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PREPARATION OF FABA BEAN (*Vicia faba L.minor*) PRODUCTS. PART IV. EFFECT OF HYDROTHERMAL TREATMENT OF FABA BEAN ON THE QUALITY OF FLOUR

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Key words: faba bean, proteins, trypsin inhibitor activity, microstructure, organoleptic quality of flour.

The most advantageous parameters of hydrothermal treatment of faba cotyledons were determined. These are: steaming temperature 110°C and time 2 min. and they caused —at relatively smay decrease of protein solubility and slight damage of cotyledons structure (SEM)—a cansiderable lowering of trypsin inhibitors activity and an improvement of organoleptic quality of flour obtained from thus prepared cotyledons.

INTRODUCTION

Seeds and flours, as well as protein concentrates and isolates obtained from leguminous plants, are of limited applicability in food industry due to their characteristic beany flavour. In order to improve the organoleptic properties of these preparations efforts are made to identify the compounds responsible for the flavour and to find ways of their elimination or inactivation during technological processes [1, 4, 17]. So far the most effective way of eliminating the beany flavour from protein preparations was to rinse them with alcohol. As this method is rather expensive, new, cheaper and simpler ones are being searched for. One of them is hydrothermal treatment of seeds. In this research faba bean cotyledons were steamed for a short period, and the quality of obtained flours was examined.

EXPERIMENTAL

Dehulled seeds of the Fribo faba bean variety were investigated. Cotyledons were treated hydrothermally in a fluidizing device of our own make enabling measurements of time and temperature of superheated steam action. The parameters of cotyledons steaming were as follows:

temperature (°C)	time (min)
100	2, 5, 10, 20
110	2, 5, 10
120	1, 2

Following steaming, the cotyledons were dried at 30°C to moisture content 10%, and grinded to 0,2 mm grain size. In thus obtained flour, the nitrogen solubility index (NSI) was determined according to AOCS [14] and trypsin inhibitors activity (TIA) according to Kakade et. al. [8]. Microscopic analysis was performed with 2 Tesla BS-300 scanning electron microscope at accelerating voltage 10 kV. Flour obtained from cotyledons steamed for 2 min at 110°C was analysed organoleptically according to a 5-point scale [3].

RESULTS AND DISCUSSION

EFFECT OF HYDROTHERMAL TREATMENT ON FABA BEAN PROTEINS

Hydrothermal treatment of faba bean cotyledons resulted in a lowering of nitrogen solubility as expressed by NSI (Fig. 1A). The changes clearly depended on the temperature and time of steaming. The higher the temperature applied, the greater the decrease of nitrogen solubility. Thus, steaming of beans for 2 min at 100°C caused a 12% decrease of NSI, at 110°C — 27%, and 120°C — 41%. The least solubility (NSI 11%) was found for cotyledons steamed for 20 min at 100°C.

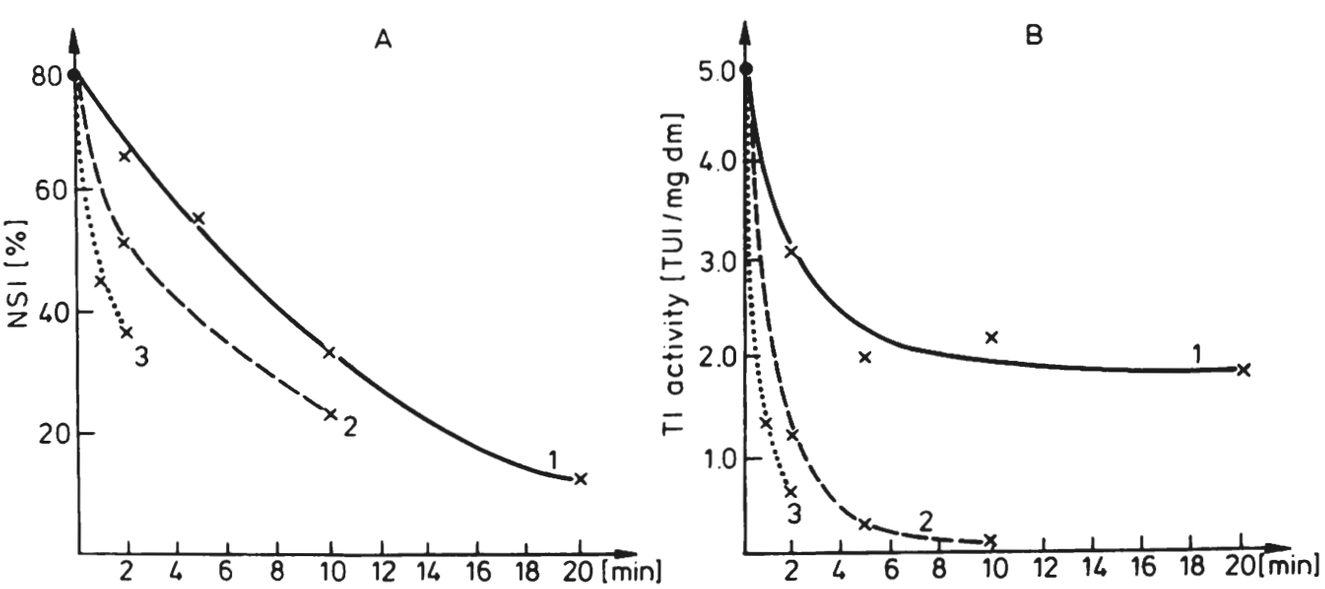


Fig. The effect of hydrothermal treatment on NSI (A) and II activity (B); ● ⊖ non steamed seeds, 1 — × 100°C, 2 — × 110°C, 3 — × 120°C

Yet it was impossible to apply such a long time of steaming in higher temperatures as the beans turned into pulp already after 10 min of steaming at 110°C and after 2 min at 120°C. There is no data in the available literature on the effect of hydrothermal treatment on nitrogen compounds solubility in faba bean cotyledons. From our investigations it follows that in order to maintain a

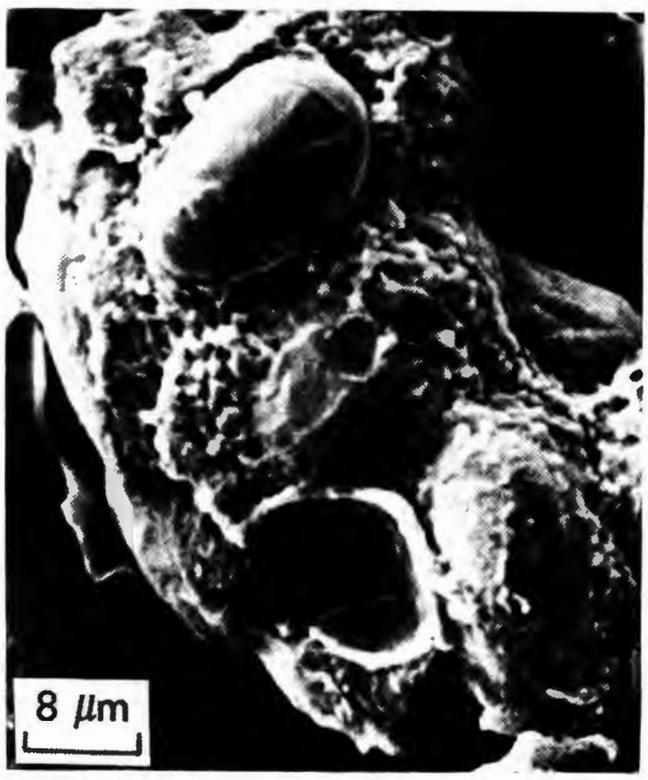
possibly high protein solubility at simultaneous serious decrease of trypsin inhibitors activity the cotyledons should be steamed at 110°C for 2 min (Fig.). The relatively small decrease of NSI (27%) in these conditions makes it possible to use the material thus prepared as a source of protein isolates. The study of this problem is reported in part V of this paper.

In the conditions of our experiment, a complete or partial inactivation of trypsin inhibitors was caused by denaturation changes of proteins (Fig. 1B). The decrease of NSI was accompanied by TIA decrease. Also, it was rather the temperature than the time of steaming that affected TIA more. For instance, complete inactivation was observed in beans steamed for 10 min at 110°C, while the extension of steaming time to 20 min at 100°C resulted in a mere 64% loss of antitrypsin activity.

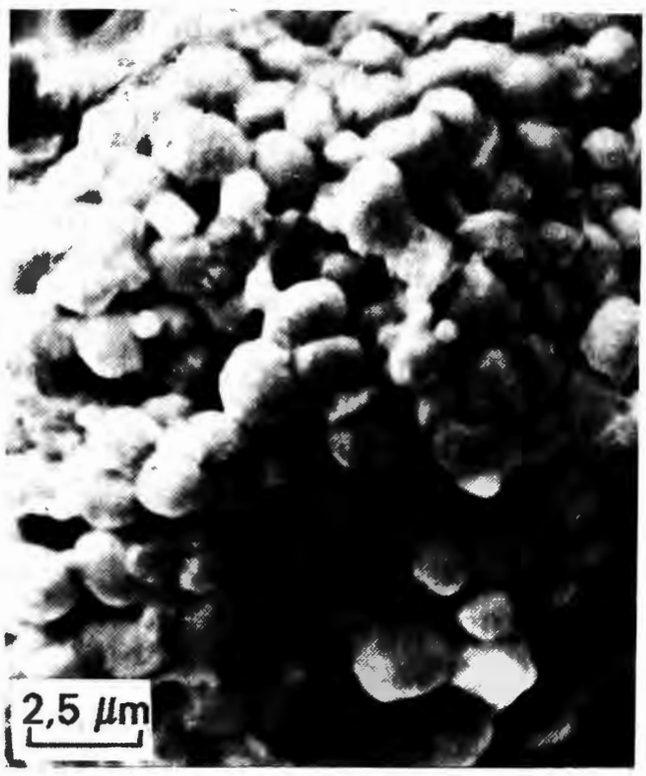
There are no data in the available literature concerning changes of TIA caused by hydrothermal treatment of faba bean, or changes of NSI. The data in hand concern TIA changes during faba bean flour granulation and flaking accompanied by steaming [11]. Granulation at 70°C caused a slight lowering of activity, while flaking accompanied by steaming at 92°C-96°C resulted in a 73%-94% loss of activity. According to Ferrier and Lopez [5], steaming of soybeans for 20 minutes at 99°C resulted in a 73% drop of TIA.

CHANGES OF FABA BEAN MICROSTRUCTURE DURING HYDROTHERMAL TREATMENT

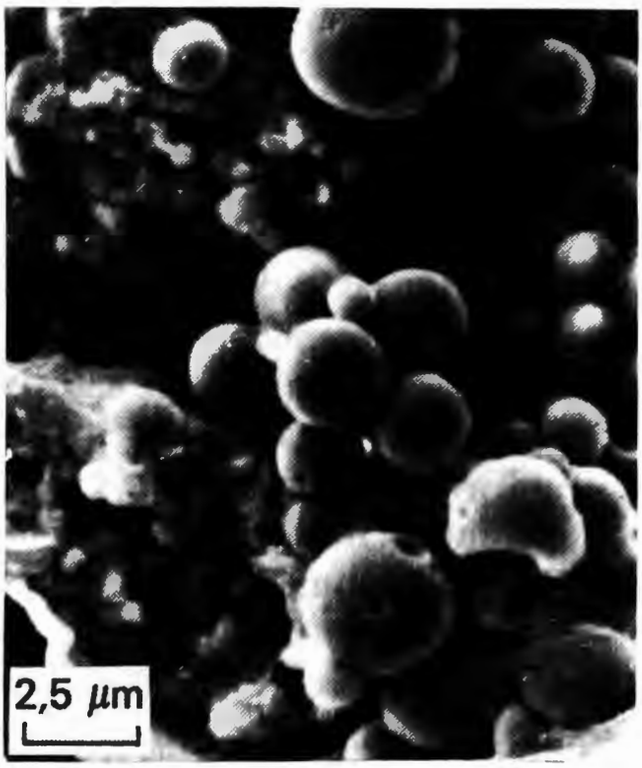
In order to confirm changes of NSI and TIA in faba bean caused by hydrothermal treatment, the structure of cotyledons was examined with a scanning electron microscope. The microscope picture of a control faba bean cotyledon cell (photo 1) doses not differ from the photographs published so far [6, 10]. The main component of the cell were starch granules surrounded by numerous clusters of matrix protein and protein bodies. Oval-shaped starch granules had an average diameter of about 30 um, while spherical-shaped protein bodies mentioned by Lorenz [6] had diameters ranging from 0.5 to 2μm (photo 2). The analytically determined lowering of NSI and TIA connected with proteins changes seemed to be confirmed by the microscopic picture of a cotyledon cell. The least NSI decrease (12%) and antitrypsin activity decrease (38%), observed in the sample of cotyledons steamed for 2 min at 100°C, were accompanied by only slight changes in the protein bodies microscopic picture (photo 3). Under the action of moisture and heat the bodies seemed to swell considerably, acquiring regular spherical shape. The sings of denaturation were visible as subsistence of spherical-shaped surfaces which, according to Gwiazda and Kocoń [7] and Schweiger [16] is connected with the change of arrangement of hydro and lipophylic groups and with the destruction of natural intramolecular protein conformation. The observed changes of protein bodies microscopic picture were accompanied by microscopic changes in starch granules, namely by swelling and gelatinization. These processes, according to Rockland et al. [13], intensify along with tempereture. The effect of steaming time extension to 20 min at 100°C on



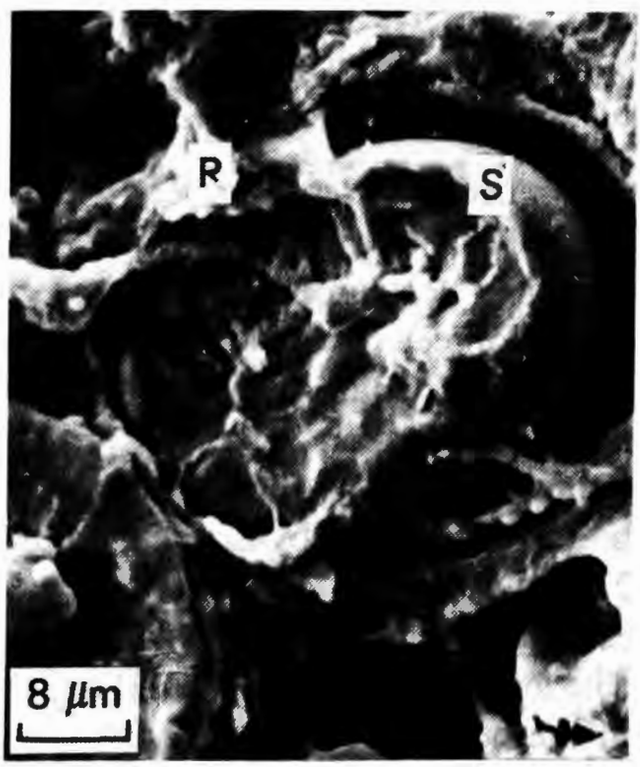
Phot. 1. Cotyledon cell of control faba bean



Phot. 2. Enlarged view of protein bodies of control faba bean

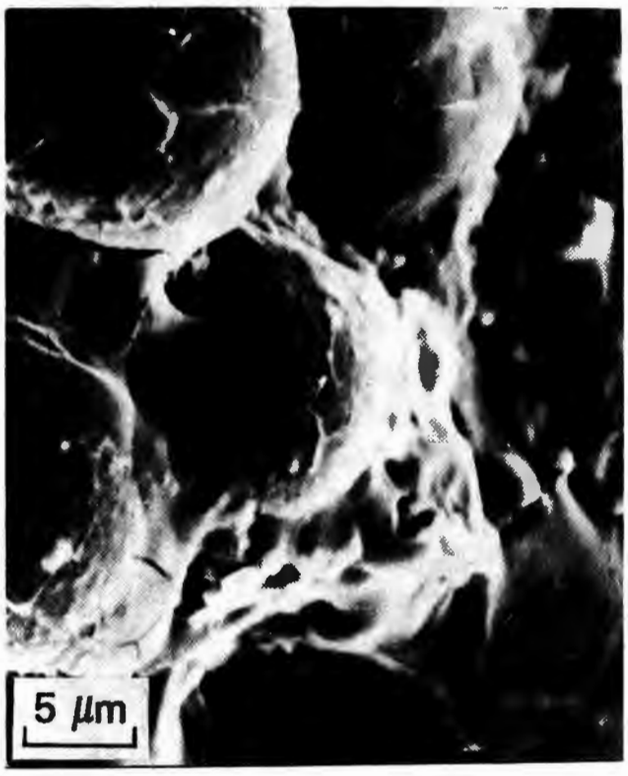


Phot. 3. Enlarged view of protein bodies of faba bean steamed for 2 min at 100°C

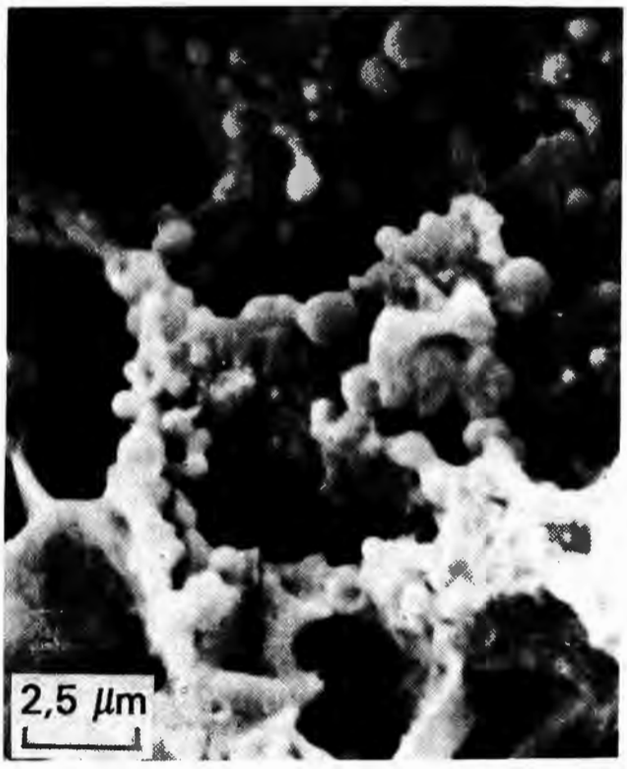


Phot. 4. Starch granule (S) and protein (P) in a faba bean cotyledon cell steamed for 2 min at 100°C

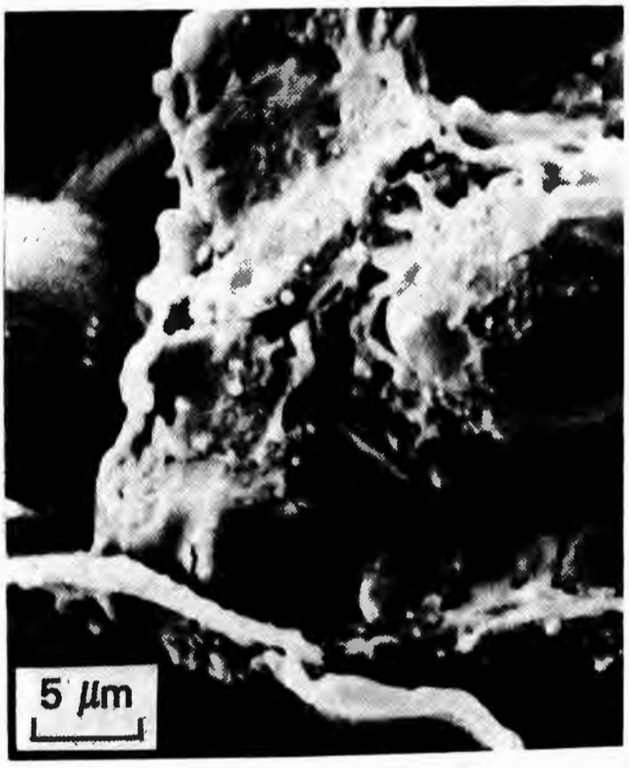
starch and protein is presented in photo 4. The obtained picture is similar to those obtained by Sefa-Dedeh and Stanley [15] for cooked seeds of leguminous plants. The presented changes of protein structure were accompanied by a 67% loss of NSI and a 63% loss of TIA. Raising the temperature of hydrothermal treatment to 110°C at unchanged time (2 min) caused further changes in the microscopic picture of protein bodies and starch (photos 5 and 6). Starch granules were tightly



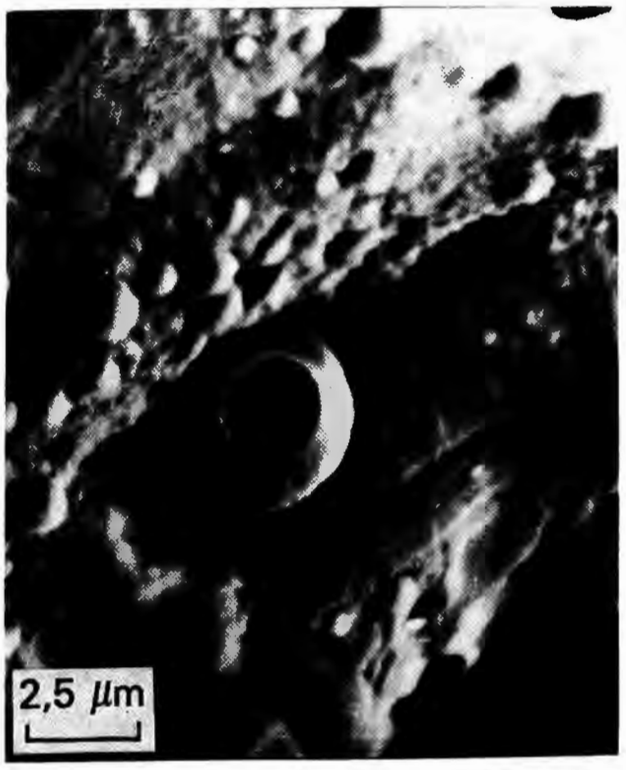
Phot. 5. Cotyledon cell of faba bean steamed for 2 min at 110°C



Phot. 6. Enlarged view of protein bodies of faba bean sreamed for 2 min at 110°C

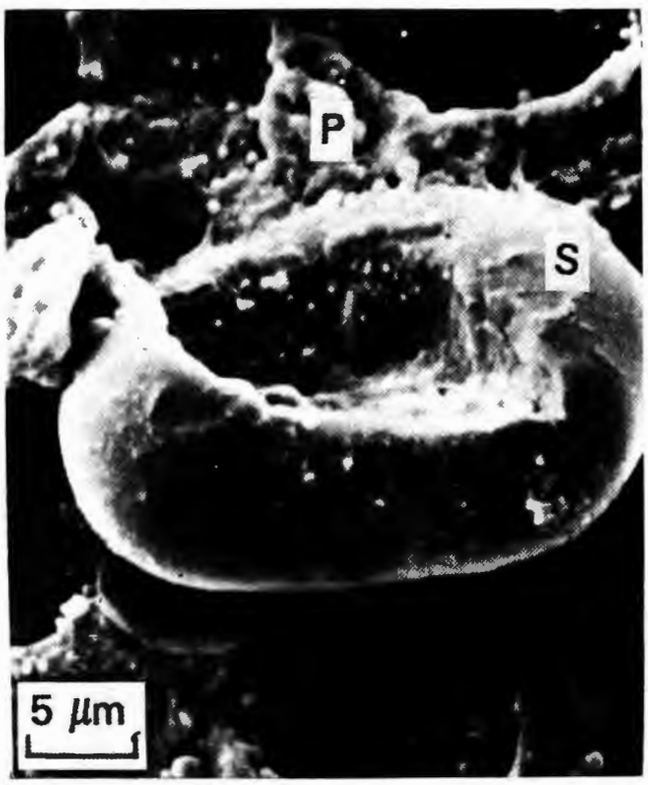


Phot. 7. Cotyledon cell of faba bean steamed for 5 min at 110°C

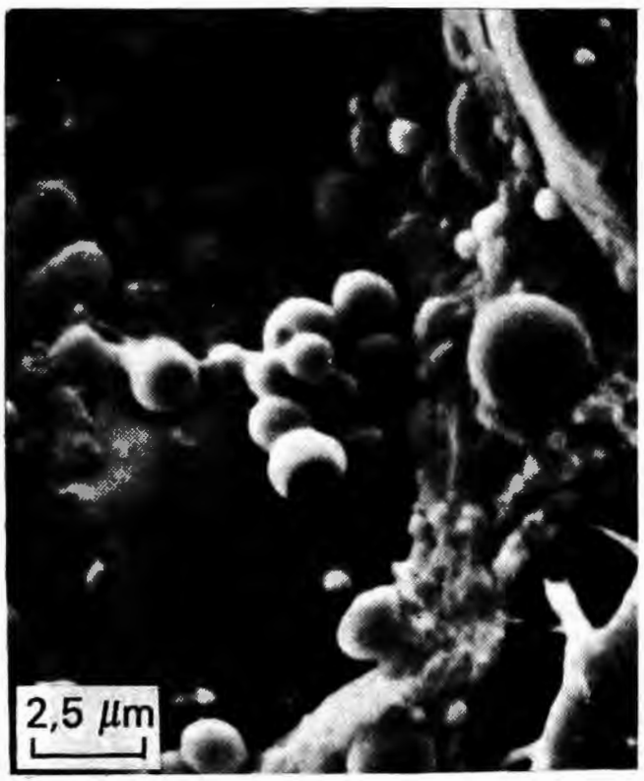


Phot. 8. Enlarged view of protein bodies and protein mass of faba bean cotyledons steamed for 5 min at 110°C

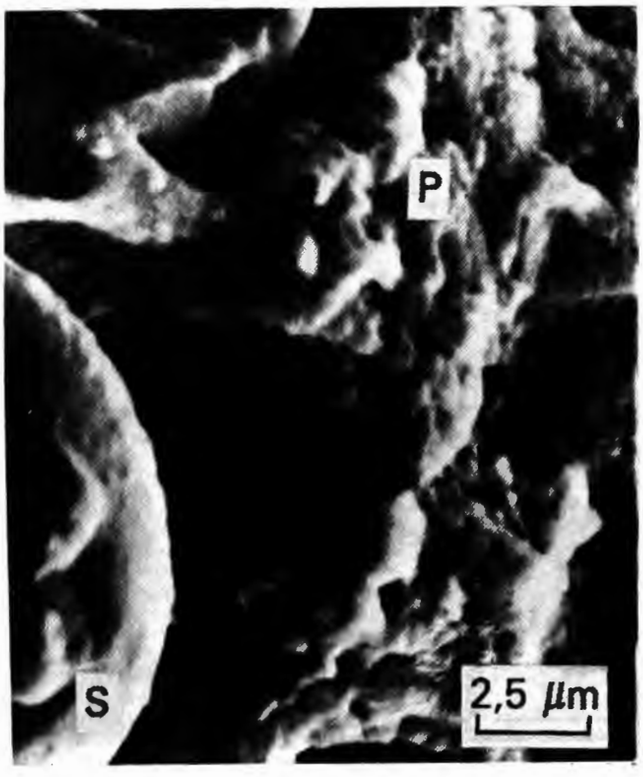
covered with an amorphous mass, while single protein bodies formed considerably larger aggregates which according to other autors [7] may be the result of the formation of cross-linking bonds. This may lead to a greater exposition of lipophylic groups and, consequently, to lowered solubility of protein in water [7]. The extension of steaming time to 5 and 10 min at 110°C resulted in further changes in the microscopic picture of cotyledon cells. There could be observed

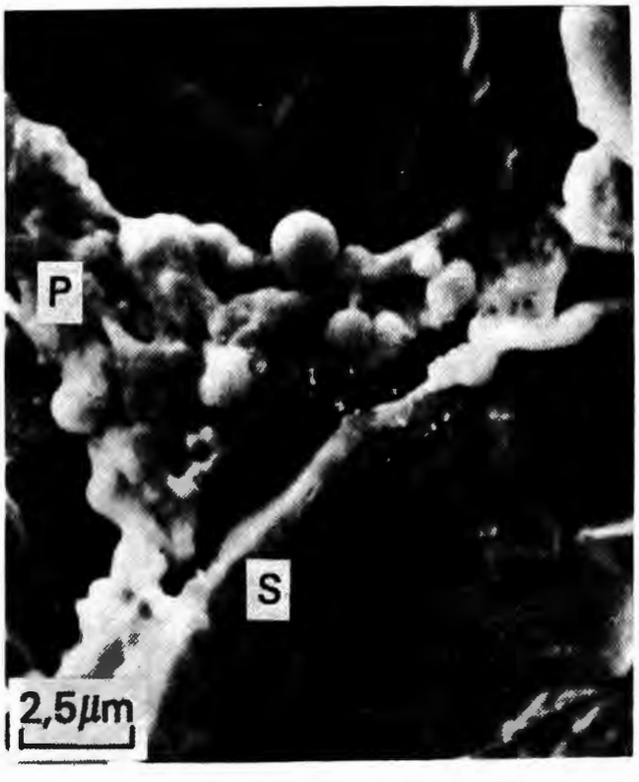


Phot. 9. Starch granule (S) and protein (P) in faba bean cotyledons cells steamed for 10 min at 110°C



Phot. 10. Enlarged view of protein bodies and protein mass of faba bean cotyledons steamed for 10 min at 110°C





Phot. 11. and 12 Starch granules (S) and protein (P) in faba bean cotyledon cells steamed for 2 min at 120°C

further joining of bodies into larger conglomerates and deepening concavities on their surface (photos 7 and 8). Nevertheless, even after 5 min of steaming there were still some untouched protein bodies, which might be the proof for their greater thermostability (photos 9 and 10). The deepening denaturation changes of proteins observed with the microscope as the steaming time was being extended were accompanied by a gradual decrease of NSI and TIA, after 10 min reaching

23% (Fig. 1A) and a trace amount (Fig. 1B) respectively. Microscopic analysis of cotyledons treated hydrothermally for 2 min at 120°C showed, in comparison to the samples treated for the same time at 100°C and 110°C, considerably greater changes of microscopic picture of protein and starch (photos 11 and 12). This was especially evident in the case of starch whose swollen and gelatinized granules, the result of migration of amylose from their inside, acguired the shape of pontoons. These essential changes of protein structure were accompanied by a 41% decrease of NSI and an 88% decrease of TIA. The presented results show that there exists a relation between NSI and protein picture as observed in the scanning electron microscope. They also show that the denaturation changes at protein depend on temperature rather than on the time of steaming.

The presented analysis of the effect of hydrothermal treatment on the basic cotyledons components, i.e. on protein bodies and starch, seems to confirm our choice of parameters temperature 110°C acting for 2 min turned out to be optimal. In these conditions the structure of cotyledons was not disturbed as much as it was in the case of longer steaming time or higher temperature despite the changes that did take place.

ORGANOLEPTIC QUALITY OF THE HYDROTHERMALLY TREATED FLOUR

Applying the optimal parameters of hydrothermal treatment, we prepared a large amount of flour and evaluated its colour, tasae and smell (Table). It turned out that steaming completely changed the flours taste and smell without affecting its colour. Flour obtained from steamed cotyledons was completely devoid of the beamy flavour so typical for this species. Such results indicate possibilities of applying faba bean as a protein rich food component and as a source of high-quality protein preparates.

Ta b l e. Effect of steaming faba beans on organoleptic properties of flour

Flour	Colour		Taste		Odour	
	points	description	points	description	points	description
Non steamed	4.5	light beige	3.0	leguminous	2.5	leguminous
Steamed 110°C, 2 min	4.5	light beige	4.5	neutral	4.5	similar to wheat flour

CONCLUSIONS

1. Hydrothermal treatment of faba bean cotyledons results in lower solubility of nitrogen compounds (NSI) and in lower activity of trypsin inhibitors (TIA), the temperature of steaming being of greater importance for these changes than the time of steaming.

2. A relation was found between the NSI coefficient decrease and changes in the picture of protein bodies observed in a scanning electron microscope.

3. The steaming of faba bean cotyledons at optimal parameters (110°C, 2 min) evidently improves the organoleptic properties of flour.

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OTRZYMYWANIE PRODUKTÓW Z BOBIKU (*VICIA FABA L. MINOR*), CZ. IV. WPŁYW OBRÓBKI HYDROTERMICZNEJ BOBIKU NA JAKOŚĆ MĄKI

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Streszczenie

Dążąc do poprawy jakości preparatów białkowych otrzymywanych z nasion roślin strączkowych, liścienie nasion bobiku odmiany Fribo poddano obróbce hydrotechnicznej w temp. 100, 110, i 120°C oraz czasie od 1 do 20 min w urządzeniu fluidyzacyjnym.

Zastosowana obróbka hydrotermiczna zdecydowanie poprawiła jakość mąki bobikowej. Ustalono wyraźne obniżenie aktywności inhibitorów trypsyny oraz poprawę cech organoleptycznych, przede wszystkim smaku. Obniżenie się aktywności inhibitorów trypsyny, podobnie jak rozpuszczalności azotu było uzależnione od zastosowanej temperatury oraz czasu jej oddziaływania.

Zaznaczył się wyraźniej wpływ temperatury, aniżeli czasu na badane wyróżniki jakościowe. Na przykład inaktywację inhibitorów trypsyny do aktywności śladowej uzyskano poddając liścienie ogrzewaniu w temp. 110°C przez 10 min, natomiast ogrzewanie w temp. 100°C przez 20 min spowodowało spadek aktywności o 64%.

Wyniki analiz chemicznych znalazły potwierdzenie w obserwacji zmian struktury komórkowej liścieni w skaningowym mikroskopie elektronowym. Spadkowi rozpuszczalności towarzyszyły zmiany ciał białkowych i skrobi widoczne w mikroskopie. Nasilały się one w miarę podwyższania temperatury, bądź też wydłużania czasu jej oddziaływania.

Na podstawie uzyskanych wyników ustalono, że temp. 110°C oddziałująca na badany materiał przez 2 min powodowała stosunkowo niewielkie zmiany denaturacyjne białka oraz istotne obniżenie aktywności inhibitorów trypsyny. Mąka otrzymana przy zastosowaniu wymienionych parametrów obróbki hydrotermicznej pozbawiona była całkowicie grochowego smaku i zapachu, co rokuje możliwości jej wszechstronnego zastosowania w żywności.