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A MODIFIED STAND FOR TESTING WATER STABILITY OF PLANT-ORIGIN AGGLOMERATES

Kazimierz Zawiślak

Department of Food Engineering and Machinery, Agricultural University of Lublin
Doświadczalna Str. 44, 20-236 Lublin, Poland
e-mail: kazimierz.zawislak@ar.lublin.pl

Summary. The paper deals with a modified device for measuring the stability of agglomerates in water at various temperatures. Studies upon water stability of agglomerates achieved by means of extrusion confirmed usefulness of that device. According to the carried out tests, an increase of water temperature caused an acceleration of the tested agglomerate's softening.

Key words: softening, plant-origin agglomerates, testing device

INTRODUCTION

Products achieved on a base of plant raw materials are characterized by variable water stability. It is an important qualitative trait determining their commercial value. Knowledge on water stability of products also allows for managing the process and composition of final products. Proper traits of agglomerates referring to their stability in water may be achieved at many stages of design and production such as:

– components selection and their percentage at particle design;
– selection of agglomerate production method;
– selection of agglomerate's shape and size;
– binder selection;
– application of agglomerate coating or greasing.

Combination of the above methods for improving the water stability as the most profitable one is usually applied in agglomerate production.

Decomposition of plant-origin agglomerates in water occurs at two stages. Water adsorption on a product can be observed at the first and particle separation at the second stage. The rate of mass penetration between liquid and product depends on the resistance of water penetration. During this process, volume increase, hardiness decrease and getting doughy takes place. When agglomerate reaches its water saturation state, separation of components from the surface occurs (Fig. 1). The separated particle makes the agglomerate surface larger resulting in an intensification of components elution.

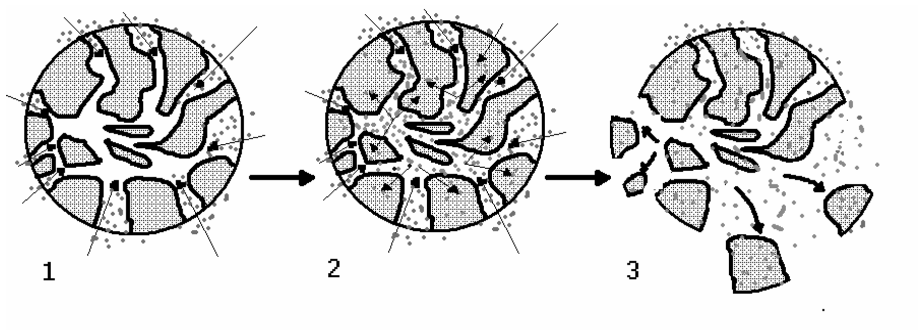

Fig. 1. Decomposition of a granule in water: 1, 2 – water adsorption,
3 – decomposition

To raise the water stability of plant-origin agglomerates, additional operations consisting in making the film around agglomerate may be applied. The layer has unique properties that protect its content against outer environment (e.g. coated pills) [Georgiou and Kupiec 1995]. Greasing recommended after cooling during production process (due to higher water content in hot product) is usually applied to protect granulates against water environment [Śmietana *et al.* 1997]. Fat as water-insoluble makes granules more water-resistant.

Method of agglomerate production greatly influences water stability. The production techniques that are characterized by heat emission (e.g. granulation, extrusion, etc.) completely or partially gelatinize substrates of such components as starch [Zawiślak 1998]. Gelatinization and liquidation of components greatly helps to bind components, thus, the agglomerates produced in such a way are characterized by high water stability.

Expanding or extrusion are the most efficient, but at the same time most expensive techniques for achieving water stability. Using these methods, also agglomerate's liquidity may be controlled, which is important for fish feeding [Grochowicz 2001].

As it follows from other studies [Zawiślak 1998], parameters of agglomerate production significantly affect the functional properties of a final product. Such traits as water solubility, ability to bind water and extrudate gelatinization mainly depend on starch extrusion temperature.

DESCRIPTION OF TESTING STAND

The device for measurement of agglomerate water stability was constructed using the method worked out by Hastings-Hepher. It consists of two water reservoirs with mounted heaters, power transmission system with continuous rotation regulation and system for controlling the water temperature in the reservoir (Fig. 2).

The device works on a principle of active interaction of water environment with tested agglomerate. Water movements, waving and sample falling-down are simulated. Sample is placed in a basket (Fig. 3) of a/b/h dimensions 90/60/30 mm, upper and lower walls are made of metal net with 1 mm mesh, side walls are made of metal sheet.

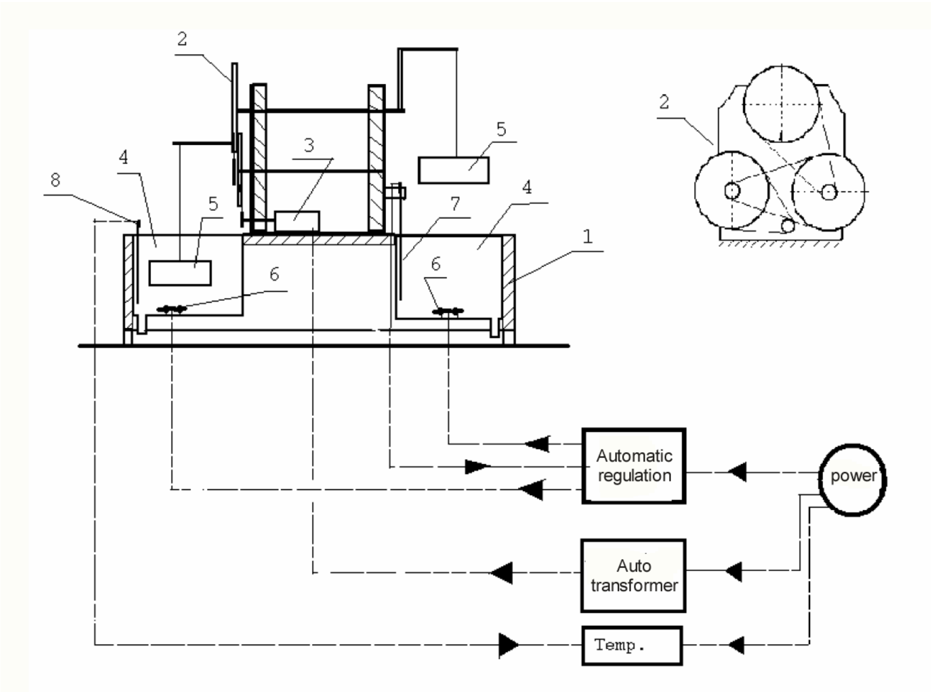

Fig. 2. Scheme of testing stand: 1 – basis, 2 – gear, 3 – engine, 4 – water reservoirs, 5 – reservoirs made of metal net, 6 – set of heaters controlled by thyristor system, 7 – thermoelement, 8 – control thermometer

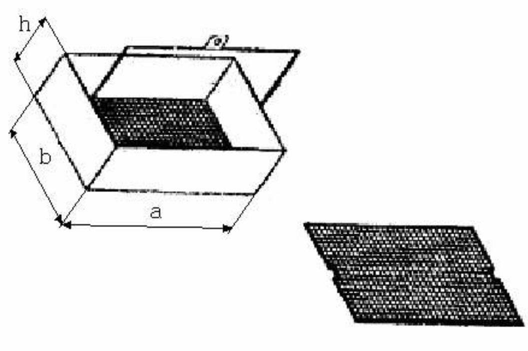

Fig. 3. Testing basket

During work, basket with agglomerate is soaked in cycles into the reservoir filled with water. Basket shifts are presented in Fig. 4.

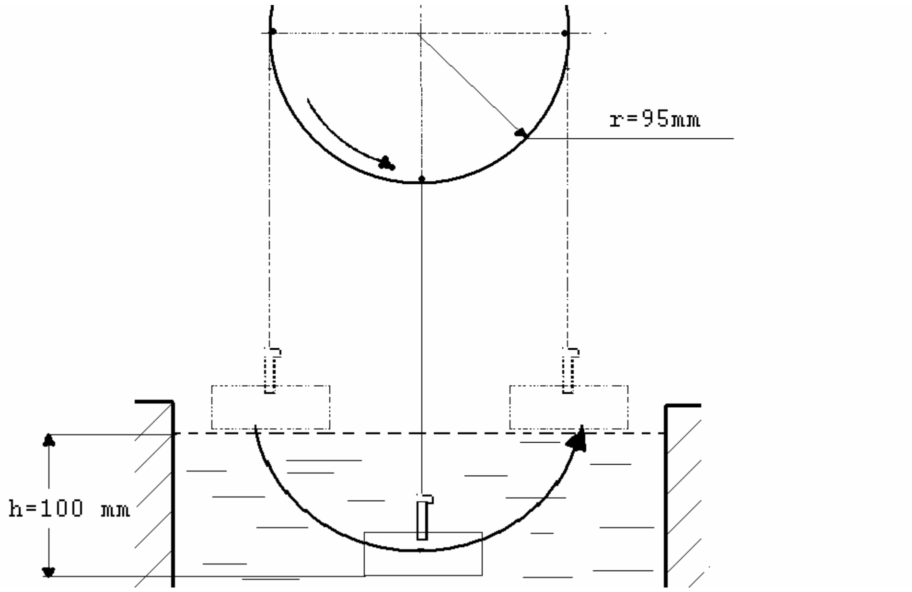

Fig. 4. Scheme of shifting the basket with sample within reservoir filled with water

METHODS

The stability tests were carried out using the device presented in Figure 2. Agglomerate achieved by means of extrusion was tested in the device. Tests were made using water of 20, 40, 60 and 80°C, at basket soaking frequency of 9 min^{-1} and soaking depth of 100 mm. Some physical properties of the tested product were also evaluated.

RESULTS AND DISCUSSION

Temperature is a direct effect of kinetic movements of dissolved particles and/or ions. Increasing the water energy makes Brownian movements in a liquid more intensive. The higher temperature, the higher kinetic energy of particles, thus the higher probability of water molecules collisions with a solid at molecular level – the higher collision energy. The increase of solubility is the effect. Results of agglomerate solubility depending on temperature are presented in Figures 5 and 6.

At 20°C, process of agglomerate components elution is slow and is characterized by small mass losses. After 40 minutes of elution, 18% of agglomerate became dissolved in water. Increasing the water temperature to 40°C causes an increase of softening. The highest mass losses during the softening process occurred at 80°C water temperature. After 5 minutes of testing, 47% of the agglomerate became softened and after 40 minutes – 97%. The trend line between points on plot indicates that the process is of linear character.

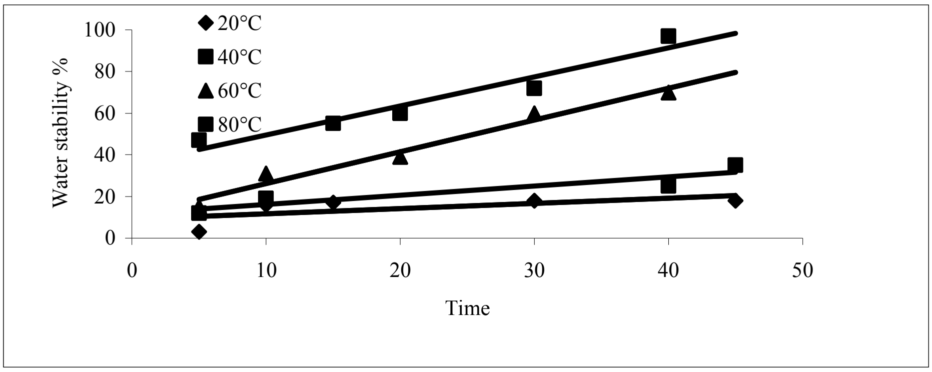

Fig. 5. Water stability agglomerates at various temperatures

Plots presented in Figure 5 may be expressed by the general formula:

$$r = at + b \quad (1)$$

where:

r – softening,
a, *b* – coefficients,
t – testing time.

Table 1. Values of coefficients *a* and *b* for agglomerate stability at various temperatures

Temperature °C	*a*	*b*	R^2
20	0.25	9.14	0.41
40	0.44	11.75	0.85
60	1.52	10.99	0.97
80	1.39	35.52	0.94

Figure 6 presents a graphical distribution of agglomerate softening depending on temperature. An increase of water temperature, in which the agglomerate was tested, caused great stability changes. At 20°C and after 10 minutes, the agglomerate mass loss was 15%, whereas at 80°C up to 50%. About 97% of the agglomerate got soaked after 40 minutes of testing in 80°C water. The achieved results confirm the usefulness of the device for determining the water stability of products.

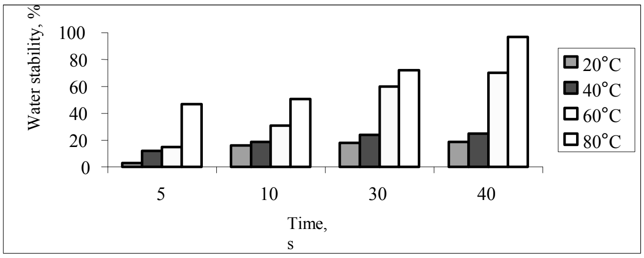

Fig. 6. Agglomerate mass losses for particular times

CONCLUSIONS

On the basis of the obtained experimental results and their analysis the following conclusions may be derived:

1. The modified device for agglomerate testing gives good results of water stability measurements for various water temperatures.
2. Water stability of the tested extrudate depends on testing time and water temperature; an increase of temperature makes the agglomerate softening faster.
3. Process of a product softening is of linear character within the tested temperature range.

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