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RHEOLOGICAL PROPERTIES OF POTATO FLAKES AND WHEAT FLOUR–POTATO DOUGHS

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Abstract

The water-absorbing capacity and dynamic rheological properties (measured with a valorigraph) of three types of potato flakes were investigated. Significant differences were found both in the water absorbing capacity and in the effect on the dynamic rheological properties of doughs containing potato flakes. Based on these observations it was stated that the water-absorbing capacity and rheological properties measured with a valorigraph may be used for characterization of potato flakes.

The physical properties of wheat flour–potato flake doughs – as measured with a valorigraph – depend on the amount of potato flakes. Addition of potato flakes causes a decrease of the period of dough formation and results in a lower consistency. The stability of the doughs containing potato flakes is practically zero and the relaxation fast. The degree of changes mentioned above is depending on the type (quality) of potato flakes used in the experiments. A method was elaborated for the instrumental measurement of the adhesivity of doughs using a Neolaborograph (Type Labor MIM, Hungary).

Keywords: wheat flour dough, potato flakes, rheological properties.

Introduction

Among the macaroni products a special position is taken by products based on wheat flour + potato (flakes, mashed potato). The well characterized consistency, high and easy digestibility, great variability in forms of use and good organoleptic properties make these products very popular in many countries. In recent years the use of dried potato products, instead of raw potato, has been growing due to the difficulties connected with transport and storage of potato tubers.

The tendency mentioned above is valid also for pasta products containing potato. The commercial level production of such products needs a standard quality of all raw materials including the potato flakes. Although the technological properties of flour and wheat flour doughs are well known and intensively studied, our knowledge concerning the rheological properties of potato-containing doughs is relatively poor.

Discussing the technological properties of potato flakes, first of all the water absorbing capacity must be mentioned. (HADZIYEV and STEELE, 1979). Potato flake, as a colloidal system, is a xerogel containing only absorptively bound water. Addition of water causes rapid absorption and swelling of the system. The rheological properties of the gel formed depend on the rigidity of the network of the system. This network contains partly gelatinized starch, some proteins and the cell walls of the potato. So it is understandable that the quality of starch and quantity of proteins may be important from this point of view. The water absorption of potato flakes has been reviewed in publications of JERICEVIC and LE MAGUER (1975), OORAIKUL (1974) and PURVES and SNIVELY (1975).

The main purpose of the studies presented in this paper was the elaboration of methods suitable for measuring and control of properties of potato flakes and wheat flour–potato doughs. Such method may also be used successfully in the future in quality control.

Knowing the technological role of individual components in the bread-making (HARRIS, 1942, HOSENEY et al., 1971), it is generally accepted that addition of potato flakes may negatively influence the consistency of dough. The extent of this effect and the role of the quantities of other components need further studies. Some of them are included in this paper.

Material and Methods

Materials

Potato flakes. Three samples were used as follows:

1. Potato flakes made in Poland (distributed by firma DÉLKER), in 125 g packages. Dry matter content 92 %. (Sample I)
2. Potato flakes made by Company Prehrambena Industrija Beograd, Beograd. Dry matter content 94 %. (Sample II)
3. Potato flakes produced by firma Knorr (Slovenia). Dry matter content 93 %. (Sample III)

Flour: White wheat flour, Type 555 BL.

Methods

The rheological properties of doughs were studied with a valorigraph (Type Labor MIM, Hungary) according to Hungarian standards.

For measuring the adhesivity a Neolaborograph (Type Labor MIM, Hungary) was used. The following samples were studied:

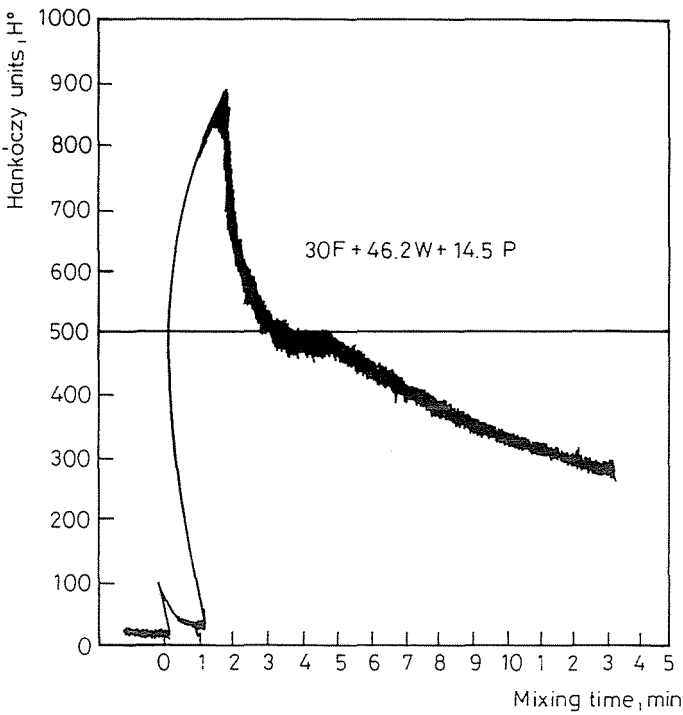

Fig. 1. Adhesivity of potato flakes – wheat flour doughs with 40 % water content and various ampunts (a,b,c) of potato flakes (F=flour, P=potato flakes, W=water amount in dough)

A. 20 g of dry matter + 10 cm^3 water
(water content of the mixture: 33 %)
20 g flour + 10 cm^3 water
18 g flour + 2 g potato flakes + 10 cm^3 water
16 g flour + 4 g potato flakes + 10 cm^3 water
12 g flour + 8 g potato flakes + 10 cm^3 water

B. 18 g of dry matter + 12 cm^3 water
(water content of the mixture: 40 %)
18 g flour + 12 cm^3 water
16.2 g flour + 1.8 g potato flakes + 12 cm^3 water
14.4 g flour + 3.6 g potato flakes + 12 cm^3 water
10.8 g flour + 7.2 g potato flakes + 12 cm^3 water

C. 15 g of dry matter + 15 cm^3 water
(water content of the mixture: 50 %)
15 g flour + 15 cm^3 water

12 g flour + 15 cm^3 water + 3 g potato flakes
9 g flour + 15 cm^3 water + 6 g potato flakes

The samples were mixed in a Labor MIM mixer for 100 s and a dough sample was formed by a Neolaborograph.

The dough sample was loaded with a metal plate of 26 mm diameter and 14 g weight and pressed with 250 g force for 1 min. After that the adhered plate was removed from the surface of dough sample measuring the force needed by a Neolaborograph recording device. The maximum height of the obtained curve and the area under curve were determined as shown in *Fig. 1.*

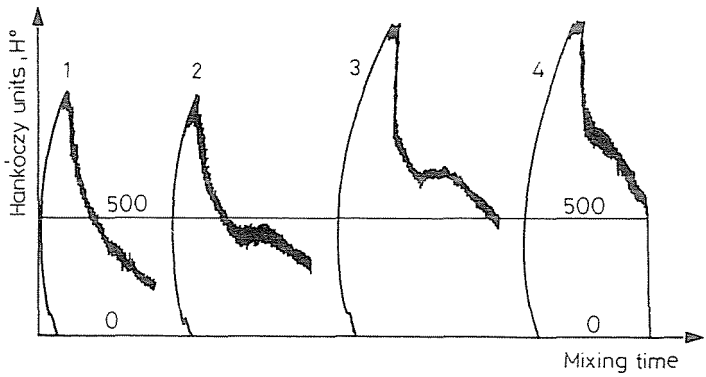

Fig. 2. Typical valorigram of a wheat flour–potato flakes–water dough. (Composition: 30 g flour + 46.2 g water + 14.5 g potato flakes

The water absorption of the potato flakes was measured as follows: 7–23 g potato flakes were filled in a 100 cm^3 graduated cylinder and a well defined quantity of water was added to the flakes (93–77 cm^3).

The swelling of flakes was registered in time. The rate of swelling and the maximum quantity of absorbed water was calculated and expressed as cm^3 water/g flakes.

Results and Discussion

Water Absorption of Potato Flakes

The data summarized in *Tables 1–3* show that significant differences exist between the water absorption and swelling of different potato flake samples both in quantity and rate of absorption and swelling. On the basis of the experiments it could be stated that the methods used may be successfully applied for evaluation of properties of potato flake samples.

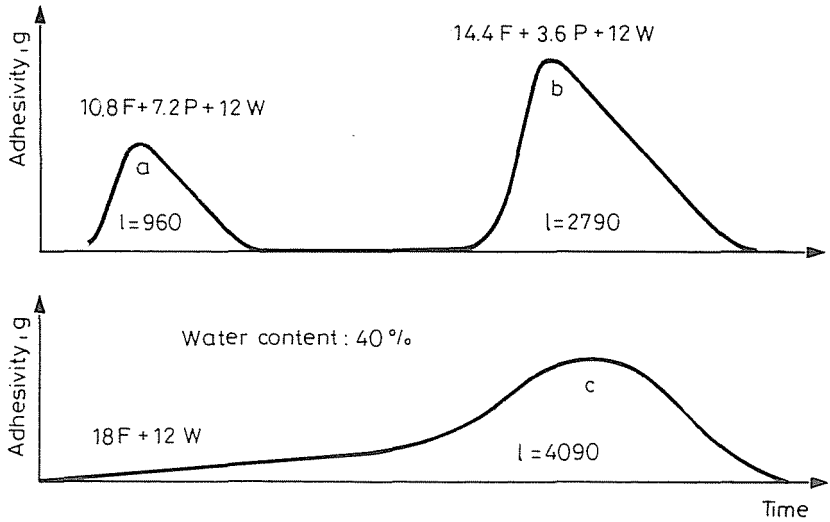

Fig. 3. The effect of the potato flakes quality on the valorigram 1 – sample I, 2 – mixture of samples I and II, 3 – mixture of samples I and III, 4 – sample III. (Codes of samples see in 'Materials'!)

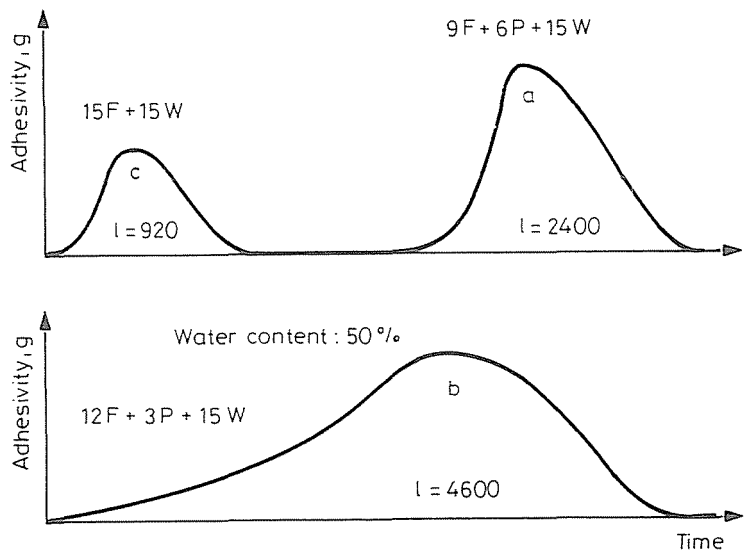

Fig. 4. Valorigram of a typical wheat flour – potato dough used in the technology of commercial production

Table 1
Effect of the flour : potato flakes ratio on the water absorption of sample I

Temperature	100 °C		50 °C		20 °C	
Potato: water ratio	Time (s)	Change in volume cm^3	Time (s)	Change in volume cm^3	Time (s)	Change in volume cm^3
23 : 77	15.23	14	26.43	14	37.43	14
21 : 79	22.84	16	27.10	16	39.33	13
19 : 81	24.42	18	30.44	18	60.65	16
17 : 83	27.38	22	34.83	28	54.30	28
15 : 85	36.90	32	41.04	36	72.55	29
13 : 87	39.35	38	42.88	46	126.50	54
11 : 89	39.52	54	48.48	56	151.32	61
9 : 91	46.69	62	55.74	64	900.00	66

Table 2
Influence of the potato : water ratio and the temperature on the water-uptake of sample II. Change in volume during the water-uptake process

Temperature	100 °C		50 °C		20 °C	
Potato: water ratio	Time (s)	Change in volume cm^3	Time (s)	Change in volume cm^3	Time (s)	Change in volume cm^3
23 : 77	15.96	27	18.32	26	Only	Only
21 : 79	32.17	31	33.31	29	part of	part of
19 : 81	34.20	32	41.72	30	the added	the added
17 : 83	35.42	33	50.36	33	water	water
15 : 85	38.35	34	83.87	35	was	was
13 : 87	45.10	39			absorbed	absorbed
11 : 89	46.62	39				
9 : 91	48.12	42				

Rheological Properties of Wheat Flour–Potato Flakes–Water (F–P–W) Doughs

A typical valorigraphical diagram (valorigram) of F–P–W doughs is shown in *Fig. 2*. Comparing the valorigram with the valorigrams of wheat flour doughs the rapid dough formation and an immediate beginning of softening is typical. As it is demonstrated in *Fig. 3*, the valorigram is depending on the quality of potato flakes used. Sample III results in better consistency than samples II and I.

Experiments were performed also using constant water quantity and replacing part of wheat flour with potato flakes in a stepwise manner. Due

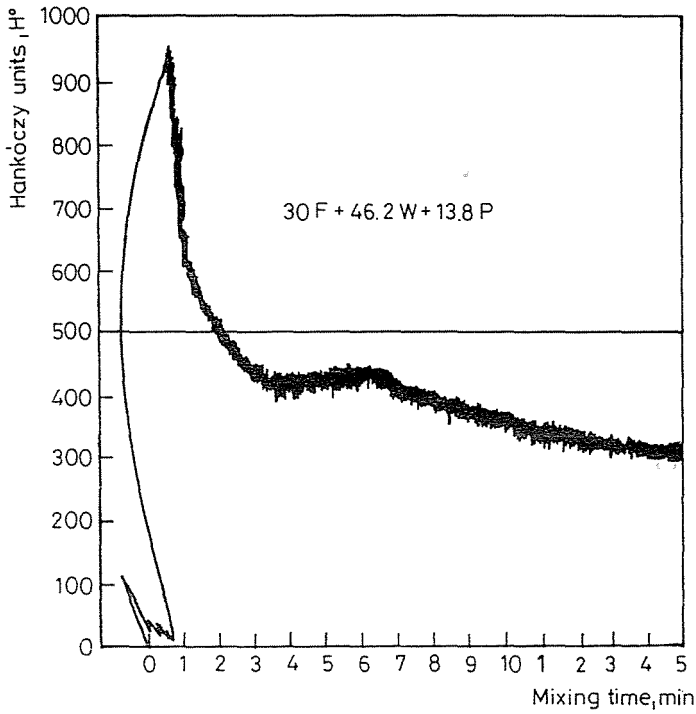

Fig. 5. Adhesivity of potato flakes – wheat flour doughs with 50 % water content and various amounts (a,b,c) of potato flakes. (F=flour, P=potato flakes, W=water amount in dough)

Table 3

Influence of potato : water ratio and the temperature on the water-uptake of sample III. Change in volume during the water-uptake process

Temperature	100 °C		50 °C		20 °C	
Potato: water ratio	Time (s)	Change in volume cm^3	Time (s)	Change in volume cm^3	Time (s)	Change in volume cm^3
23 : 77	9.12	3	10.41	3	12.21	3
21 : 79	12.01	4	12.11	4	14.52	4
19 : 81	13.48	6	14.60	8	23.12	8
17 : 83	15.25	8	16.17	9	35.87	9
15 : 85	15.55	11	18.45	11	41.31	11
13 : 87	16.02	13	21.30	13	49.30	13
11 : 89	18.26	15	30.03	15	52.55	15
9 : 91	19.22	19	45.00	19	135.00	19

to the high water-absorbing capacity of potato flakes, the initial dough strength measured immediately after dough formation also increased. Nevertheless, the stability is practically zero and very rapid decrease of consistency (relaxation) occurs. Even from the production technological point of view, at the optimum temperature the softening is quick, however, at a lower level a short stability period may be observed (*Fig. 4*).

Adhesivity of Wheat Flour–Potato Flakes–Water Doughs

The data of experiments are demonstrated in *Figs. 1* and *5*. It was found that the stickiness of doughs is depending on the water and potato flake content of the mixture. Lower water content and higher proportion of potato flakes result in a decrease of stickiness.

References

1. HADZIYEV, D. – STEELE, L. (1979): Dehydrated Mashed Potatoes–Chemical and Biochemical Aspects. *Advances in Food Research*, Vol. 25, pp. 55–136.
2. HARRIS, R. H. (1942): The Baking Quality of Gluten and Starch Prepared from Different Wheat Varieties. *Bakers Digest*, Vol. 16, pp. 217–223.
3. HOSENEY, C. R. – FINNEY, K. F. – POMERANZ, Y. – SHOGREN, D. (1971): Functional and Biochemical Properties of Wheat Flour Components. *Cereal Chemistry*, Vol. 48, pp. 191–201.
4. JERICEVIC, D. – LE MAGUER, M. (1975): Influence of the Moisture Content on the Rate of Rehydration of Potato Granules. *Can. Inst. Food Sci. Technol. J.*, Vol. 8, p. 88.
5. PURVES, E. R. – SNIVELY, C. O. (1975): Decreasing of Retrograded Starch Level and Increasing the Rehydration Rate of Rehydrated Potato Granules. *US. Patent*, 3.917.866.
6. OORAIKUL, B. (1974): Objective Method for Evaluation of Texture of Dehydrated Mashed Potatoes Using Sensory Evaluation as a Guideline. *Am. Potato J.*, Vol. 51, p. 105.