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THE IMPROVEMENT OF EQUIPMENT FOR STUDY OF RHEOLOGICAL PROPERTIES OF CHICKEN FILLET DURING THE «SOUS VIDE» COOKING

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ABSTRACT

The scheme of measuring system for study of rheological properties of chicken fillet on the different stages of heat cooking treatment was given.

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INTRODUCTION

In the process of manufacturing, packing and storage of food products, changes of structural-mechanical properties of the raw material, semi-finished goods, finished goods are happening (Sydorenko 2016). Knowing the character of these changes it is possible to control the manufacturing process by realizing it in the optimum mode. The influence of technology by using of high pressure as a technique of handling food at the food industry was described in the scientific publications more than once (Norton and Sun 2008). The main aspect of usage of high pressure and heat treatment under high pressure is significant loss of biological value substances, and also intensive changes of structure that lead to decrease of product quality. Because poultry meat has tender consistence, an essential deterioration of consistence happens during heat treatment under high pressure. Traditionally the culinary treatment under low pressure is used for food products drying (Patel *et al*. 2013).

But the method of cooking «sous vide» or vacuum cooking is gaining popularity in restaurants (Baldwin 2012). It has been determined that chicken breast prepared by «sous vide» method has higher organoleptic characteristics than traditionally cooked product (Church *et al*. 2000). Also temperature control in the process of heat treatment «sous vide» allows making a dish with more tender texture of the meat and more expressive color (García-Segovia 2007). Taking into consideration the uncertainty of readiness condition of study samples, the tasting is harmful. That is why structural-mechanical properties of products in the study process of new cooking methods it is appropriate to determine by method of penetration (Hinnergardt *et al*. 1970). For assessment of products consistence with intact structure it is reasonable to use equipment, the operational principle of which bases on the usage of needle indenter or conical indenter. Modern constructions of penetrometers give an opportunity to determine the complex of structural-mechanical properties during a few minutes: penetration value, shear

stress, ultimate shear stress. The value of these properties determines the consistence of product (Huts and Koval 2007). Effective work of command and measuring complexes is achieved by usage of advanced measuring instruments, mathematical models and modern computer equipment that is needed for processing of accurate results. The aim of study was development of measuring complex for study physical characteristics of food products on the different stages of cooking. The subjects of research were the samples of cooled chicken fillet produced by the trademark «Nasha Ryaba», Kyiv region, Ukraine.

Experimental Set Up

Background Information and Apparatus

For studying changes of structure of chicken fillet during the heat treatment, the module «penetration» of setting MIG-1.3 was used (Shapoval 2017a). The developed module is an automatic penetrometer with two needle hollow indenters (Fig.1). The majority of apparatus for study of structural-mechanical properties by penetration method are constructed on the principle of measurement: effort at predetermined depth of indenter's dipping into the product or depth of indenter's dipping into the product at the constant efforts (Shapoval 2017b). The developed «penetration» module of setting MIG-1.3 allows managing of depth of dipping and determines an effort that is spent for indenter's dipping.

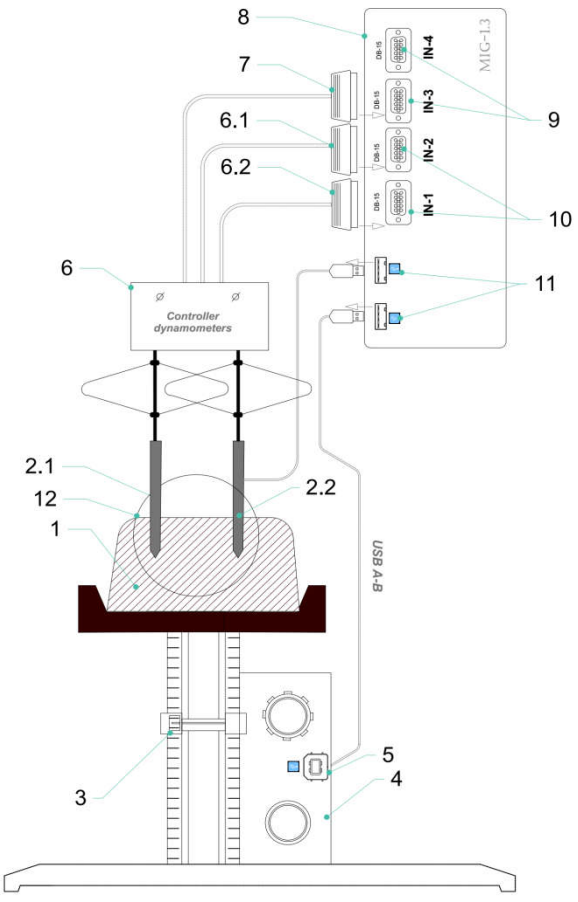

Figure 1. The scheme of «Penetration» module of setting MIG-1.3

1 – studied sample, 2.1, 2.2 – indenters, line of the lifting platform with height limiter, 4 – platform lift mechanism, 5 – USB-B cable (handling of lifting platform), 6 – controllers of dynamometers, 6.1, 6.2 - digital inputs DB-15, 7 – connect ohmmeter, 9 - Analog input jack (connect ohmmeter), 10 - Digital input jack (connection dynamometers), 11- USB output (control film heater and platform motion), 12 - measuring cell The developed module is comprised of such elements: measuring unit MIG-1.3 (8), which has 2 analog (10) and 2 digital (9) inputs DB-15, also 2 USB-A (11) outputs for managing external apparatus. The high-speed dynamometers (2.1 and 2.2) are fixed on the stand. Dynamometer 2.2 has film heating apparatus that can heat the product to the predetermined temperature and determine the ultimate shear stress. Dynamometer 2.1 contains of three temperature sensing transducers that are measuring the velocity of heat passing from film heating apparatus of dynamometer 2.2. The indications of dynamometers are recorded by controllers (6) and transmitted to the measuring unit (8) using digital inputs DB-15 (6.1 and 6.2). Because food products, most commonly, have an uneven structure, it is important to increase the number of measurements for reducing random inaccuracies. For that purpose each dynamometer has its own controller (6) and data transmitted from it independently. The scale division of the digital dynamometer 0,00001H and the upper limit of measurement 4H, absolute error of measurement is less than ±0,000014H. The period of recording of dynamometers is 0,005s.

On the platform that is covered by rubber, is situated the platform lift mechanism (4), which consists of a reversible electric motor with a reduction gear (redone mechanism of ejecting external DVD). The platform connects with measuring unit with a help of USB (11) for start and stop of penetration. After the start of measurement, the electric motor (4) via reduction gear drives a translational movement with constant speed the platform (3) with a product, setting it on the indenters (2.1 та 2.2) gradually. The distance between product sample and indenters can be regulated. On contact of indenter with product appear forces that prevent penetration. The recording of indications is made by digital dynamometers (6) with consideration for deformation of springs. Indenters stay almost immovable, but the movement of product (the depth of indenter's dipping into the product - L1+L2) is limited to menu «External devices control». The process of study of structural-mechanical and thermophysical properties of the sample is realized in the measuring cell (12). The detailed structure of measuring cell of «Penetration» module presented on the Figure 2.

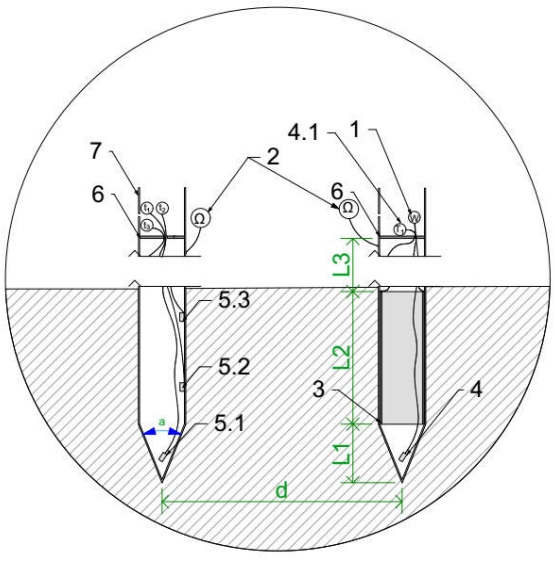

Figure 2. Measuring cell device MIG-1.3

1. Vat meter 2.Connection of the ohmmeter, 3. Film heater, 4. Thermometer of the indenter №1, 4.1- Connection of the thermometer, 5.1, 5.2, 5.3 – Thermometers of the indenter №2, 6 – Polyurethane plugs in the hollow indenters, 7 – Housing of indenter Indenters (7) are the hollow cylinder 5 mm in diameter that are sharpened at an angle α. The angle depends on the consistence of product. That is why for harder products it is recommended using the indenters with sharper angle. Indenter was dipping into the studied sample to the depth L_1+L_2 (12±2 mm) during each experiment. The depth of dipping is regulated by setting of range of platform movement (3 Fig. 1). Film heater (3) works with a voltage of 1.5-5 V and has power up to 7.5 W. The amount of energy that uses for heating the product is calculated due to voltage (U) and current intensity (I) on the USB output. Because the heater works with direct current, the electric parameters of heater's work are easily determined by vat meter (1). The programming of heater's work is making via the menu «External devices control». Electronic thermometer (4) is used for control of temperature of the indenter №1. Because food products have an uneven structure, it can be occurred a situation when the temperature of indenter №1 come up to a critical level but the product do not come up to the set temperature because of air-bubble voids. In such case, according to a signal of semiconducting thermometer (4) a heat turns off. The setting up of critical temperature is making via function «Automation of measurement».

Experimental Procedure

The experimental studies of chicken fillet samples were hold to study the influence of low pressure treatment in vacuum packaging and meat freshness. The subjects of research were the samples of chicken fillet 45x45mm. Each sample was taken the heat treatment under the determined temperature then it was made 8-10 pin holes on the penetrometer and the structure was determined. The fillet was cooked in pure form without marinating or adding any food additives or excipients because they essentially influence on the consistency of finished product (Nyati 2000). Heat treating was doing under the temperature 40-100^{0}C at intervals 10^{0}C during 20 minutes. Temperature range was due to a desire to determine the minimum temperature of protein change under the cooking by «sous vide» method. The time of heat treatment was chosen optimally according to the data of the scientific publications (Hinnergardt 1970).

RESULTS AND DISSCUSIONS

The measurements were carrying out on the setting MIG-1.3 that was developed and now using at the laboratory of Kyiv National University of Trade and Economics (Kyiv, Ukraine). The studied samples were treated under the influence of temperature. Changing of the resistance force was recorded by the software «The laboratory MIG-1.3» as graphic dependencies in the periods of increasing and decreasing of pressure on the indenter. Figure 3 shows the example of the results of studies of the chicken fillet strength limit on the developed setting.

The distinction of chicken fillet consistence after the traditional heat treatment and cooking in vacuum packaging was determined for testing of the developed setting. Measurements were made promptly after the heat treatment and after cooled a product to room temperatue (30±3 ^{0}C).

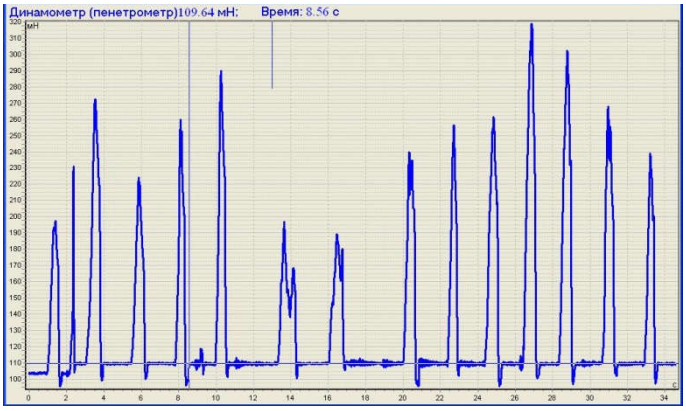

Figure 3. Program window "Multimedia laboratory MIG 1.3" Determination of strength by the penetration of chicken fillet

Figure 4 shows the results of chicken fillet penetration that was cooking for 20 min at the specified temperature of the heat carrier.

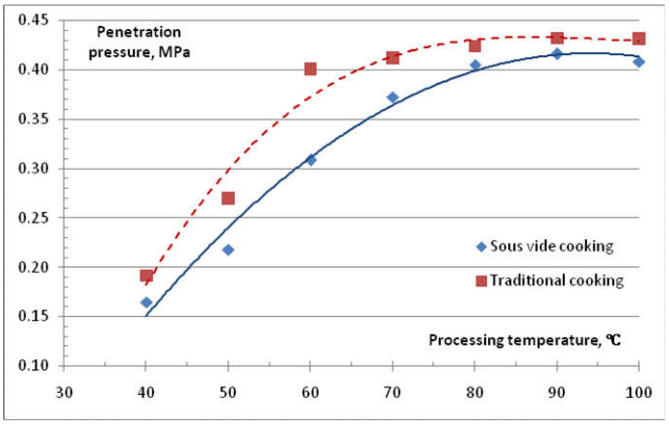

Figure 4. Change in tensile strength chicken fillets depending on temperature cooking

The product didn't get the organoleptic properties of readiness at the temperature below 50^{0}C during 20 min. The tasting of meat without proper cooking can be harmful for health. Steep increase of the penetration effort indicates a denaturation of proteins and culinary readiness of fillet. The denaturation of proteins occurred at the temperature 60^{0}C and more under the heat treatment approximately during 20 min at the traditional way of heat treatment. At the cooking in vacuum packaging the essential changes of the fillet structure began at the temperature 70^{0}C. But it can be determined that the consistence of the chicken fillet, cooked in vacuum packaging, at a level of 12.3 per cent on average is softer than the consistence of the chicken fillet cooked at the traditional way. It allows decreasing both the temperature of cooking (up to 80^{0}C) and the time of cooking. This is coinciding completely with the obtained data (Church and Parsons 2000). Because the boiled poultry meat is being used in cooking, mostly, cooled, on the next stage of studies the penetration was made. The fillet was cooled to room temperature (Figure 5).

After the cooling of fillet, its structure has significantly changed. In particular the sample, that was heat treated at the temperature 40^{0}C, after the cooling become more tightly in 5.1 times both after the traditional cooking and after vacuum cooking. The sample that was heat treated by the «sous vide» method at the temperature 100^{0}C, had a limit surface strength less 0,20 MPa.

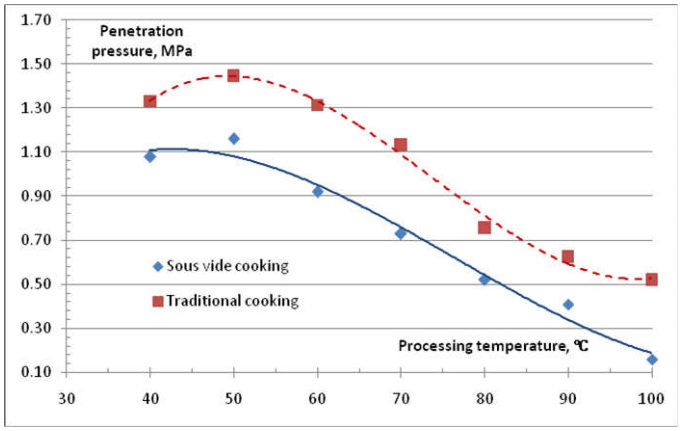

Figure 5. Changing the breaking strength of chilled chicken fillets depending on the cooking temperature

It indicates a friable consistence of the product. Fibers structure won't be tasted at the eating, that is why at a limit fibers strength less 0,40 MPa a consistence is unsatisfactory.
The obtained data don't consider the microbiological safety of the chicken fillet cooked by «sous vide» method that was studied more than once (Wang, 2004). The results of studies of chicken fillet structure after the heat treatment by «sous vide» method meet the results of the tasters' organoleptic assessment (Shapoval 2017b) and allow determining the product's structure at the temperatures of cooking less 60^0C, when the tasting is impossible.

Conclusions

The developed equipment allows conducting the studies of the consistence of different products at the variable efforts and speeds of its indenters' dipping into the studied sample. Moreover it is determined the additional parameters (temperature inside a sample, heat conductance and electrical conductance). Thus, the minimum temperature of chicken fillet vacuum cooking was determined. At such temperature the heat denaturation of proteins (approximately 60^0C) occurs. This is impossible to do by the expert method because of impossibility of eating by tasters unprepared products. It is determined that the usage of the «sous vide» method at the temperature $90…100^0$C makes the meat muscle fibers too tender that leads to unsatisfactory structure of the product.

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