Effect of dietary fiber on technological properties and safety of protein systems

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Abstract. Dietary fibers are components of vegetable and animal raw materials, from which until recently were released in the process of obtaining purified, refined food. The most accessible and frequently used dietary fibers are formed in the process of processing wheat into flour of higher grades. In the production process there is a different degree of grinding, which according to some authors can have a significant impact on their biological value. The purpose of the research is to determine these effects on the model protein systems and to justify the possibility of regulating the technological properties and safety of protein systems by dietary fibers. The quality of the materials used wheat bran, obtained during the processing of wheat. Model protein systems were prepared from crushed muscle tissue of freshly caught Pacific herring (Clupea pallasii) and Pollock (Theragra alcogrogramma). Embraced are characterized by different technical characteristics. As a result, it was found that wheat bran makes it.

1. Introduction

In the modern mechanical engineering a significant number of parts are fabricated from lead-tin-base bronzes. Dietary fiber is a component of plant and animal raw materials, which until recently were released to produce the purified, refined food. They consist mainly of polysaccharides and may be soluble (pectic substances, alginic acids, gums, mucus, arabinoxylans, etc.) as well as insoluble (cellulose, lignin, cellulose lignin complexes, some types of hemicelluloses) in water. All these substances can be components of food, but they resist to the action of digestive enzymes and are not susceptible to absorption. However, their functional properties are associated with the proper organization of the gastrointestinal tract in the human body[1, 2].

The most accessible and frequently used dietary fibers are formed under the processing of wheat into higher-grade flour. Formed so-called wheat bran are quite well studied. They are used as food fillers for diet and medical nutrition and have an established maximum allowable intake rate of 25 mg / day [3, 4].

Wheat bran in the production process have varying degrees of grinding, which, according to some authors, impact significantly on their biological value. In addition, the degree of grinding, and the total amount of wheat bran can affect the sensory properties (taste, smell, appearance) and the activity of digestive enzymes.

The purpose of the research is to determine these effects on model protein systems and to
substantiate the possibility of regulating the technological properties and safety of protein systems in dietary fibers.

2. Materials and methods

2.1. Wheat bran produced under the processing of wheat were the initial materials. Model protein systems were prepared from crushed muscle tissue of freshly caught Pacific herring (*Clupea pallasii*) and pollock (*Theragra chalcochroma*). The models differ not only in different chemical composition, but also in the activity of their own enzymatic systems.

2.2. The mass fractions of water, lipids, and nitrogenous substances were determined according to the methods adopted for the study [5, 6]. The activity of proteolytic enzymes by the methods of Kaverzneva [7, 8]. Pepsin - trypsin primacy of proteins "in vitro" by the method of A. A. Pokrovsky and E. D. Ertanov (1965) [9].

2.3. The sorption capacity of wheat bran was determined using a Hitachi atomic absorption spectrophotometer. Wheat bran was added to a solution containing a certain amount of metals (lead, cadmium, and zinc ions) in the water under the temperature of 18-20 °C with a ratio of 4 and the filtrate was collected after 0.5 and 3 hours. The experiments were carried out at the same time with the different values of pH (2.0;7.0;8.0). The metal amount in the filtrate was measured by atomic absorption spectrometry.

For comparison, the measurements were carried out in “blank samples” in which distilled water was used instead of a solution containing the metal ions. From the difference in the values of the amount of metals in the standard solution and in the filtrate, the sorption capacity of bran was defined separately for each pH value.

2.4. Structural and mechanical characteristics were evaluated by water-holding capacity (WHC%), determined by the method of G. Grau and R. Hamm, by pushing strength (F g / cm2) of heat-treated samples on a Food Checken instrument (Japan) and a FUDON rheometer (Japan) - according to the instructions to the instruments.

Studies were performed with 3-5 replications. The measured data were processed by the methods of mathematical statistics using the Microsoft Excel application programs and the SPSS program.

3. Results and discussion

According to some authors, all components of wheat bran when grinding to particle sizes less than 250 microns become more accessible to the human body and even able to increase the nutritional value of products. As a result of our research, it was defined that the main size fraction (85% of the mass fraction of the sample) has the particle sizes of 200 to 600 μm (Table 1). Particles with sizes less than 200 and more than 600 μm add up to only 15%.

| Particle size, microns | The number of particles of this size, % |
|------------------------|----------------------------------------|
| <150                   | 3                                      |
| 150 – 200              | 7                                      |
| 200 – 315              | 15                                     |
| 315 – 420              | 50                                     |
| 420 – 600              | 20                                     |
| 600 – 850              | 4                                      |
| >850                   | 1                                      |
| Total                  | 100                                    |

Taking into account the significance of the WHC, the change of which entails a change in other structural and mechanical characteristics of protein systems, we studied the effect of different sizes of wheat bran particles on this indicator.
For the study, model protein systems were prepared, each of which contained protein mass from crushed muscle tissue of fish and wheat bran of one fraction. Bran was added in the amount of 4% to the protein mass. This amount is below the norm of maximum permissible concentrations. It is limited by the effect of bran on the sensory properties. The results showed that there was no clear dependence of the WHC of the protein system on the size of the bran particles (Table 2).

The main size fraction (from 200 to 600 μm) has stable, slightly varying values of the WHC, equal to, on average, the value of the WHC of the bran itself.

So, for the pollock protein system with the inclusion of the main bran fraction, the average value of the WHC is 71.87%, and the WHC of the protein mass with bran not divided into fractions corresponds to 71.85%.

Table 2. Influence of the size of the particles of wheat bran on the WHC protein masses

| Particle size, microns | Pollock muscle tissue | Herring muscle tissue |
|------------------------|-----------------------|-----------------------|
|                        | WHC, %                | F, g/cm²               | WHC, % | F, g/cm² |
| <150                   | 70,19                 | 430                   | 73,9   | 540      |
| 150 - 200              | 69,73                 | 460                   | 73,5   | 480      |
| 200 - 315              | 72,45                 | 440                   | 73,3   | 510      |
| 315 - 420              | 71,38                 | 430                   | 73,5   | 540      |
| 420 - 600              | 71,80                 | 480                   | 73,0   | 520      |
| 600 - 850              | 70,07                 | 490                   | 73,2   | 530      |
| >850                   | -                     | -                     | -      | -        |
| Not sifted             | 71,85                 | 480                   | 73,3   | 540      |

For the model system of the herring's muscle tissue, these values are 73.26 % and 73.30 %, respectively. The results indicate statistically significant values, since their discrepancy does not exceed 1 %.

The strength of thermally treated samples varies slightly. For the pollock model, the F value ranges from 430 to 490 g/cm²; for herring models - from 480 to 540 g/cm². At the same time, differences in the chemical composition of the model masses affect only the values of the MAS and F, and do not depend on the presence of bran (Table 3). From the above, it follows that the degree of grinding of bran does not affect their MAS and insignificantly affects the strength characteristic.

Table 3. Chemical composition of the muscle tissue of fish for the preparation of model mass %

| Kind of fish       | Protein (N total - Nb) x 6.25 | Lipids | Water | Minerals |
|--------------------|-------------------------------|--------|-------|---------|
| Pollock            | 17,1                          | 0,3    | 81,4  | 1,2     |
| Pacific herring    | 13,6                          | 7,9    | 76,3  | 2,2     |

Therefore, it is advisable to use the pre-grinding operation if the inclusion of bran affects the sensory characteristics of the finished product (appearance, patches on the surface, etc.). It should be noted that the addition of wheat bran and the chemical composition of model systems have some influence on the strength characteristics after heat treatment.

To identify the degree of inhibition by wheat bran of its own enzymatic activity of protein masses, the magnitude of the hydrolysis depth after exposure to pepsin and in parallel after exposure to trypsin was determined. Under the study of in vitro pepsin-trypsin activity, the model system from crushed muscle tissue of Pacific herring served as a source of proteins, since this fish has a higher activity of proteolytic enzymes of muscle tissue compared to pollock muscle tissue. To compare the effect on the enzymatic activity of wheat bran, we studied the effect of the addition of microcrystalline cellulose in doses recommended for food use. It turned out that the value of the hydrolysis depth of samples with
additives during pepsin fermentation is close to the hydrolysis depth of the control sample (without both wheat bran and microcrystalline cellulose) (Figure 1).

![Figure 1](image1.png)

**Figure 1.** Value of the hydrolysis depth during pepsin fermentation

The amount of 3-4 g of an inhibitor per 1000 g of a food product is harmless to the human body.

Wheat bran dietary fibers are represented by a number of different fiber properties: cellulose, hemicellulose, lignin, etc. This diverse chemical composition of the bran determines the complex mechanism of complexation with respect to metals and characterizes them as polyfunctional type cation exchangers.

Complexation depends on the chemical composition of the sorbent, the pH of the medium, temperature and other factors.

In the process of studying the sorption capacity of wheat bran, it was defined that the initial time (0.5 h) after contact of the bran with a solution containing salts of heavy metals, is characterized by the greatest sorption of all metals at pH 8 (Figure 3c). In this case, the sorption capacity in the amount of deposited metal for lead is for the experiment, 100% of the total number was introduced into the solution, which is: 87.5; for cadmium 75.0 and for zinc 37.5%. In an acidic medium (pH 2), the sorption value at the beginning of the experiment corresponds to 62.5% for lead, and 40.0% for cadmium it remains zero (Figure 3a). In a neutral environment, the initial binding values of lead and cadmium ions are the same and amount to 75%, and zinc does not enter into cation-exchange processes at this moment and remains at zero value (Figure 3b).
After three hours in an acidic environment, the process of lead sorption continues to 87.5% and cadmium to 40.0%. Wheat bran is indifferent to zinc.

In a neutral environment, the sorption capacity for lead and cadmium increased to 100%, for zinc – to 75%. At pH 8 before the expiration of three hours, the sorption capacity of wheat bran is decreases for all three metals: for cadmium to 35%, for lead to 5%, for zinc to zero.

**Figure 3.** Sorption capacity of wheat bran depending on the pH of the medium
Preliminary data during the experiment when conducting the experiment on the binding of copper, iron and zinc ions by six types of dietary fiber, including wheat bran. It was defined that with a parallel effect on dietary fibers of solutions with different values of pH, the main amount of metals is bound at pH 6.8. [10]. Sequential treatment of the fibers with a solution of hydrochloric acid and phosphate buffer does not lead to significant changes in the sorption capacity compared to dietary fibers, which were only affected by a solution with a pH of 6.8. Based on these data, it was concluded that these metals do not demonstrate active sorption properties at low pH values.

We assumed that the metals will be bound by wheat bran already in a neutral medium and the successive effects of the acidic and alkaline medium will not be able to destroy the complex formed. To check this assumption, the series of experiments were carried out on sequential processing of model protein mass with the inclusion of 4% wheat bran with a solution of hydrochloric acid and phosphate buffer to simulate the environment of the gastrointestinal tract.

Protein mass with bran and pepsin were added to the working solution (lead and zinc concentration - 40 µg/ml, cadmium - 20 µg/ml) and the pH was adjusted to 2.6 by hydrochloric acid, then it was incubated for two hours at 37 °C. After that, the sample was neutralized by sodium bicarbonate and the pH was adjusted to 8 by phosphate buffer, and trypsin was added. The incubation took place for 2 hours at the same temperature. Samples were taken at pH values of 2.6 and pH 8.0 after incubation. Samples were taken at pH of 2.6 and 8.0 after incubation. Similarly, a blank was prepared under distilled water used instead of the working metal solution. At the end of the temperature control process, the solutions were filtered and the amounts of metals were determined on an atomic absorption spectrometer. Knowing the amount of metals in the standard solution, the filtrate and the blank sample, the degree of extraction of metals was determined (Figure 4).

![Figure 4. Sorption capacity of bran under conditions that imitate human gastrointestinal tract](image-url)

From the obtained results, it follows that the sorption capacity of bran under conditions that mimic the human gastrointestinal tract increases in the series: lead / zinc / cadmium. Lead sorption occurs particularly effectively - 96.5% of the amount of metal deposited, slightly less than cadmium - 73.2% and zinc - 62.3%. Then the studied metals had the highest values of sorption in a neutral environment: lead and cadmium up to 100%, zinc - 75%. Comparing this conclusion with the results of the experiment conducted under conditions simulating the gastrointestinal tract, we can say that the values...
are somewhat decreased, but the overall. The trend of the process confirms the assumption that the use of wheat bran in food will promote the binding and removal of metals such as zinc, cadmium and lead from the body.

4. Conclusion

Wheat bran provides an opportunity to regulate the technological properties, safety and overall nutritional value of protein systems based on fish muscle tissue. Their addition contributes to the formation of the desired structural and mechanical characteristics, while there is no need for additional grinding and separation of bran into fractions. The activity of the own enzymes of the protein systems, when adding wheat bran at the recommended doses, decreases slightly, which is not a disadvantage. Their ability to absorb heavy metals will allow them to design new types of finished products that meet the requirements for organic healthy nutrition.

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