PRODUCTION OF HIGH-PROTEIN QUALITY PASTA PRODUCTS USING A SEMOLINA-CORN-SOY FLOUR MIXTURE. II. SOME PHYSICOCHEMICAL PROPERTIES OF THE UNTREATED AND HEAT-TREATED CORN FLOUR AND OF THE MIXTURES STUDIED[1]

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ABSTRACT

Several physicochemical tests were conducted both on heat-treated and untreated whole corn flours and on semolina-whole corn flour and semolina-whole corn-defatted soy flour mixtures prepared for pasta manufacture. Heat-treated whole corn flours were found to have a significant ($P < 0.05$) increased damaged starch content, lower sedimentation values, and a higher maximum amylographic viscosity (87°C) than untreated corn flour. The higher damaged starch content and maximum amylographic viscosity of the heat-treated corn flours were reflected in the amylographic viscosity and water absorption capacity changes observed in the semolina-corn and semolina-corn-soy flour mixtures studied. A high correlation was found between the maximum amylographic viscosity value of the mixtures and both the solids-in-cooking water value and the organoleptic score ($r = 0.76$ and -0.86, respectively) of the pasta products prepared. This finding indicates the favorable effect of a partial corn starch gelatinization prior to pasta production. The addition of 8% defatted soy flour had a significant ($P < 0.05$) favorable effect on the water absorption capacity of the mixtures.

In a previous study, Molina *et al.* (1) reported that a heat treatment applied to whole corn flour prior to spaghetti production induced a significant improvement in the quality of the pasta prepared from either a 60:40 mixture of semolina-whole corn or a 32:60:8 mixture of semolina-whole corn-defatted soy flour mixtures.

[1]Data are from a thesis submitted by I. Mayorga to the Centro de Estudios Superiores en Nutrición y Ciencias de Alimentos (CESNA), University of San Carlos de Guatemala / INCAP, in partial fulfillment of the requirements for the M.S. degree.

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Because there are no reports in the literature relevant to the physicochemical properties of semolina-corn or semolina-corn-defatted soy flour mixtures, it seemed useful to determine some of these properties in the flour mixtures used by Molina *et al.* (1). The study of such properties would help to establish the basis for the beneficial effects that a heat treatment of whole corn flour has on the quality of the final product (1).

The present paper describes the effect that the two heat treatments evaluated had on some physicochemical properties of the whole corn flour, and of the semolina-whole corn and semolina-whole corn-defatted soy flour mixtures studied.

MATERIALS AND METHODS

Common corn (*Zea mays*), semolina, and the defatted soy flour used in this study corresponded to the same lot previously used by Molina *et al.* (1), and the preparation of the whole corn flour and the heat treatments applied to it were the same also. Likewise, the semolina-whole corn and the semolina-whole corn-defatted soy flour mixtures studied here were prepared using the same proportions as those reported earlier (1).

To provide a clearer picture of the heat treatment applied to the corn flour, the actual temperature reached by the whole corn flour during the heat treatments was measured and recorded, both at the edge and at the geometrical center of the contents.

The damaged starch content was determined according to Farrand (2). The sedimentation value was measured by the method of Zeleny (3), using an 80-mesh flour.

The amylographic viscosity of the flours was measured using a Brabender amylograph (Model AV-10) according to AACC methods (4). In all instances, 60 g of sample (14% moisture basis) was used for the test. For both the untreated and heat-treated whole corn flours tested, no malt flour was added. When using the flour mixtures, 15 mg of malt flour (approximately 125 units of activity per g) was added per sample. In all cases, the total amount of buffer reagent used was 460 ml (4).

The water absorption capacity of the flour mixtures was determined in a Brabender farinograph according to AACC methods (4). All samples weighed 300 g each (14% moisture basis). No malt flour was added for this test. The water absorption was determined in all instances at a standard maximum resistance value of 500 Brabender Units (BU).

All determinations were carried out in triplicate.

RESULTS AND DISCUSSION

The actual temperature reached by the whole corn flour both at the edge and at the geometrical center of the contents during the two heat treatments applied (15 and 30 min) at 15 psi (121° C) is shown in Fig. 1. Data revealing the temperature reached during the heating (around 5 min) and cooling (prior to removal of the contents) periods are also included.

As may be seen, after the 15-min heat treatment in the retort, the center of the contents had reached a maximum temperature of only 73° C, while after the 30-

min heat treatment the center reached a maximum of 90° C. However, maximum temperature reached at the edge after the 15-min heat treatment (104° C) is similar to that attained after the 30-min heat treatment (107° C). As the data indicate, at no point during both heat treatments studied did the temperature at the center of the contents reach a plateau. This finding indicates that even after the 30-min treatment, the center of the contents had not reached as yet the maximum temperature possible to obtain. No change in the moisture content (13.0%) of the whole corn flour was observed after the heat treatments.

Typical amylograph curves for the untreated and heat-treated whole corn flours are presented in Fig. 2. The maximum viscosity value obtained at 87° C increased as the heat treatment time increased, thus indicating a progressive starch gelatinization of the whole corn flour during the heat treatments.

The damaged starch content and Zeleny sedimentation values of the untreated and heat-treated whole corn flours are given in Table I. A progressive starch gelatinization of the whole corn flour during the heat treatments evaluated is also indicated by the progressive increase in the damaged starch content of the heat-treated samples. Such increase was found to be statistically significant ($P<0.05$). The Zeleny sedimentation value, on the other hand, decreased significantly ($P <0.05$) after the 15-min heat treatment and remained virtually unchanged thereafter.

The maximum viscosity values obtained at 87° C in the amylograph curves for the semolina and flour mixtures studied, including those containing defatted soy flour, are given in Table II. As the data show, the maximum viscosity value for those mixtures containing raw whole corn flour increased proportionally to the amount of this ingredient in the mixture. The absolute maximum viscosity value of any mixture containing untreated—or raw—whole corn flour, however, is lower in those mixtures containing 8% of defatted soy flour than in the corresponding mixtures where no defatted soy flour was included. This phenomenon could be attributed to the much lower starch content of the defatted soy flour when compared to that of either semolina or corn flour (1). At any level of substitution of semolina by the whole corn flour studied, both with and without addition of defatted soy flour, the heat treatment of the whole corn flour had a lowering effect on the maximum viscosity value obtained. Analysis of variance of the data indicated that the effect of the heat treatment on the maximum viscosity value was statistically significant ($P<0.05$). We believe that this decrease in the maximum amylographic viscosity value of the mixtures containing heat-treated corn flour is a reflection of the higher damaged starch content of the heat-treated corn flour (Table I). This is true, since a sample with a higher proportion of damaged starch would be more susceptible to the action of the α-amylase contained in the malt flour used for the test, thus producing a consequent lowering in the maximum viscosity value (2).

The maximum amylographic viscosity value reached by the flour mixtures studied (Table II) presented a high correlation with the solids-in-cooking water values reported by Molina *et al.* (1) for the pasta products prepared from the same mixtures ($r = 0.76$). A high negative correlation was also established between the same maximum viscosity values and the organoleptic scores reported earlier (1) for the pasta products obtained from the same mixtures ($r = -0.86$). Both correlations clearly indicate the favorable effect of a partial

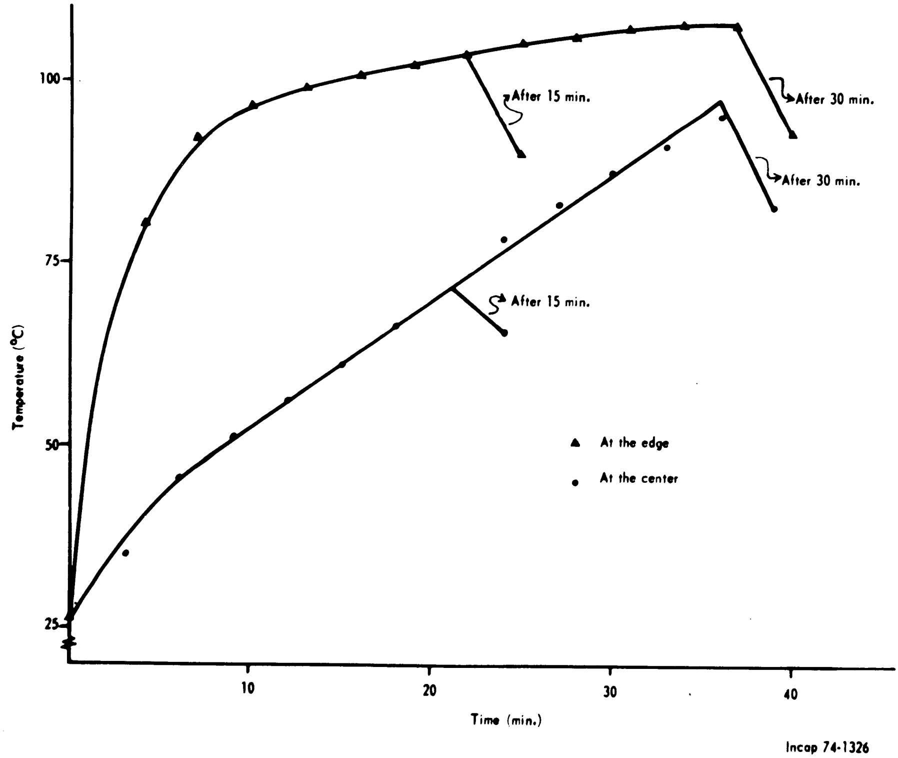

Fig. 1. Temperature reached by the whole corn flour during heat treatments for 15 and 30 min as measured at the edge and geometrical center of the contents.

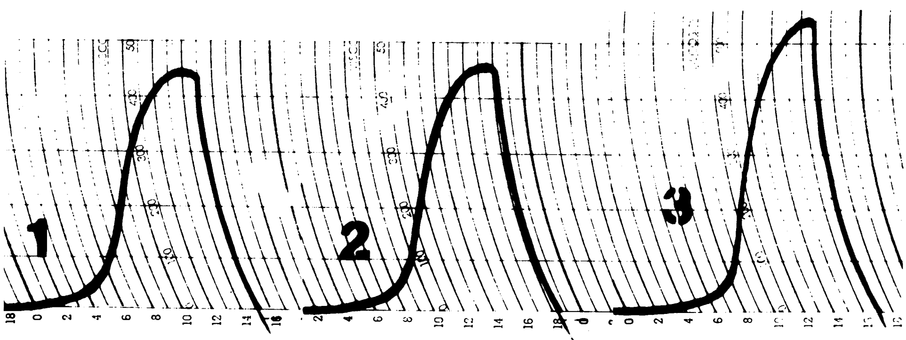

Fig. 2. Amylograph curves for whole corn flour subjected to different heat treatments: 1) Untreated, 2) heat-treated 15 min at 15 psi (121°C), and 3) heat-treated 30 min at 15 psi (121°C).

TABLE I
Damaged Starch Content and Zeleny Sedimentation Values of Untreated and Heat-Treated Corn Flours

Whole Corn Flour	Damaged Starch Content %	Zeleny Sedimentation Values ml
Untreated	11.7	35
Heat-treated 15 min at 121°C	15.3	29
Heat-treated 30 min at 121°C	22.5	28

TABLE II
Maximum Amylographic Viscosity Values Obtained for Semolina and for the Semolina-Corn and Semolina-Corn-Soy Flour Mixtures Studied[a]

Mixture Semolina-Corn-Soy Flour	Heat Treatment Given to Corn Flour (min:psi)		
	0:0	15:15	30:15
100	240 ± 6[b]	...	...
80:20	265 ± 4	245 ± 6	240 ± 5
60:40	360 ± 5	290 ± 7	270 ± 4
40:60	380 ± 3	320 ± 4	300 ± 5
72:20:8	250 ± 7	225 ± 4	220 ± 8
52:40:8	290 ± 5	240 ± 6	220 ± 7
32:60:8	310 ± 5	280 ± 6	240 ± 6

[a]In Brabender Units.
[b]Standard error of the mean.

TABLE III
Per Cent Farinographic Water Absorption Capacity of Semolina and of the Semolina-Corn Flour and Semolina-Corn-Soy Flour Mixtures Studied[a]

Mixture Semolina-Corn-Soy Flour	Heat Treatment Given to Corn Flour (min:psi)		
	0:0	15:15	30:15
100	53.9 ± 0.5[b]	...	...
80:20	52.2 ± 0.7	53.1 ± 0.8	53.6 ± 0.7
60:40	49.3 ± 0.6	50.7 ± 0.9	53.8 ± 0.6
40:60	43.3 ± 0.8	43.6 ± 0.3	46.2 ± 0.4
72:20:8	57.4 ± 0.5	57.7 ± 0.2	58.1 ± 0.2
52:40:8	54.1 ± 0.6	54.9 ± 0.3	55.5 ± 0.5
32:60:8	49.8 ± 0.4	50.4 ± 0.5	52.0 ± 0.6

[a]Measured at 500 BU.
[b]Standard error of the mean.

gelatinization of the corn starch prior to pasta production on both the solids-in-cooking water values and the organoleptic acceptance of the final product. These results appear to be in accordance with the British patent obtained by the General Foods Corporation (5). Further research (6) has shown that if gelatinization of the starch of a 25:30:45 semolina-peeled bean-whole corn flour mixture is effected through a drum dryer, one can achieve a final pasta product with statistically equal organoleptic acceptance and solids-in-cooking water values to those determined for a similar commercial pasta.

The water absorption values obtained for the different flour mixtures included in this study are provided in Table III. As the data reveal, at any level of substitution studied, the untreated whole corn flour had a detrimental effect on the water absorption of semolina. Nevertheless, such effect was minimized in the heat-treated whole corn flour-containing mixtures. This is not surprising if one considers it has been reported that a corn or a wheat flour with a higher gelatinized or damaged starch content has a higher water absorption capacity (2,7). Furthermore, the detrimental effect caused by the corn flour on the water absorption capacity of semolina was completely overcome when 8% of defatted soy flour was included in the mixture. As mentioned in a previous communication (1), the soy flour used had a high nitrogen solubility index (NSI). As is known, this has a high water absorption capacity, which explains the effect of its addition to the corn flour-semolina mixtures. This beneficial effect of the defatted soy flour on water absorption was statistically significant ($P < 0.05$). At the levels of semolina substitution studied (using either corn or corn-soy flours), no appreciable effect was observed on the stability of the dough at 500 BU. In general, the stability values at 500 BU determined both for the semolina and the flour mixtures studied varied between 5 and 6 min. The time needed for the dough to develop prior to reaching 500 BU varied from 2.5 to 3.0 min in all cases.

In conclusion, from the evidence herein presented, we can state that the beneficial effects of a heat treatment of the whole corn flour prior to the pasta production reported earlier (1) are mainly owing to a partial gelatinization of the corn starch. This partial gelatinization also favors the water absorption capacity of the corn flour-containing mixtures.

The possibility of obtaining a higher degree of improvement in the pasta quality through a more severe heat treatment of the whole corn flour is now being investigated. A cost evaluation of the different available techniques to effect this heat treatment is underway, and will serve as a basis for choosing that procedure with the lower cost figure and, perhaps more important for our area, representing a simpler technology. Needless to say, the use of a locally produced cereal grain in substitution of imported wheat, together with a simpler technology, would have significant implications for the economy and nutrition of nonwheat producing countries.

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