NOTE

Physical, Chemical, and Baking Properties of Wheat Dried with Microwave Energy

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ABSTRACT

Physical, chemical, and baking properties of two wheat cultivars with different natural moisture contents, as well as a rewetted mix of commercial wheat cultivars, were investigated after drying with microwave energy. Although the total protein content was not affected, the functionality of gluten was altered gradually with increasing time of exposure, as indicated by rheological and baking properties. The level of damage depended on both the intensity of the drying treatment and the initial moisture content.

The disadvantages of drying wheat with hot air have been reported (Hutchinson 1944, Finney et al 1962, Fanslow and Saul 1971, Fritz 1974, Tosi 1983). There have also been some reports on the use of microwave energy to heat and dry corn, wheat, and wheat flour (Fanslow and Saul 1971, Doty and Baker 1977, Nofsinger et al 1980, McArthur and D'Appolonia 1981, Campaña et al 1986).

In this article, we report the effects of microwave energy on the physical, chemical, and baking properties of wheats with different initial moisture contents.

MATERIALS AND METHODS

The wheat samples used were Buck Ñandú and La Paz INTA cultivars, harvested from the Agronomy Faculty farm at La Plata, Argentina. The moisture contents were 15.6 and 22.7%, respectively. Also, a mix of hard commercial wheat with an initial moisture of 13.2% was rewetted to 17, 19.5, and 22%. Buck Ñandú and La Paz INTA samples were divided into five 1.5-kg portions. One portion was dried at room temperature as a control. The other portions were dried in a microwave oven for a fixed accumulated time using irradiation time doses (ITD) of 1, 1.5, 2, and 2.5 min (Table I). The rewetted mix of commercial wheat was divided into three 1.5-kg portions. One portion was dried at room temperature as a control. The other two portions were dried in a microwave oven for a fixed accumulated time using ITDs of 1.5 and 2.5 min. The microwave oven was a White-Westinghouse model KM5OV (24O V, 6.5 A) with an operating frequency of 2,450 MHz. No forced airflow was used.

For each test, 1.5 kg of grain was weighed and placed on a plastic sieve tray (400 × 250 mm) at a grain thickness of about 20 mm. Grain temperatures were measured immediately after each ITD with a mercury-in-glass thermometer. The temperature of the grain was recorded as an average of 12 readings. Hot spots from nonuniform heating were observed in all cases. After the temperature was measured, the grain was hand-mixed to allow

TABLE I
Microwave Drying Conditions

Wheat Sample	Irradiation, min		Number of Doses	Final Temperature (°C)	Moisture Content, %	
	Dose	Total			Initial	Final
Buck Ñandú	1.0	8.0	8	48	15.6	12.7
	1.5	7.5	5	55	15.6	12.8
	2.0	6.0	3	60	15.6	12.6
	2.5	5.0	2	65	15.6	12.4
La Paz, INTA	1.0	17.0	17	50	22.7	13.5
	1.5	16.5	11	55	22.7	13.8
	2.0	16.0	8	60	22.7	13.5
	2.5	15.0	6	64	22.7	13.7
Rewetted	1.5	10.5	7	52	17.0	13.3
Commercial Wheat	1.5	13.5	9	53	19.5	13.8
Mix	1.5	19.5	13	55	22.0	13.6
	2.5	10.0	4	67	17.0	12.6
	2.5	12.5	5	63	19.5	13.5
	2.5	17.5	7	65	22.0	13.7

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the water to evaporate. The sample was allowed to cool about 5–10 min. In all tests, the final moisture content was about 13.5%. This was calculated from the weight difference during the experiment and by using a Brabender semiautomatic moisture tester. Germination tests were done in an environmental cabinet at 23°C. The germinated seeds were recorded on the third and seventh days. The weight per hectoliter was determined with a Schopper balance (Leipzig, Germany). The weight of 1,000 grains was determined using recommended method R-520 of the ISO (1977). The flour was obtained in a Buhler, model MCK laboratory mill (AACC method 26.20). Total protein content of the flour was estimated using the Udy dye test (method 46-14A, AACC 1983) with a Udy model S protein analyzer (Udy Corp., Boulder, CO). Mechanical determination of the wet-gluten content was done according to ICC standard 137 (ICC 1982) using a Glutomatic analyzer (Falling Number AB, Stockholm, Sweden). The rheologic test used a Chopin alveograph, according to ICC standard 121 (ICC 1982). This is the most used test in Argentina to determine flour quality.

The baking method used optimum mixing time. The baking formula was 100 g of flour, 1 g of salt, 2.5 g of sugar, 3 g of yeast, and water as needed. The dough was mixed in a Diosma mixer (Dierks & Söhne, Osnabrück, Germany). Doughs were fermented at 28±1°C and 85% rh. The baking temperature was 235°C, and the baking time was 25 min.

RESULTS AND DISCUSSION

As expected, the moisture loss of the wheat samples as plotted against the total exposure time was linear. The mean temperature was dependent on the ITD but not on the total time of irradiation (Table I).

Grain Characteristics

Germination capacity was affected by the microwave energy, as shown in Figure 1A. The decrease in germination capacity was related to the final temperature and the initial moisture content of the grains. This result is similar to that obtained by Hutchinson (1944) in drying wheat with conventional heating. The higher the initial moisture content, the lower the germination capacity for the same drying conditions. As an example, Buck Ñandú (low initial moisture content of 15.6%) had a germination capacity higher than La Paz INTA (high initial moisture content of 22.7%) with the same drying treatment (Fig. 1A). On the other hand, the hectoliter weight was not affected by the drying with microwave energy, even though in some cases the temperature of the sample had gone over 70°C. In contrast, Finney (1962) and Kirleis et al (1982) found that, in drying wheat with conventional heating, the hectoliter weight was reduced by temperatures over 70°C. This effect could be a result of expansion and cracking of the endosperm. The weight of 1,000 grains was also not affected by the microwave drying.

Flour, Dough, and Bread

Total protein content did not change after microwave drying. This is in agreement with earlier observations (Campaña et al 1986). However, the wet-gluten content did change with the treatment (Fig. 1B). In Buck Ñandu (initial moisture content of 15.6%), the wet-gluten content decreased with increasing ITD. In La Paz INTA (initial moisture content of 22.7%), the wet-gluten content greatly decreased with an ITD of 1.5 min. With ITDs of 2 and 2.5 min, the mechanical determination of wet-gluten was unsuccessful. It is clear (Fig. 1B) that the wet-gluten content depends not only on the intensity of the heating but also on the initial moisture content. The results for the commercial wheat mix were similar (Fig. 1B). Furthermore, in all cases, the dry-gluten content was the same. Changes in the rheological properties, tested with the Chopin alveograph and baking experiments, also showed the decrease in gluten quality. The Chopin alveograph gives the characteristics of strenth (W), tenacity (P), and extensibility (L) of the dough, allowing calculation of the ratio P/L, which represents the relative importance of the tenacity compared with the extensibility of the dough. The ratio of these two parameters provides a better assesment of flour strength than do the individual parameters alone. In our experiments, the P/L ratio increased in all cases, compared to that of the control, with increasing intensity of the treatment (Fig. 1C). It was a consequence of an increase in the tenacity and the decrease in the extensibility. The strength (W) decreased gradually with the increase in the aggressiveness of the drying (Fig. 1D). Indeed, in the most critical cases, obtaining the dough was difficult. As a result, abnormal alveograms were obtained (i.e., without extensibility). The dough did not resist the inner air pressure in the bubble, and it broke early. The alteration in the P/L and W parameters was higher when the initial moisture content was higher and when the microwave exposure was greater. In the baking test, a progressive reduction of the loaf volume (cm^3/g) was observed, as compared with that of the control (Fig. 1E). In all cases, the reduction

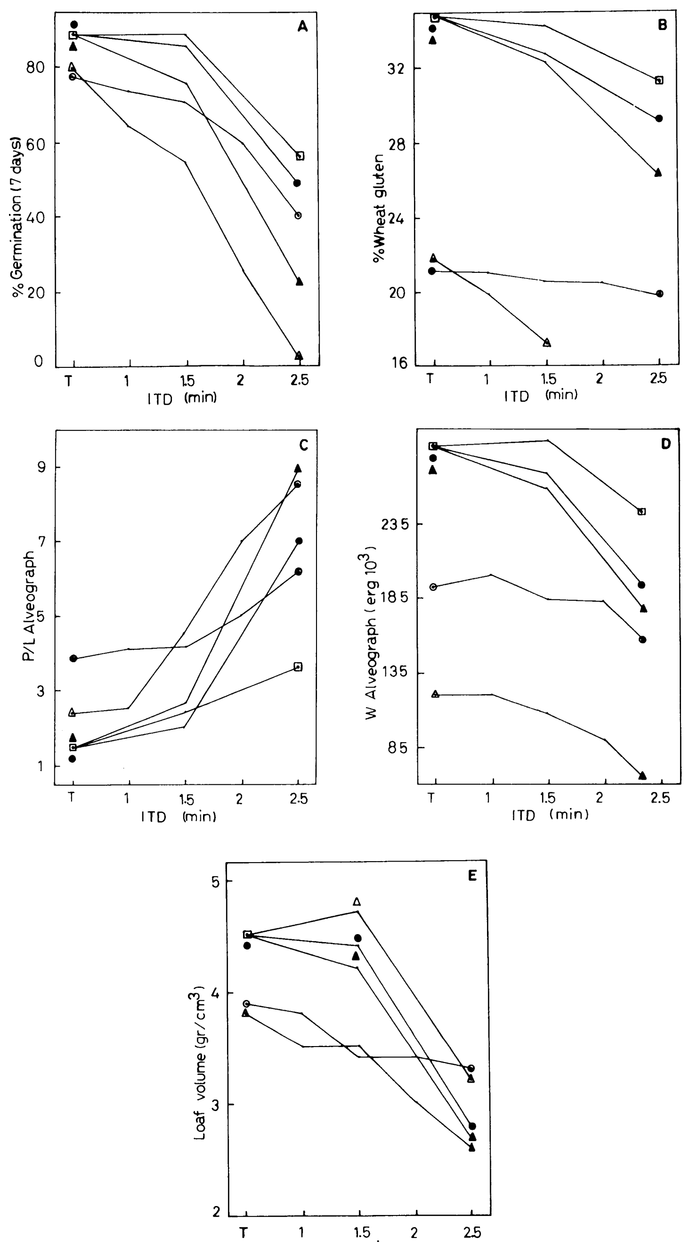

Fig. 1. Effects of irradiation time dose (ITD) on **A,** germination capacity; **B,** wet-gluten content; **C,** alveograph characteristics representing the relative importance of the tenacity (P) compared with the extensibility (L) of the dough; **D,** alveograph characteristic showing strength (W); **E,** loaf volume. □ = commercial mix rewetted to 17.0%. ● = commercial mix rewetted to 19.5%. ▲ = commercial mix rewetted to 22.0%. ○ = Buck Ñandú, 15.6% initial moisture. △ = La Paz INTA, 22.7% initial moisture.

in the loaf volume was simultaneous with a deterioration in the internal and external appearance of the breads. Internally, the texture and grain were more compact, and the color was darker. Externally, the crust of the bread lost color. With the most aggressive treatments, the surface showed fissures.

LITERATURE CITED

AMERICAN ASSOCIATION OF CEREAL CHEMISTS. 1983. Approved Methods of the AACC. Method 46-14A, approved November 1972, revised October 1975 and September 1985. The Association: St. Paul, MN.

CAMPAÑA, L. E., SEMPÉ, M. E., and FILGUEIRA, R. R. 1986. Effect of microwave energy on drying wheat. Cereal Chem. 63:271-273.

DOTY, N. C., and BAKER, C. W. 1977. Microwave conditioning of hard red spring wheat. I. Effects of wide power range on flour and bread quality. Cereal Chem. 54:717-727.

FANSLOW, G. E., and SAUL, R. A. 1971. Drying field corn with microwave power and unheated air. J. Microwave Power 6:229-235.

FINNEY, K. F., SHOGREN, M. D., HOSENEY, R. C., BOLTE, L. C., and HEYNE, E. C. 1962. Chemical, physical and baking properties of preripe wheat dried at varying temperatures. Agron. J. 54:244-247.

FRITZ, W. 1974. Zur Bildung cancerogener Kohlenwassestoffe bei der thermischen Behandlung von Lebensmitteln. 6. Mitteilung Untersuchung zur Kontamination bei der direkten Rauchgastrocknung von Getreide. Nahrung 48:83-87.

HUTCHINSON, J. B. 1944. The drying of wheat. III. The effect of temperature on germination capacity. J. Soc. Chem. Ind. 63:104-107.

INTERNATIONAL ASSOCIATION FOR CEREAL SCIENCE AND TECHNOLOGY (ICC). 1982. Standard methods 121 and 137. Moritz Schafer: Detmold, Germany.

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. 1977. Cereals and Pulses. 1st Ed. TC 34. Recommendation R-520. ISO: Geneva.

KIRLEIS, A. W., HOUSLEY, T. L., EMAM, A. M., PATTERSON, F. L., and OKOS, M. R. 1982. Effect of preripe harvest and artificial drying on the milling and baking quality of soft red winter wheat. Crop Sci. 22:871-875.

MacARTHUR, L. A., and D'APPOLONIA, B. L. 1981. Effects of microwave radiation and storage on hard red spring wheat flour. Cereal Chem. 58:53-56.

NOFSINGER, G. W., VAN CAUWENBERGE, J. E., ANDERSON, R. A., and BOTHAST, R. J. 1980. Preliminary biological evaluation of the effect of microwave heating on high-moisture shelled corn. Cereal Chem. 57:373-375.

TOSI, E. 1983. Modificación de la calidad industrial del trigo por acción del secado forzado. Pages 27-31 in: Revisión técnica sobre calidad de trigo. Asociación de Ingenieros Agrónomos, Norte de Buenos Aires (AIANBA): Pergamino, Argentina.

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