CHANGE IN STRUCTURAL-FUNCTIONAL PROPERTIES OF FLOUR MODIFIED FOR MANUFACTURE OF MEAT PRODUCTS

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Key words: modified flour, extrusion, microstructural analysis, water-binding, fat-binding, hydration

Background

Wheat flour is a traditional kind of vegetable raw materials widely used in technology of meat products as a functional-technological filler. It has higher water-binding and water-retaining capacities due to availability of a great number of hydrophilic centers in its protein structure, but fat-binding and fat-emulsifying capacities of wheat flour are very low. Another disadvantage of this raw material lies in the fact that finished products may have rubber-like consistency and "blank" taste in case of using great amounts of flour.

To improve functional-technological properties of the above kind of raw material, specialists from VNIIMP and VNIIPB developed the method of breadwheat flour modification by thermomechanical treatment. Such treatment resulted in destruction of the polymer chain of semisaccharides and protein substances, appearance of new hydrophilic centers affecting change in functional properties of the product being manufactured, as well as its structural characteristics.

Objective

The objective of this study was to investigate functional properties of modified wheat flour and its microstructure during hydration.

Methods

Modified wheat flour (MWF) and original breadwheat flour (WF) served as an object of investigations. Breadwheat flour was modified by the cooking extrusion method.

During investigations by standard methods water-binding, fat-binding and fat-emulsifying capacities, as well as solubility of MWF, compared to those of WF, were determined. Both samples of flour were hydrated under the following conditions: hydration coefficient (hydromodulus) 1 : 5-6, temperature 20 °C during 30 min, 60 °C during 1 hour, 72 °C during 1 hour. Microstructure of the hydrated samples was studied using the image analysis system "VideoTest".

Results and Discussion

Functional properties of MWF compared to those of WF are characterized by the following indices (Table 1).

Table 1. Functional properties of MWF and original WF

Sample	Capacity, %		
	fat-emulsifying	fat-binding	water-binding
WF, 1st grade	750	240	102
MWF	960	529,8	595

Table 2. Change in water- and fat-binding capacities of MWF during thermal heating

Index	Duration of heating, h				
	0	1	2	3	4
Water-binding capacity, %	595,0	652,2	675,14	682,73	594,4
Fat-binding capacity, %	529,8	542,1	559,6	572,2	538,2

The given data show that due to thermomechanical treatment considerable improvement of functional properties of wheat flour took place: its water-binding capacity was 5.8-fold higher than that of the original one; the fat-emulsifying capacity increased by 1.3-fold, and fat-binding capacity, by 2.2-fold.

Simultaneously change in water- and fat-binding capacities of dry MWF during long-term heating was studied. The MWF samples were heated during 1-4 hours (duration of thermal heating of cooked sausage products) at 72 °C in the center of flour being heated. Change in water- and fat-binding capacities is given in Table 2.

Thus, as a result of long-term heating, imitating the process of thermal heating of cooked sausage products, the water- and fat-binding capacities of MWF increase insignificantly during the first 3 hours, and later on they return to their initial level. It results from this, that in the process of thermal heating of cooked sausage products, MWF being part of the ground meat, will exclude moisture losses and appearance of water-fat pockets.

Characteristics of water absorption closely correlate with solubility. Solubility, as well as water-binding capacity, depend on conformation and degree of protein denaturation. It has been established, that solubility changes during heat treatment. Under the influence of temperature and pressure denaturation of proteins takes place: quaternary, tertiary and, probably, secondary structures are destroyed. Intensive thermomechanical treatment in the extruder results in orientation of molecules in the field of limiting forces. At this time redistribution of ties responsible for the structure of proteins takes place: hydrogenous and ionic ties, hydrophobic interactions of disulfide bridges. This chemical phenomenon is accompanied by decrease of protein solubility. Wheat flour also contains a great amount of starch in which amylose-aminopectin ratio amounts to 24 and 76 %, respectively. Changes taking place in them during thermomechanical treatment affect solubility of the finished product. Thus, with the rise of heating temperature of starch being treated up to 135 °C solubility of extrudates increases. At 175 °C solubility somewhat decreases, but then increases again, reaching 70 % at 190 °C. The above changes of solubility are caused by thermal destruction of starch polysaccharides (gelatinization, combination of amylose and lipids). Thus, total solubility of wheat flour is determined by changes taking place during thermomechanical treatment. Experimental investigations demonstrated that as a result of extrusion solubility of flour at 20 °C increased 3-fold, compared to that of the primary raw material (namely, from 4.91 to 14.43 %). With the rise of temperature the above differences in solubility of the two kinds of flour increase. Thus, at 60 °C solubility of MWF is 4,67-fold higher than that of WF.

It has been established that solubility of MWF, irrespective of the medium pH, is several times higher than that of WF. Minimal solubility of both samples of flour was registered at pH 6, what testifies of isoelectric point of flour proteins. Displacement of pH both to the side of decrease and increase leads to the rise of total solubility value of dry substances in the samples.

Microstructural investigations of MWF and WF demonstrated that the original product (WF) in the transient beam of light microscope represented particles of different size (from small- to medium-sized) and their aggregates. The particles mostly have irregular shape: small spherical, polyoctahedral, similar to cylindrical ones. In some of them complicated internal structure can be seen; when coloring the flour with Lugol solution, starch grains are revealed in it. The modified flour, compared to the original one, has totally different structure. The particles in it are larger, the range of their size changes is more narrow, and their form is more flattened, squamous, angular. The grain component is not revealed in them. It has been established by hydration at 20 °C during 30 min, that in the process of a short-time interaction of flour and water at the room temperature (suspension) its aggregates are fragmented into less-sized particles and multiple rounded grains. These grains contain mainly the starch component which doesn't swell under the above conditions (Fig. 1). At the same time contact of MWF particles with water, even during a limited period of time, and at rather moderate temperature (+20 °C) leads to their obvious hydration. During analysis of their structure under microscope one can see that extrusion results in transformation of the grain form of starches into the linear one. In consequence, components form as if a striated pattern in MWF particles. Under the action of water the particles swell moderately, and their size (square) increases (Fig. 2).

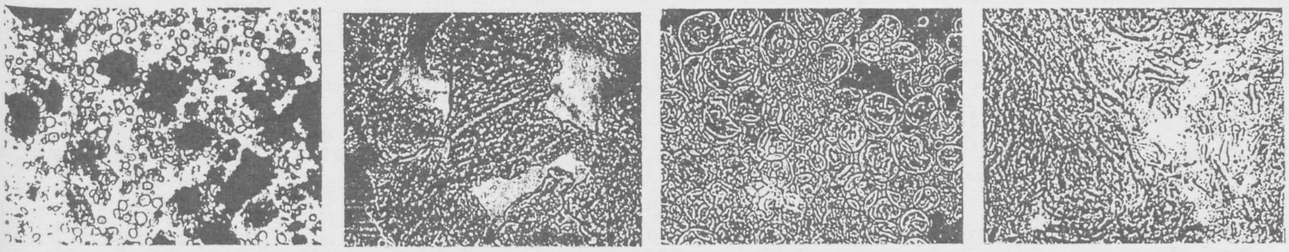

Fig.1. Microstructure of WF treated at 20 °C.

Fig. 2. Microstructure of MWF treated at 20 °C.

Fig. 3.Structural characteristics of WF at 72 °C.

Fig. 4. Structural characteristics of MWF at 72 °C.

Thermohydration treatment of the original flour at 60 °C during 1 hour (provided the water, utensils and flour are separately preheated) results in obvious changes of its structure. The most part of aggregates and large grains separate into smaller particles forming rather homogeneous mass. Hydration of the starch grains themselves is restricted, and their gelling is not observed. However, the starch grain size increases a little bit. MWF treatment under the same conditions leads to expressed hydration of glycoprotein components with formation of a gel-like structure. On the light microscope separate fragments stretched lengthwise and having sufficient optical density are revealed; they, probably, represent MWF protein component. The boarder between separate particles of flour most often is not revealed, and mass as a whole is characterized by a linearly striated pattern.

Original flour maturation in water at 72 °C during 1 hour leads to considerable hydration and gelatinazation of carbohydrate components. The total mass represents a system of rounded bodies with a revealed complicated laminated structure. In this case starch grain sizes substantially exceed those at more sparing heat treatment. The protein component obtains the form of fine-grained mass placed between large bodies of hydrated starch. Differences in the degree of hydration of the original flour at 60 and 72 °C are very significant (Fig. 3).

Structural characteristics of MWF exposed in water at 72 °C don't undergo principal changes, compared to the flour treated at 60 °C. During analysis in the transmitting light microscope the total flowing structure of flour particles remains. The boarder between its separate fragments mostly is not revealed. The degree of hydration of flour components is high, however, it differs from that at 60 °C not so much, as it is observed for the original flour (Fig.4).

Conclusions

Change in functional-technological characteristics and microstructure of breadwheat flour in the process of extrusion is of great interest for exposure of the mechanism of processes taking place during modification of starch containing raw materials and interaction of the modified product with the animal raw material when manufacturing ground meat products. Such treatment results in changes in interactions of modified raw materials containing starch with animal proteins and products of collagen hydrothermal disaggregation, that lead to formation of new carbon-lipoprotein complexes affecting greatly the quantitative and qualitative characteristics of finished products.

Thermomechanical treatment of WF changed greatly its functional properties: water-binding, fat-emulsifying and fat-binding capacities of the modified flour, compared to those of the original flour, are 5.8-, 1.3- and 2.2-fold higher, respectively. Simultaneously (3-5)-fold increase of its solubility took place, as compared to that of the original wheat flour.

MWF is characterized by a higher degree of carbon components hydration at soft regimes of treatment (60 °C). In the process of extrusion starch particles (grains) obtain a more unfolded, as if linear, form, what makes easier interaction of starch with water.

When rising temperature of treatment from 60 to 72 °C, the original breadwheat flour, in which starch grains are gelled, is hydrated more strongly. The degree of hydration and structural differences are less expressed in MWF particles under the above conditions.

The findings predetermine advisability of using MWF in manufacture of ground meat products in order to increase their water- and fat-binding capacities.