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THE ROLE OF STRUCTURE-FORMING PREPARATIONS (PROVICO AND APROPORK) AFFECTING RHEOLOGICAL PROPERTIES OF FINELY GROUND SAUSAGE FILLINGS

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Abstract. Employing the dynamic-mechanical thermal analysis (DMTA) method, an attempt was made to determine the effect of the replacement of fat by a mixture of preparations (Provico lV, starch thickener E1412, pea fibre ID90 and swine blood plasma Apropork) on the mechanical-rheological properties of finely-ground sausage fillings during thermal treatment. It was found that, at room temperature, the fat solid phase had a decisive influence on the development of the rheological properties of the control filling as well as systems with fat replaced by a mixture of preparations. Changes caused by the temperature increase within the confines of the continuous phase of meat fillings at the initial stage resulted in the liquefaction of fats and liberation of water dispergated in fats causing increased liquidity of the system. The comparison of the value of the rigidity modulus of the final product cooled down to room temperature with the filling which was not subjected to thermal treatment revealed a fivefold increase of its value. Together with the increase in the level of fat replacement by the mixture of preparations, there was a decrease of the product elastic properties and, consequently, an increase of its plasticity.

Keywords: DMTA, fat, rheology, water

INTRODUCTION

Excessive fat consumption poses the threat of obesity, arteriosclerosis, coronary heart disease, diabetes, as well as certain cancer diseases. The aspiration propagated by nutritionists and motivated by health considerations to decrease fat consumption also finds wide confirmation in numerous investigations devoted to the development of food products of limited caloric value, including low-fat meat products. Meat products of reduced energetic value can be obtained, among others, by reducing the content of fat in traditional products or by the application

of fat substitutes with lower caloric value [6,9,16,19]. More and more often, manufacturers employ various substances of natural or synthetic nature which are known as hydrocolloids or structure-forming additives. In the majority of cases they occur as components modifying the structure and texture of food products by way of thickening, jellifying or emulsification [4,5,8,10]. Complete fat elimination from the recipe formulations of meat products is not possible as fat raw material, together with proteins and water, constitute the main constituents of meat products. Fat affects the rheological properties of fillings, the texture of the finished product, as well as its palatability and juiciness [12,20] and has a significant influence on the stability of emulsions in finely-comminuted sausages. From the point of view of food techno-logy, mechanical-rheological properties are specifically associated with the texture of food products [1,13,21]. Despite the increasingly widespread application of rheometric techniques [11,22], few experi-ments have been devoted so fat to relationships between changes in the molecular structure and values describing macroscopic properties of the poly-dispersive materials of complex internal structure such as meat-containing products.

The aim of the study was to investigate the role of functional additives in the development of the extramolecular structure of fillings subjected to thermal treatment in which part of fat was replaced by a mixture of various preparations as exemplified by finely ground sausage fillings of the frankfurter type.

MATERIAL AND METHODS

The experimental material comprised finely comminuted sausage fillings manufactured from pork of the 3rd class (48.71%), fine pork fat (20.88%), water (27.83%) and additives (pickling mixture, table salt, seasonings and sodium ascorbate) (2.48%). The fine fat added to the experimental sausages was replaced by mixtures of preparations in the amount of: 40, 50 and 60%:

- the 40% replacement comprised: half of the replaced fine fat was substituted by the Provico lV preparation and the other half by the ID90 pea fibre,
- the 50% replacement comprised: 20% replacement of the fine fat by the Provico lV preparation, 20% by the ID90 pea fibre and 10% by the E1412 starch thickener,
- the 60% replacement comprised: 20% replacement of the fine fat by the Provico lV preparation, 20% by the ID90 pea fibre and 20% by the E1412 starch thickener.

Additionally, 10% of the pork meat of class 3 was replaced by swine blood plasma Apropork. Prior to their application, the applied preparations were hydrated: the Provico lV preparation at the ratio of 1:10 (1 part of preparation and 10 parts of water), Apropork – at the ratio of 1:6 (1 part of preparation and 6 parts of

water), the E1412 starch thickener – at 1:4 ratio (1 part of preparation and 4 parts of water) and the ID90 pea fibre – at 1:4 ratio (1 part of preparation and 4 parts of water). The control experimental treatment was the meat filling without the addition of fibre.

Investigations of changes in the rheological properties of the applied fillings in the function of temperature were conducted by the DMA method using a mechanical relaxometer described elsewhere [18]. The following parameters were determined during the performed measurements: component values of the combined rigidity modulus G_1 and G_2 as well as tgδ in the temperature interval from 20°C to 85°C. The frequency of the system's own vibrations was 0.364 Hz. The readings were taken 20 minutes after the system reached the set temperature. Components of the combined rigidity modulus and the loss tangent, which are basic parameters determined in investigations employing the DMA technique, were ascertained. Temperature changes of these parameters reflect changes occurring in the molecular structure of the examined material, where G_1 is associated with this part of the deformation potential energy which is retained in the course of periodic deformations, G_2 is referred to as the loss modulus and is associated with the part of energy which undergoes dissipation in the form of heat, while $tg\delta$ is the loss tangent which is the measure of internal friction and describes the relative amount of energy dissipated in the material in relation to the accumulated energy during one cycle of deformations. The presented research results are represen-tative for three replications.

RESULTS AND DISCUSSION

Figure 1 presents temperature relationships of rigidity moduli (G_1) of the examined meat fillings: control and with fat replaced by the mixture of hydrated experimental preparations.

In the entire interval of fat replacement (40-60%), with the increase in temperature, the values of the rigidity modulus were below the value of the filling which did not undergo modification.

Similarly to temperature changes in the rigidity modulus, the courses of temperature changes in the values of the loss tangent $tg\delta$ were analysed (Fig. 2).

The observed drop of the $tg\delta$ value in the entire range of the examined temperatures indicates the declining relative capability for the dissipation of mechanical energy. The change in the level of fat replacement by solutions of preparations became reflected in the form of the diverse decrement and level of values of these changes.

During the initial temperature interval (20-40°C), the fat solid phase, at room temperature, determined the values of the elasticity modulus from 4400 Pa for the non-modified filling to 2400 Pa (on average) for fillings with the replaced fat.

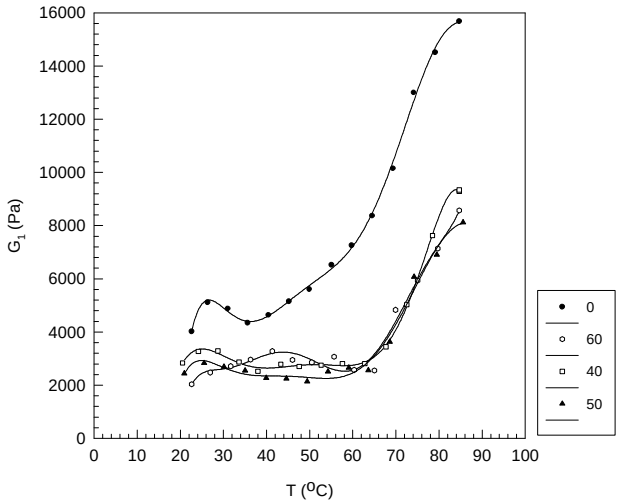

Fig. 1. Temperature relationships of the true component (G_1) of the rigidity modulus of the examined meat fillings: control and with fat replaced by solutions of experimental preparations, in %

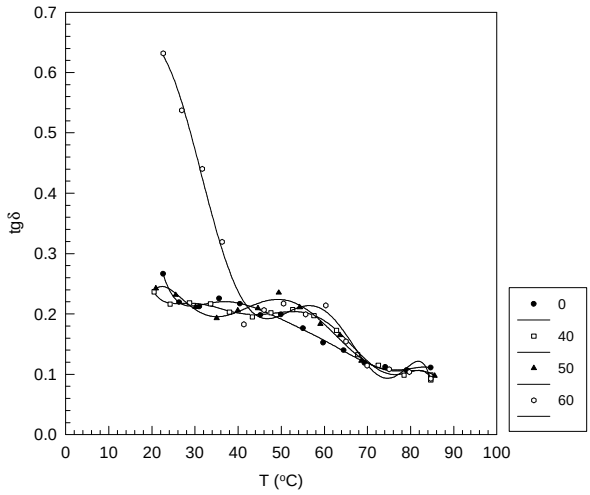

Fig. 2. Temperature relationships of the loss tangent of the examined meat fillings: control and with fat replaced by solutions of experimental preparations, in %

This high variability of the initial values was associated with a very high degree of hydration of the preparations used as fat replacers. In addition, this also influenced the level of both the rigidity modulus G_1 (Fig. 1) and dynamic viscosity η (Fig. 3) in the entire range of the examined temperatures.

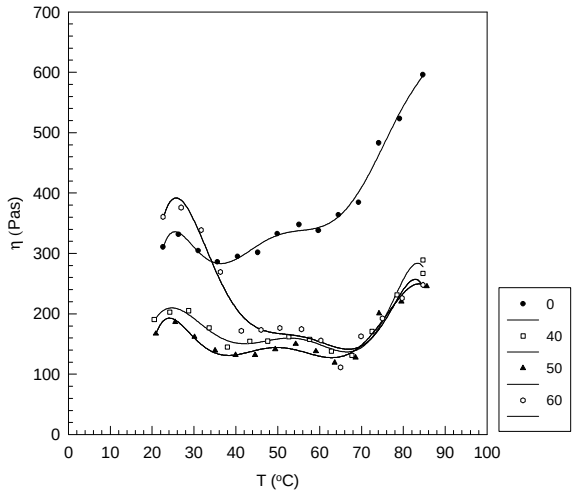

Fig. 3. Temperature relationships of the dynamic viscosity of the examined meat fillings: control and with fat replaced by solutions of experimental preparations, in %

In studies performed earlier [14,15,17], it was found that, at the range of temperatures from 40 to 65°C, the mechanical-rheological properties of fillings were strongly influenced by changes taking place within the continuous hydro- colloidal-fat phase, in particular, the denaturation processes of protein components and the conformation changes of the polypeptide chains, which were the consequence of the former, (above the temperature of 65°C) and which led to the development of the spatial protein network. Its density depended, primarily, on the quantity and degree of saturation with water of hydrophilic groups of the developed polypeptide chains.

This finds its reflection in the temperature run of the value changes of the rigidity modulus G_1 (Fig. 1).

The main trend of value changes of the above-mentioned modulus, in the analysed range of temperatures (40-65°C), was their drop. The minimum value was reached by the system in which 50% of its fat was replaced by the examined mixture of preparations. The replacement of 60% of fat in the experimental filling resulted in an increase of the value of the rigidity modulus.

An identical nature of changes was observed in the case of values of the dynamic viscosity (Fig. 3).

The applied preparations – Proviko and Apropork – were made up, primarily, of proteins, whereas the additional components were: pea fibre and starch thickener. Depending on the applied mixture of preparations (degree of fat replacement), the above-mentioned changes in the levels and values of the rigidity modulus could be observed.

In the treatment with the 40% fat replacement, this component was substituted in half by the pea fibre and the other half – by the protein preparation. In this treatment, a considerable decline in the value of the rigidity modulus (G_1) was observed (Fig. 1) accompanied by a simultaneous increase of energy losses (Fig. 2). The applied fibre, making up elements of the spatial network created by proteins [2,3], led to an increase of its density but, at the same time, restricted conformation changes of the polypeptide chains and, consequently, delayed the structuralisation processes in the filling. These effects were visible mainly in the considerably smaller increment increase of the rigidity of the systems above 65^{o}C (Fig. 1). The hydrated pea fibre, even though it was evenly distributed in the entire volume of the filling, failed to act as a stiffening element. This can be explained by the fact that there was so much fibre in the meat filling that forces acting in the fibre itself began to prevail. This led to loosening of the hydrocolloid structure and, consequently, to the observed significant decline in the G_1 value.

The situation was not improved by the reduction of the pea fibre proportion at the expense of the starch preparation (variant 50%).

The applied starch was modified potato starch which is completely dissolved at high temperatures. In contrast to the native starch, it is only slightly crystalline and its macromolecular components are strongly aggregated associations which occur in the shape of bihelix forms [7,23].

Heating caused the transfer from the orderly forms of spiral fragment of polymer chains to the state of spatially disorderly ball. This was connected with the exposure of hydroxyl groups capable of water binding. At a specific polymer concentration, which exceeded the critical strength, a mutual infiltration of macromolecular balls took place so that fragments of different macromolecules abutted one another in a small volume. In conditions in which permanent bonds could develop between the above-mentioned fragments, a spatial network of macromolecular gel could develop.

This found its expression in the temperature runs of changes of both the rigidity modulus and the dynamic viscosity. In the case of the fillings in which proportions of the pea fibre and the protein preparation (variant 50%) in the process of fat replacement were decreased with starch suspension, a further decline of values of both the rigidity modulus G_1 (Fig. 1) and the dynamic viscosity η (Fig. 3) was observed, in comparison with the respective values for the unmodified fillings. This allowed concluding that, at this level of fat replacement by starch solution, it failed to form any network (the concentration of starch applied in the system in relation to the total amount of water in the system did not reach its critical value). Starch formed only a viscous solution which acted as a "filler" of dissipative nature.

It was not until the concentration of starch in the system reached 20% (variant 60%) that effects of starch networking became apparent, as confirmed by the increased value of the rigidity modulus G_1 (Fig. 1). Simultaneously, lower values of the loss tangent $tg\delta$ (Fig. 2), in comparison with the remaining modified fillings, indicated its greater elasticity.

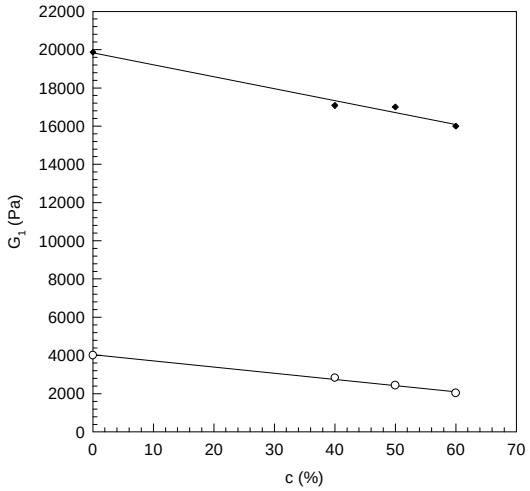

Fig. 4. Dependence of the true component (G_1) of the rigidity modulus of model meat fillings subjected to the thermal treatment (full points) and raw fillings (empty points) in the function of the degree of fat replacement by preparations

The comparison of values of the rigidity modulus of the final product cooled down to room temperature with the filling which was not subjected to the thermal treatment (Fig. 4) revealed a several-fold increase of its value. With the increase in the degree of fat replacement by preparations, a decline of the elastic properties of the product and, hence, the increase of its plasticity occurred.

CONCLUSIONS

1. At room temperature, the fat solid phase was decisive in shaping the rheological properties of both the control filling and systems in which fat was replaced by a mixture of preparations.
2. Changes caused by the increase of temperature within the continuous phase of meat fillings, at the initial stage, caused fat liquefaction and liberation of water dispersed in fats, which increased the liquefaction of the system.

3. The comparison of the rigidity modulus value of the final product cooled down to room temperature with the filling which was not subjected to the thermal treatment revealed a fivefold increase of its value.

4. As the level of the fat replacement by the mixture of preparations increased, a decline in the elastic properties of the product and, hence, increase of its plasticity were observed.

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ROLA PREPARATÓW STRUKTUROTWÓRCZYCH (PROVICO I APROPORK) W KSZTAŁTOWANIU WŁAŚCIWOŚCI REOLOGICZNYCH FARSZÓW KIEŁBAS DROBNOROZDROBNIONYCH

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Streszczenie. Wykorzystując metodę DMTA, w pracy określono wpływ wymiany tłuszczu mieszaniną preparatów (Provico IV, zagęstnikiem skrobiowym E1412, błonnikiem grochu ID90 oraz plazmy krwi wieprzowej Apropork) na własności mechaniczno-reologiczne farszów kiełbas drobno rozdrobnionych podczas obróbki termicznej. Stwierdzono, że w temperaturze pokojowej faza stała tłuszczu ma decydujące znaczenie w kształtowaniu właściwości reologicznych farszów kontrolnego jak i układów z wymienionym tłuszczem mieszaniną preparatów. Wywołane wzrostem temperatury zmiany w obrębie fazy ciągłej, farszów mięsnych na początkowym etapie prowadzą do rozpłynniania tłuszczów i uwalniania dyspergowanej w tłuszczach wody, co wywołuje wzrost płynności układu. Porównanie wartości modułu sztywności produktu finalnego ochłodzonego do temperatury pokojowej z farszem, który nie był poddany obróbce termicznej pozwala stwierdzić pięciokrotny wzrost jego wartości. Wraz ze wzrostem stopnia wymiany tłuszczu mieszanką preparatów następuje spadek właściwości sprężystych produktu a tym samym wzrost jego plastyczności.

Słowa kluczowe: DMTA, tłuszcz, reologia, woda