gravity centre O_2 of the pendulum 5. The shearing elements of the table are placed in the distance a calculated from the dependence:

$$a=b+2\,dk$$

where a - gap between the shearing elements of the table, b - the width of the shearing knife of the pendulum, d - the maximum diameter of the grains of the processed raw material, k - factor resulting from the extend to which the raw material has been processed.

The shape of the shearing elements of the table and pendulum is also strictly defined. The size of the angles $\alpha_1 \geq 0$ and $\alpha_2 \geq 0$ depends on the kind of the processed raw material in the tested sample and on the internal friction coefficient as well as on the material of which the shearing elements were made. The angles α_1 and α_2 must eliminate the use of energy needed to overcome the friction forces during the movements of the specimen crushed elements, which happens in the methods used so far. Thus, on alreday known methods influence an error resulting from the use of energy needed to move the crushed elements of the specimens among the shearing elements.

In the construction of the texture tester the constant length of the knife table, 80 mm, was assumed. Hence, the specimens prepared for testing cannot be shorter than 80 mm, but can be longer. The longer ends of a specimen just stay uncrushed and do not affect the measurement results. This solution to the problem ensures explicit inter- pretation of the research results.

Detailed information describing raw materials used in these experiments are given elsewhere [4].

RESULTS AND DISCUSSION

The investigations carried out confirmed the usefulness of the method tested. The new method is simple and reliable. The tests are carried out on a cheap tester of small size

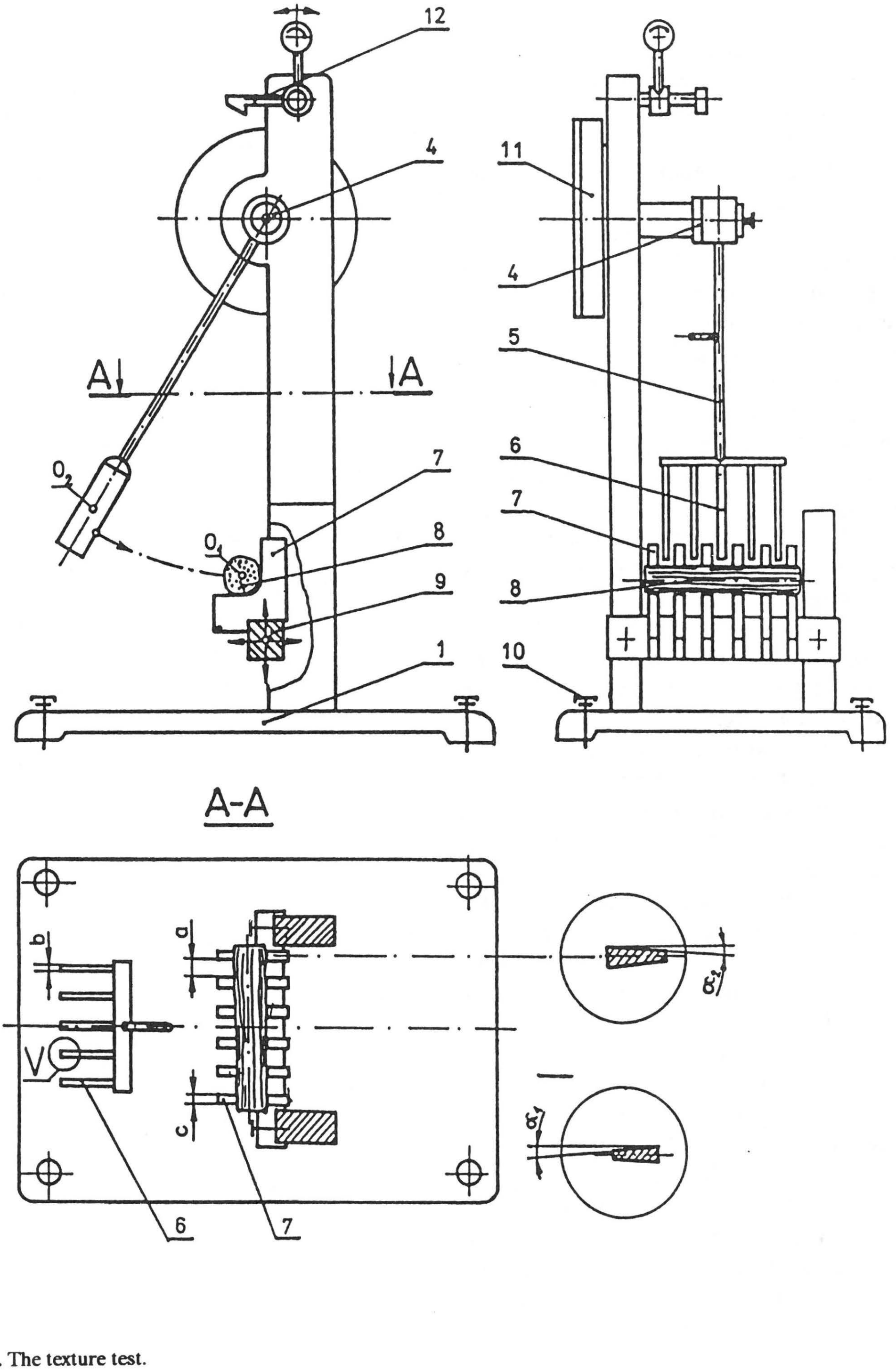

Fig. 1. The texture test.

in which even a small workshop can be equipped. The measurements are taken very quickly and conveniently. The evaluation of the method was carried out on 62 test samples of corn-pulses extrudate and 46 test samples of broad bean extrudate. The tests were to examine the influence of: the raw material composition, the raw material fineness, the barrel temperature, the raw material moisture content, the die diameter, the product moisture content and the design parameters of the shearing elements of the pendulum and the table on the specific crushing energy value (Figs 2-7). The test samples extruded on 5 mm die had greater crushing energy than the test samples extruded on 4 mm and 3.5 mm dies (Fig. 2a). The specific crushing energy value is also influenced by the raw material composition. The highest crushing energy characterised the test samples of corn extrudate containing peas, a lower one belonged to those containing beans and the lowest one to those containing lentils. It must be mentioned, however, that this is true for the samples extruded in the identical conditions of the process (Fig. 2a).

The tests were also carried out for the influence of the main parameter of the tester, i.e., the width of the tables knives on the character of the received results and the course of investigations. The tester was examined for the knives of 6, 5, 4, and 3 mm. The worst results were received for the knives 6 mm. In this case it often happend that the crushed samples blocked between the knives of the table and therefore this solution should be recognized as useless.

Far better results were achieved for the knives of 5 mm and 4 mm. Far less blocking of the sample material between the table knives occurred. The best results were achieved for 3 mm knives. Here, the tested sample gets crushed into small pieces and does not block itself in the table. For 3 mm knives also the least results scan was achieved and this surely is the best recommendation for the adoption of this solution to further investigations. It should be emphasized here that each point of the diagrams is the mean of the 26 measurements.

The change in the width of th knives and therefore the change in the size of the gap between the knives significantly affects the value of energy needed to crush the sample. This is caused by the change in the working principle of the tester. For the 6 mm width of the table knives and 8.8 mm size of the gap between the knives basically clear shearing of the specimen in 20 planes can be observed. The specimen gets cut into many discs and is little ground. We can observe here basicaly multiplane shearing. Reduction of the width of the table knives and therefore the enlargement of the gap between the knifes also changes the character of the tester work. The specimen is not longer cut into discs and gets more ground. At the same time decreasing of energy needed to crush the specimen can be observed. Taking into account the principle that tester should possibly in the highest degree immitate the biting effect and correlate with the results of the organoleptic evaluation of texture, it is recommended to accept the 3 mm width of the table knives as a standard one.

CONCLUSIONS

1. The worked out method of the dynamic measurement ot texture proved efficient in the testing investigations carried out.

2. The design tester for the measurement of crushing energy is small, cheap and can be used at any production site.

3. The energy used for multiplane crushing of the specimen can be used as measure unit of crispy material texture.

4. It is proposed to introduce the expression 'material crispiness' which could be measured by the value of energy used per mass unit.

5. It is proposed to introduce the expression 'specific crushing energy' (J/g) as the measure of the quantity of energy needed to destroy 1 g of the tested sample.

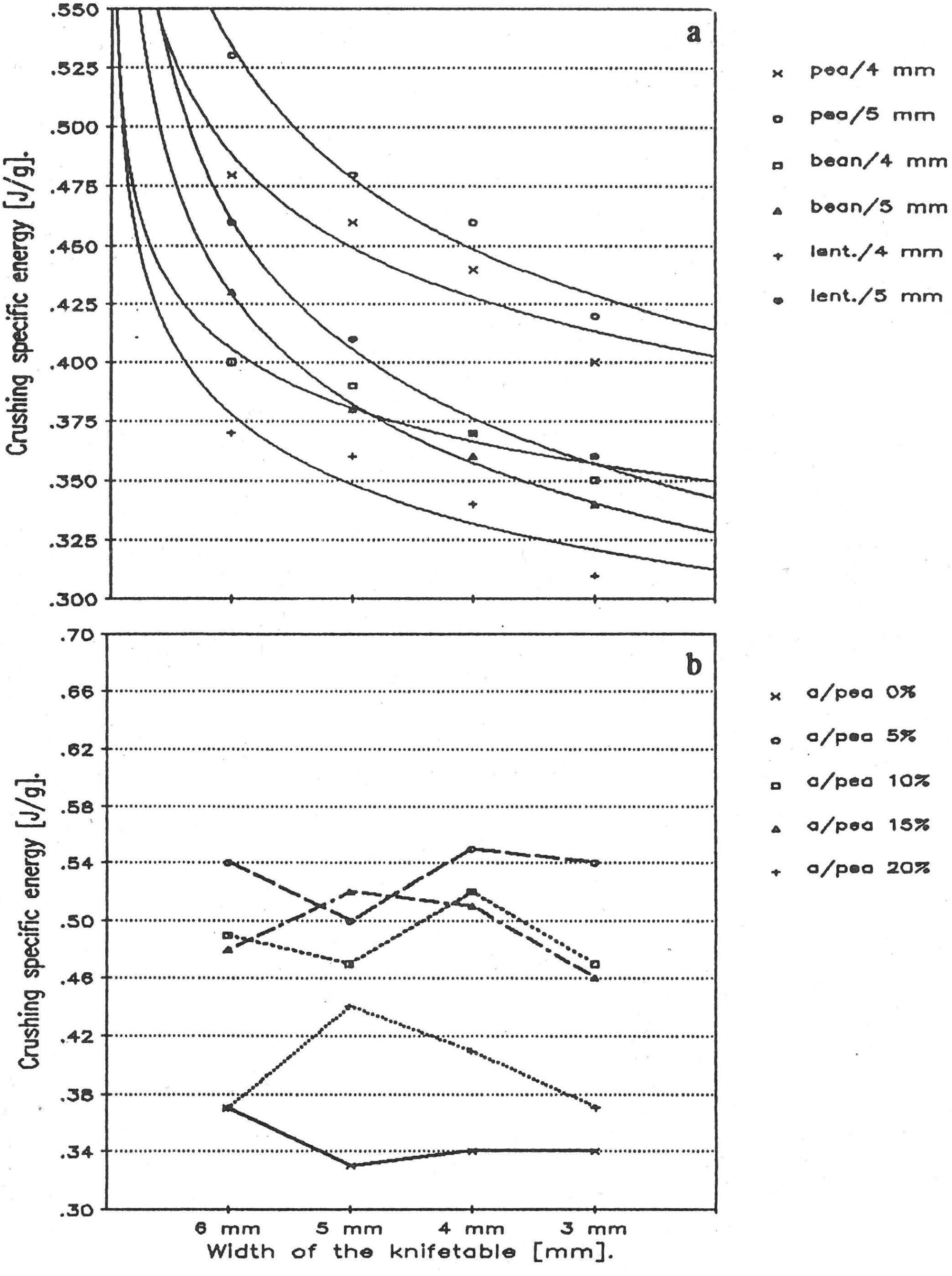

Fig. 2. The influence of the width of the knife table on the specific crushing energy. Pulses rate 20 % (a); Die 3.5 mm, mixture A/a (b).

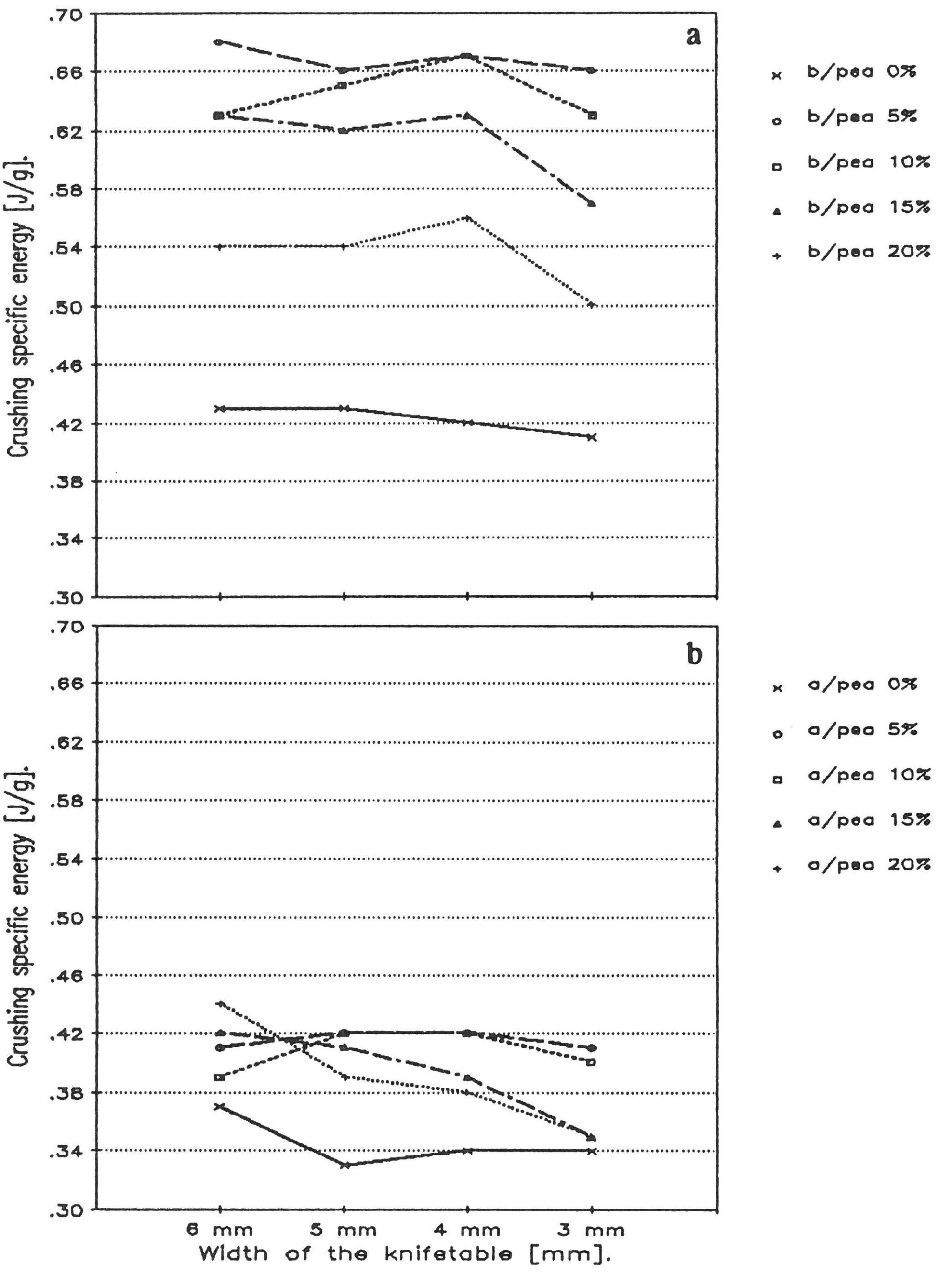

Fig. 3. The influence of the width of the knife table on the specific crushing energy. Die 3.5 mm, mixture A/b (a); Die 3.5 mm, mixture B/a (b).

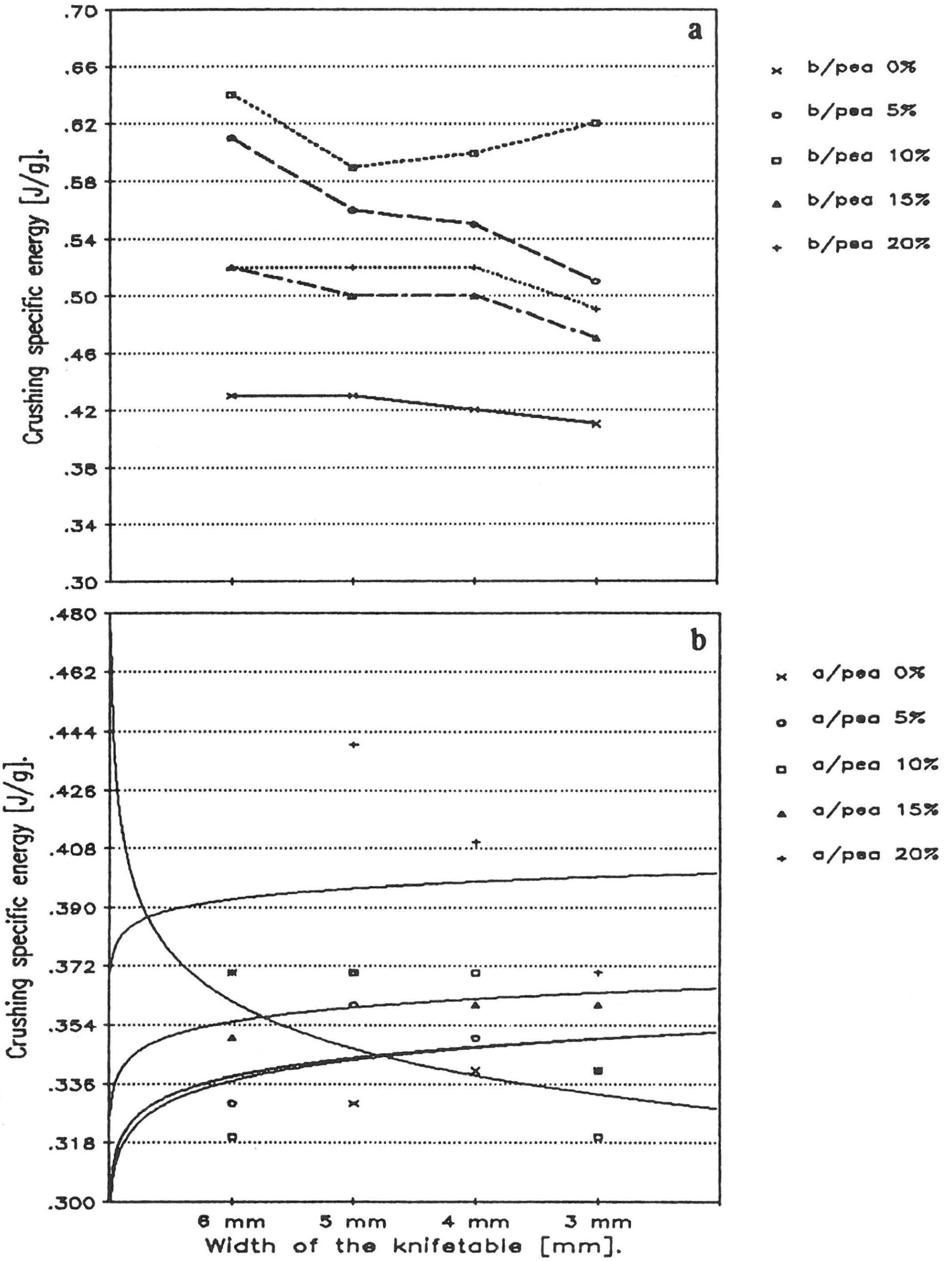

Fig. 4. The influence of the width of the knife table on the specific crushing energy. Die 3.5 mm, mixture B/b (a); Die 3.5 mm, mixture C/a (b).

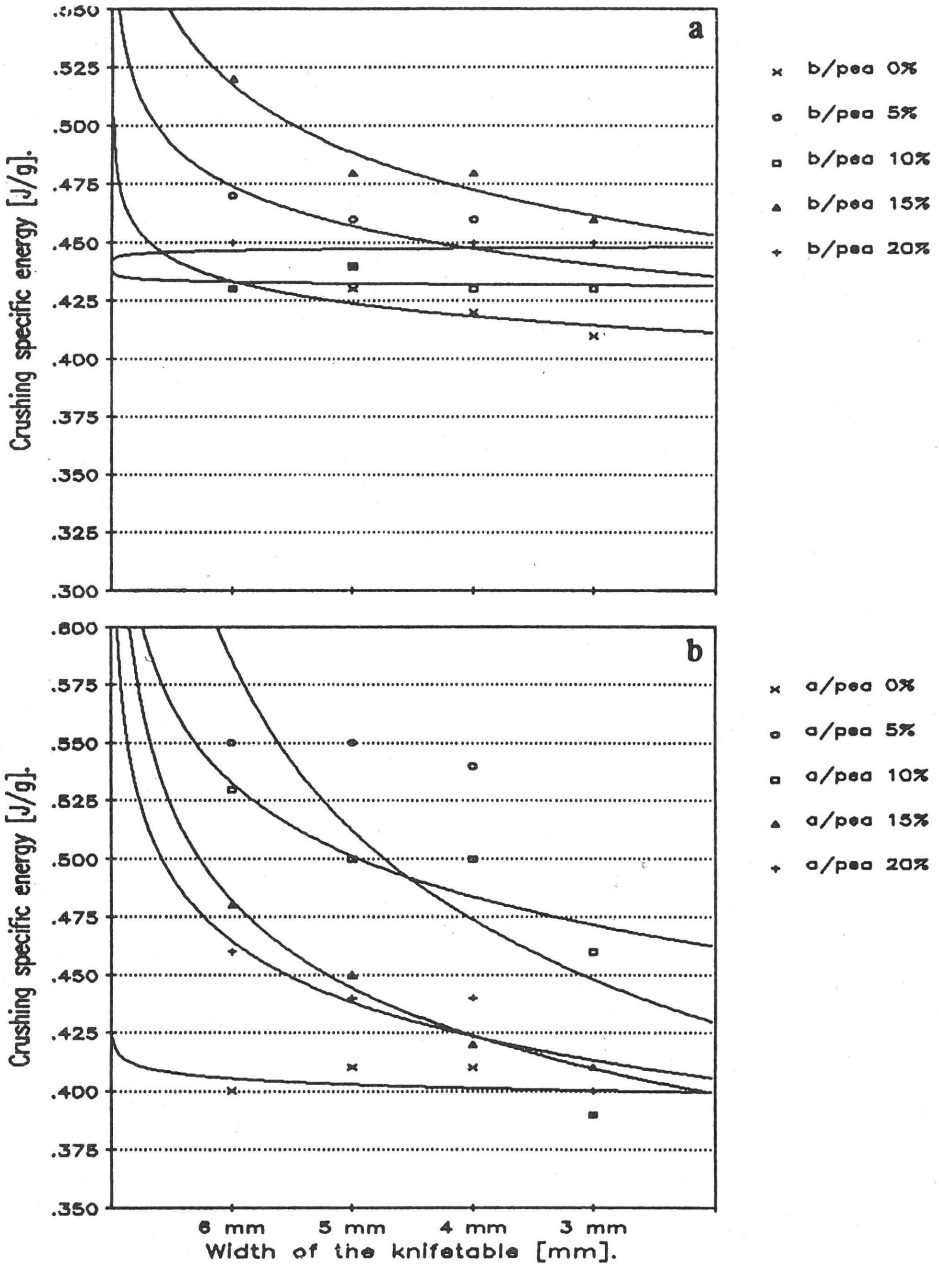

Fig. 5. The influence of the width of the knife table on the specific crushing energy. Die 3.5 mm, mixture C/b (a); Die 4 mm, mixture A/a (b).

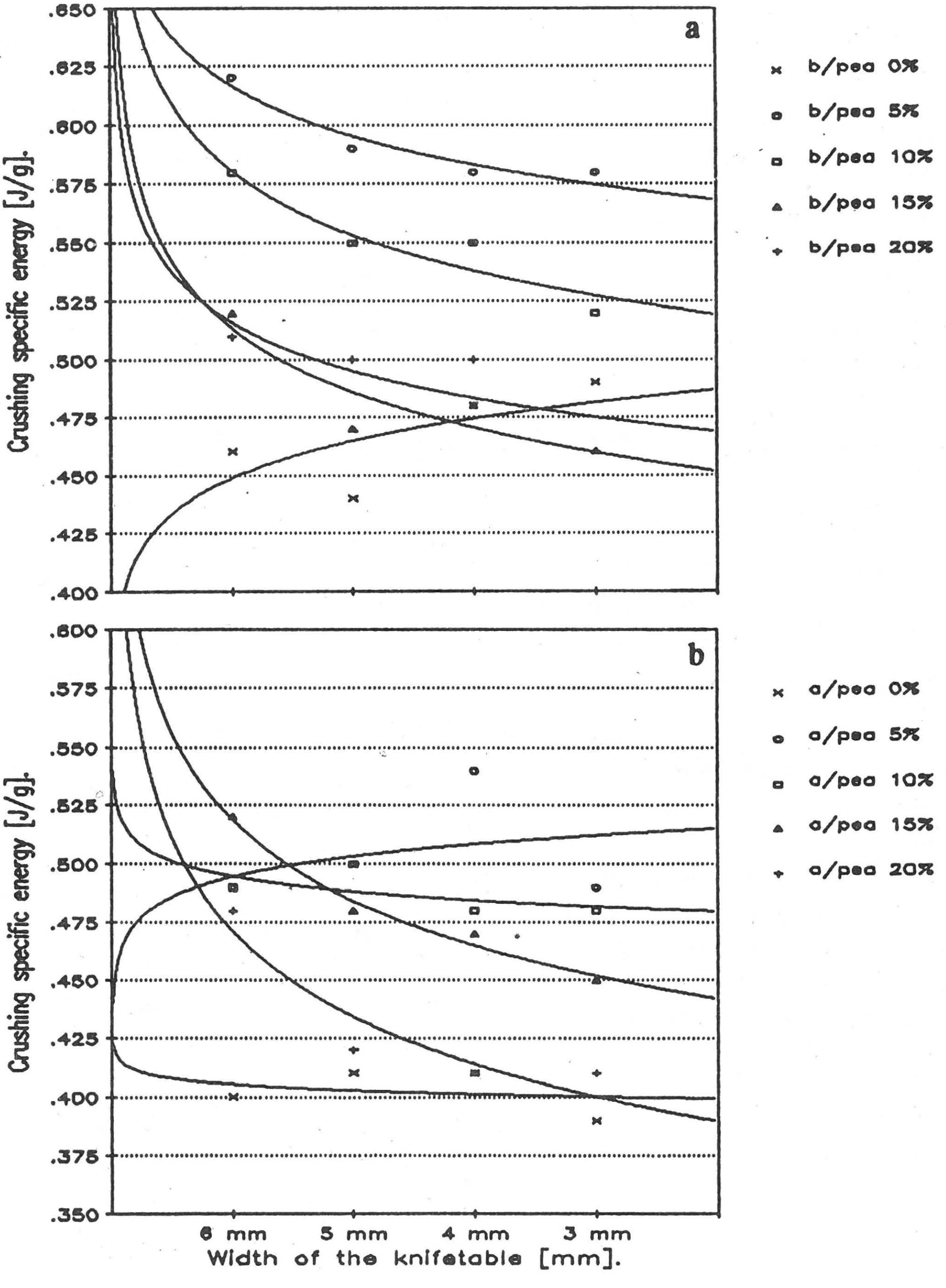

Fig. 6. The influence of the width of the knife table on the specific crushing energy. Die 4 mm, mixture A/a (a); Die 4 mm, mixture B/b (b).

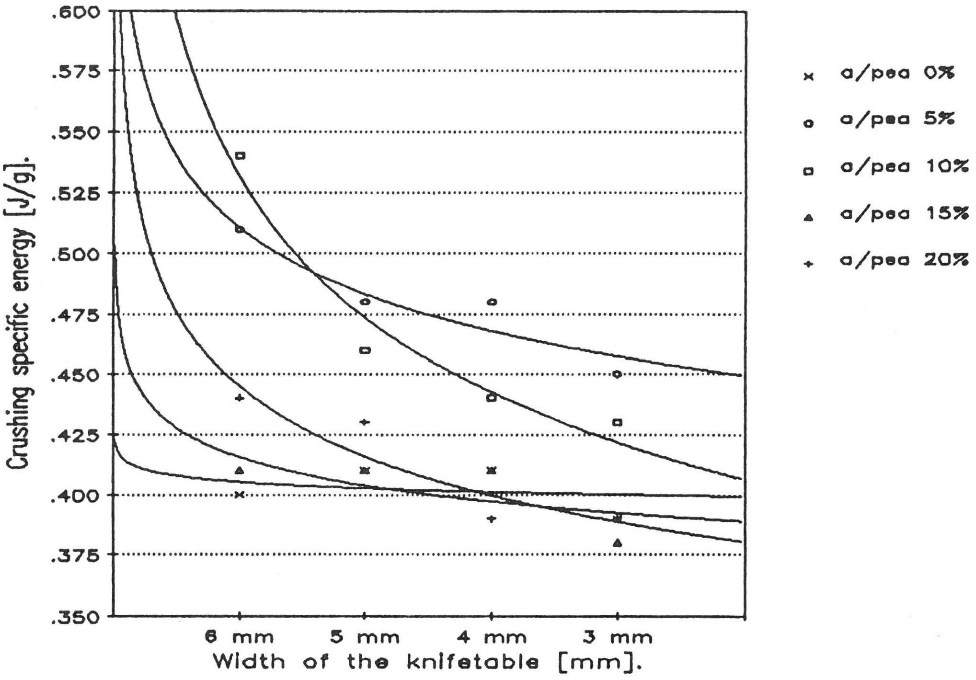

Fig. 7. The influence of the width of the knife table on the specific crushing energy. Die 4 mm, mixture C/a.

6. For the evaluation of some articles it may prove useful to introduce a measure of energy consumption per cubic unit (J/cm^3).

7. It is proposed to adopt the standard tester dimensions: the width of the tester knives 3 mm, the width of the gap between the table knives 12 mm, the width of the pendulum knives 2 mm, the size of the gap between pendulum knives 13 mm.

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