Characterization and Utilization of Durum Wheat for Breadmaking. II. Study of Flour Blends and Various Additives[1]

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ABSTRACT

A blending study was conducted to investigate the changes in flour properties, physical dough properties, and baking quality when untreated bread wheat flour was replaced with either durum flour, durum first clear flour, or semolina at 0, 25, 50, 75, and 100% levels. Physical dough and baking properties of the blends were also studied after the incorporation of ascorbic acid, sodium stearoyl lactylate, and vital wheat gluten. Of these additives, ascorbic acid had a greater dough-improving effect on durum wheat flours than it did on bread wheat flours. The results demonstrated that durum wheat cultivars with strong gluten properties would be suitable for breadmaking. Blends that produced bread with acceptable characteristics contained 25% durum flour or durum first clear flour and 75% untreated bread wheat flour and a combination of sodium stearoyl lactylate (0.5%) and ascorbic acid (75 ppm).

It is well known that durum wheat has been used traditionally to produce pasta products. However, in some areas of the world, in addition to its use for pasta, durum wheat is also used to make various types of bread. Therefore, additional information on the use of durum wheat in breadmaking could increase the utilization and value-added potential of durum wheat in domestic and export markets. From an economic perspective, a study of the utilization of durum clear flour in breadmaking could increase its commercial value.

The objective of this research was to investigate the flour properties, physical dough properties, and baking quality of bread in which a portion of the untreated bread flour is replaced with durum flour, durum first clear flour, or semolina and to study the use of various additives as bread improvers with these flour blends.

MATERIALS

Flour Samples

The wheat flour samples used in this study included: durum flour, durum first clear flour 2, semolina, and untreated bread flour samples. The sample selection was based on the physical dough tests and baking results from Boyacioğlu and D'Appolonia (1994).

Chemicals

The bread additives used in this study included: L-ascorbic acid (J. T. Baker, Inc., Phillipsburg, NJ); Emplex, sodium stearoyl-2-lactylate (SSL) (American Ingredients Co., Kansas City, MO); Provim-ESP, vital wheat gluten (Ogilvie Mills, Inc., Minnetonka, MN); and potassium bromate (Mallinckrodt, Paris, KY). Other chemicals were those typically found in a laboratory.

METHODS

Blending and Additive Study

Blends of durum flour, durum first clear flour, and semolina with untreated bread flour were prepared. Flour properties, physical dough characteristics, and baking properties of the blends were evaluated. The untreated bread flour was used for comparison and blending purposes. The blending study was undertaken with replacement levels of 0, 25, 50, 75, and 100% of the untreated bread flour with durum flour, durum first clear flour, and semolina. The flours were blended before analysis and mixed well to obtain a homogenous sample. Bread additives were incorporated separately (amounts based on flour weight): ascorbic acid (100 ppm), SSL (0.5%), and vital wheat gluten (3.0%). Bread was also prepared with other treatments: 1) potassium bromate (10 ppm); 2) potassium bromate (10 ppm) + ascorbic acid (100 ppm); 3) potassium bromate (5 ppm) + ascorbic acid (50 ppm); 4) SSL (0.5%) + ascorbic acid (75 ppm). Treatments 3 and 4 were used with the 25:75 blends of durum flour, durum first clear flour, or semolina with the untreated bread flour.

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Flour Properties and Physical Dough Tests

Moisture, protein, ash, wet and dry gluten, microsedimentation height, falling number determinations, farinograph, and extensigraph measurements were made using the methods described by Boyacioğlu and D'Appolonia (1994).

Bread Properties

Baking procedures and bread evaluation were the same as those described by Boyacioğlu and D'Appolonia (1994).

Data Analysis

The general linear model (SAS 1985) was used for analysis of the effects of additives on physical dough and baking properties of flours. The blend percentage was entered as a regression variable (covariant), and the additive was entered as a class variable. Analysis produced significant F values by analysis of variance, followed by Duncan's multiple range test for comparison of means. The means used for comparison represented the treatment means of the additives and the control.

RESULTS AND DISCUSSION

Effect of Blending

Blending durum flour and durum first clear flour with the untreated bread flour at levels of 25, 50, and 75% increased protein, falling number, wet and dry gluten, ash, and water absorption values and decreased the microsedimentation height, farinograph peak time, mixing tolerance index (MTI), extensibility, and resistance to extension values.

Incorporating semolina slightly decreased protein and greatly decreased microsedimentation height, water absorption, farinograph peak time, MTI, extensibility, and resistance to extension values. It also increased falling number, wet and dry gluten, and ash values (data not shown).

Effect of Additives

Adding ascorbic acid did not significantly affect farinogram patterns for all blends, but it did affect extensigram patterns. With all blends, the extensibility decreased, but resistance to extension increased, with the addition of ascorbic acid. It should be noted that blends with 25% durum flour or durum first clear flour had very high resistance to extension figures with the 180-min stretch.

The incorporation of SSL markedly increased farinograph peak time and stability and decreased the MTI value. Water absorption decreased with addition of SSL, with the exception of the 50, 75, and 100% semolina blends, where it showed an increase. The addition of SSL decreased extensibility but had a strong effect on resistance to extension values, except for the 25 and 50% durum first clear flour blends, where it showed an increase.

As expected, the addition of vital wheat gluten increased water absorption and farinograph peak time for all samples and showed a greater improving effect on MTI and stability values in the high-percentage durum first clear flour or semolina blends. The blends containing vital wheat gluten exhibited decreased extensibility and increased resistance to extension values when compared to the control flour (data not shown).

Overall, ascorbic acid appeared to have a greater improving effect on blends of durum flour and untreated bread flour in both farinograph and extensigraph parameters. It is generally accepted that the physical properties of dough depend on the composition of the gluten proteins and their state of aggregation, which is mediated by secondary forces and disulfide bonds (Grosch 1986). Also, Wostman (1950) concluded that the quality of flour protein for breadmaking increases with an increase in the number of possible disulfide linkages, as determined by its cystine content. Furthermore, Tsen and Anderson (1963) found that durum wheat flours contained more sulfhydryl (thiol) groups than did soft and hard wheat flours. It is also well known that the weakening effect of thiol-disulfide interchange reactions during dough preparation is inhibited when thiol compounds are removed by the addition of oxidants or thiol-blocking agents (Bloksma 1975, Kläui 1985). After oxidation to its dehydro form, ascorbic acid promotes the oxidation of thiol groups to disulfide links in the dough (Grosch 1986). Therefore, it acts as a flour- and dough-improver, and it strengthens the dough-forming properties of the flour. Based on our extensigraph observations and on the findings of other researchers, we concluded that ascorbic acid has a greater dough-improving effect on durum wheat flours than it does on bread wheat flours. The dough-improving effect of ascorbic acid on blends of durum first clear flour and untreated bread flour was more pronounced than it was for the durum and control bread flours. This may be due, in part, to the greater effect of oxidants on low-grade flours than on patent flours, because the former contain high amounts of fatty acids (D'Appolonia 1984, Galliard 1986).

TABLE I
Comparison of Loaf Volume and Bread Evaluation Scores[a] for the Effects of Additives on Bread Properties of Durum Flour Blends[b]

Additive	Bread Formula[c]	Loaf Volume (cm^3)	Bread Properties: External Appearance	Crust Color	Grain and Texture	Crumb Color
Control	0:100	775	9.0	10.0	8.5	9.0
	25:75	775	9.0	10.0	8.5	8.0
	50:50	725	8.0	10.0	7.5	6.5
	75:25	700	7.0	9.0	6.0	5.0
	100:0	605	6.0	7.5	4.0	3.0
Ascorbic acid	0:100	775	9.0	10.0	9.0	10.0
	25:75	850	10.0	10.0	9.5	9.5
	50:50	825	10.0	10.0	8.5	7.0
	75:25	740	8.0	9.0	8.0	6.0
	100:0	680	7.0	7.5	7.5	4.0
Sodium stearoyl lactylate	0:100	850	10.0	10.0	9.0	10.0
	25:75	830	10.0	10.0	9.0	9.0
	50:50	805	10.0	10.0	8.0	6.5
	75:25	755	8.0	9.0	7.0	6.0
	100:0	650	7.0	7.5	5.5	3.0
Vital wheat gluten	0:100	830	10.0	10.0	9.0	9.5
	25:75	805	10.0	10.0	9.0	8.0
	50:50	780	9.0	10.0	8.0	6.5
	75:25	765	8.0	9.0	7.0	5.0
	100:0	710	7.0	7.5	6.5	3.0

[a] Score of 1–10 with 10 being the highest score.
[b] Values represent the mean of two replicates.
[c] Ratio of durum flour to untreated bread wheat flour in blend samples.

Durum Flour Blends: Effects and Properties

Results of baking evaluations for blends of durum flour and untreated bread flour are presented in Table I. All blends containing durum flour decreased loaf volume and bread scores, with the exception of the 25% durum flour blend. The loaf volume of the 25:75 durum flour and untreated bread flour blend was the same as the loaf volume of bread made from 100% untreated bread flour.

Harris and Sibbitt (1950) reported that using less than a 25% durum flour blend in a lean baking formula increased the loaf volume. Furthermore, using a 50% durum flour blend still did not produce loaves any smaller than those of bread flour alone. However, when these investigators used a rich baking formula, the loaf volume decreased rather uniformly as the amount of durum flour increased. They concluded that durum flour apparently contributed to baking performance of a lean formula but not to that of a rich formula. Boggini and Pogna (1990) also reported a significant increase in loaf volume with addition of 25% durum flour to Italian bread flours with poor breadmaking quality. They indicated that durum wheat could be valuable in improving flours from common poor quality wheat cultivars. More recently, Lopez-Ahumada et al (1991) reported that the best blend was obtained by replacing 40% of a bread flour with Mexican durum flour. Bread characteristics were also improved using a commercial additive containing SSL, glyceryl monostearate, and whole soy flour (Lopez-Ahumada et al 1991).

In our study, increasing the level of durum flour above 25% decreased the loaf volume and bread scores, including the crumb color. The increase in loaf volume for the 25% durum flour blend with ascorbic acid could be due, in part, to the change in gluten structure derived from the untreated bread flour. It is widely accepted that gliadin and glutenin differ in their physical properties, most notably in their viscoelasticity. Gliadin is cohesive and extensible but has low elasticity, whereas glutenin is both cohesive and elastic but has low extensibility (Payne 1983, Schofield and Booth 1983, Wrigley and Bietz 1988, Autran et al 1989, Hoseney and Rogers 1990). Also, gliadin is a facilitator for dough expansion (Wall 1979). Durum wheat contains substantially more gliadin and less glutenin than bread wheat (Walsh and Gilles 1971, Huebner and Wall 1976, Dexter and Matsuo 1980, Dick 1981, D'Egidio et al 1991). Furthermore, there is speculation that the relative proportions of gliadin and glutenin account for the overall gluten properties (Schofield and Booth 1983) and a significantly positive correlation with loaf volume per unit protein (Orth and Bushuk 1972). Therefore, in the present study, blending durum flour with untreated bread flour may increase the overall gliadin content. This increase may result in a greater dough extensibility and increase the expansion of gluten during fermentation and baking, consequently producing a higher loaf volume.

Overall, the additives showed a significant effect on bread characteristics of durum flour and untreated bread flour blends in Duncan's multiple range test (Table II). However, no change was observed in crust color upon incorporation of the additives. Bread made from the 25:75 blend of durum flour and untreated bread flour, with ascorbic acid added to the baking formula, showed higher loaf volume than bread made from all other blends, including the control bread (Table I). Bread from the 25:75 blend also had better external and internal scores, including crust color, grain and texture, and crumb color. As noted with the extensigraph, ascorbic acid had the most pronounced improving effect

TABLE II
Comparison of Mean Values for the Effect of Additives on Loaf Volume and Bread Property Scores[a] of Durum Flour Blends[b]

Additive	Loaf Volume (cm^3)	Bread Properties: External Appearance	Crust Color	Grain and Texture	Crumb Color
Control	714.5 b	7.8 b	9.3 a	6.9 c	6.3 c
Ascorbic acid	773.0 a	8.8 a	9.3 a	8.5 a	7.3 a
Sodium stearoyl lactylate	777.5 a	9.0 a	9.3 a	7.7 b	6.9 b
Vital wheat gluten	776.5 a	8.8 a	9.3 a	7.9 b	6.4 c

[a]Score of 1–10 with 10 being the highest score.
[b]Means followed by the same letter in columns are not significantly different at $P = 0.05$ according to Duncan's multiple range test ($n = 10$).

TABLE III
Comparision of Loaf Volumes and Bread Evaluation Scores[a] for the Effects of Additives on Bread Properties of Durum First Clear Flour Blends[b]

Additive	Bread Formula[c]	Loaf Volume (cm^3)	Bread Properties: External Appearance	Crust Color	Grain and Texture	Crumb Color
Control	0:100	765	9.0	10.0	8.5	9.0
	25:75	735	9.0	10.0	8.0	8.0
	50:50	695	8.0	10.0	7.5	6.5
	75:25	650	7.0	9.0	6.0	5.0
	100:0	585	5.0	7.5	4.0	3.0
Ascorbic acid	0:100	745	9.0	10.0	9.0	10.0
	25:75	820	10.0	10.0	9.0	8.5
	50:50	745	9.0	10.0	8.5	7.5
	75:25	665	8.0	9.0	7.5	6.0
	100:0	605	6.0	7.5	6.5	4.0
Sodium stearoyl lactylate	0:100	840	10.0	10.0	9.5	9.5
	25:75	800	10.0	10.0	8.5	8.0
	50:50	740	9.0	10.0	7.5	7.0
	75:25	705	8.0	9.0	7.0	5.0
	100:0	600	6.0	7.5	5.0	4.5
Vital wheat gluten	0:100	825	10.0	10.0	9.0	9.5
	25:75	805	10.0	10.0	8.5	8.0
	50:50	795	10.0	10.0	7.5	6.5
	75:25	755	9.0	9.0	7.0	5.0
	100:0	665	7.0	7.5	5.0	4.0

[a]Score of 1–10 with 10 being the highest score.
[b]Values represent the mean of two replicates.
[c]Ratio of durum first clear flour to untreated bread wheat flour in blend samples.

on dough characteristics. In addition to its effect as an oxidizing agent, ascorbic acid also inhibits the oxidation of durum wheat flour pigments (Walsh et al 1970, Milatovic 1985, Milatovic and Mondelli 1991). The significant improving effect of ascorbic acid on the durum flour blends could be due, in part, to a higher sulfhydryl content in durum wheats as discussed previously.

Durum First Clear Flour Blends: Effects and Properties

The baking results of bread baked from durum first clear flour and untreated bread flour with additives incorporated are given in Table III. As the percentage of durum first clear flour was increased, the loaf volume and bread scores decreased, except for the crust color, which was only affected with the addition of 75% durum flour. As reported earlier, durum wheat is higher in gliadin but lower in glutenin content than is bread wheat. Also, Abecassis et al (1987) demonstrated that, within the durum wheat milling streams, the semolina fraction contained more gliadin and less glutenin than the flour fractions did. Therefore, the blend of durum first clear flour with bread wheat flour would not necessarily have the same effects on the gluten properties as the durum flour blend had. Also, the amount of sulfhydryl groups in the endosperm increases from the center to the outer portions of the kernel (Pomeranz and Shellenberger 1961). Thus, durum clear flour would contain more sulfhydryl groups than would durum flour. The quality of the flour protein for breadmaking purposes increases with an increase in the number of possible disulfide linkages (Grosch 1986, Pomeranz 1988, Popineau and Feillet 1990); therefore, the low disulfide content of durum first clear flour could have a negative effect on its breadmaking quality.

The addition of vital wheat gluten had a significant effect on the loaf volume of the blends (Table IV). To produce acceptable bread from high-extraction flours, wheat gluten is often added to increase the protein content and, consequently, improve bread volume and texture (Galliard 1986). The effect of gluten on high-extraction flours could be similar to that of durum first clear flour. Within the blends, the highest bread volume was obtained with the 25:75 durum first clear flour and untreated bread flour blend containing ascorbic acid. These loaves of bread were slightly lower in volume than the bread from the control flour containing SSL or vital wheat gluten. These results can be explained, in part, by the greater response of low-grade flour to oxidizing agents. In addition, the speculated change in the gluten structure of blends could result in a higher loaf volume. Adding ascorbic acid resulted in significantly higher scores for grain and texture and crumb color. None of the additives showed any effect on bread crust color (Table IV).

Semolina Blends: Effects and Properties

Results of baking evaluations for blends of semolina and untreated bread flour are given in Table V. The loaf volume and bread scores decreased with incorporation of semolina in the untreated bread flour. No change was observed in the external appearance or crust color scores of bread containing 25% semolina. Otherwise, as the percentage of semolina increased, the loaf volume and bread scores decreased.

The effect of additives on bread made from semolina and bread flour was different from the effects on bread from either durum flour or durum first clear flour blends. The loaf volume was higher for the 25:75 semolina and untreated bread flour blend with SSL

TABLE IV
Comparison of Mean Values for the Effect of Additives on Loaf Volume and Bread Property Scores[a] of Durum First Clear Flour Blends[b]

Additive	Loaf Volume (cm^3)	Bread Properties: External Appearance	Crust Color	Grain and Texture	Crumb Color
Control	684.5 b	7.6 c	9.3 a	6.8 c	6.3 c
Ascorbic acid	714.5 bc	8.4 b	9.3 a	8.1 a	7.2 a
Sodium stearoyl lactylate	737.0 b	8.6 ab	9.3 a	7.5 b	6.8 b
Vital wheat gluten	768.5 a	9.2 a	9.3 a	7.4 b	6.6 b

[a]Score of 1–10 with 10 being the highest score.
[b]Means followed by the same letter in columns are not significantly different at $P = 0.05$ according to Duncan's multiple range test ($n = 10$).

TABLE V
Comparison of Loaf Volumes and Bread Evaluation Scores[a] for the Effects of Additives on Bread Properties of Semolina Blends[b]

Additive	Bread Formula[c]	Loaf Volume (cm^3)	Bread Properties: External Appearance	Crust Color	Grain and Texture	Crumb Color
Control	0:100	705	9.0	10.0	8.5	9.0
	25:75	670	9.0	10.0	8.0	8.0
	50:50	620	8.0	9.5	7.0	6.5
	75:25	570	7.0	9.5	5.5	5.0
	100:0	485	6.0	9.0	3.5	3.0
Ascorbic acid	0:100	740	10.0	10.0	9.5	10.0
	25:75	705	10.0	10.0	8.5	8.5
	50:50	660	9.0	9.5	7.5	7.5
	75:25	600	8.0	9.5	6.0	6.0
	100:0	515	6.0	9.0	4.0	3.5
Sodium stearoyl lactylate	0:100	800	10.0	10.0	9.5	9.5
	25:75	730	10.0	10.0	8.0	8.0
	50:50	690	9.0	9.5	7.5	7.5
	75:25	640	8.0	9.5	5.5	5.0
	100:0	550	6.0	9.0	3.5	3.0
Vital wheat gluten	0:100	750	10.0	10.0	9.0	9.0
	25:75	705	9.0	10.0	8.0	8.0
	50:50	640	8.0	9.5	7.5	7.5
	75:25	630	8.0	9.5	6.0	6.0
	100:0	590	6.0	9.0	4.5	4.0

[a]Score of 1–10 with 10 being the highest score.
[b]Values represent the mean of two replicates.
[c]Ratio of semolina to untreated bread wheat flour in blend samples.

than it was for any of the other blends. The 25% semolina blend with ascorbic acid gave a loaf volume comparable to that of the control. Overall, SSL had a significant effect on loaf volume, as shown by Duncan's multiple range test (Table VI). Grain and texture and crumb color scores were higher in semolina blends with ascorbic acid added. As with the durum flour and durum first clear flour blends, no change was observed in crust color with the use of additives. The lower average loaf volumes obtained with the semolina and bread flour blends could be due to the particle size difference of semolina, which is greater than that of durum flour or durum first clear flour.

Effects of Other Treatments

The positive results of the use of ascorbic acid with the durum and bread wheat flour blends prompted additional studies of bread made with added potassium bromate (10 ppm) or potassium bromate (10 ppm) + ascorbic acid (100 ppm). A synergistic effect between potassium bromate and ascorbic acid has been reported (Kulp 1981, Kläui 1985, Fitchett and Frazier 1986, Matz 1987, Pyler 1988).

Positive loaf volume results were noted with the 25:75 and 50:50 durum flour and untreated bread flour blends containing bromate or bromate and ascorbic acid (Table VII). The bread, however, showed slightly overoxidized properties. The 25:75 durum first clear flour blend containing potassium bromate gave bread volume higher than that of any other blends or the control bread wheat flour. However, the bread had a coarse grain and texture as a result of overoxidation. This could be explained, in part, by the greater response of low-grade flours to oxidizing agents. Overoxidized characteristics were noted in the semolina blends; however, the use of potassium bromate alone showed a significant improving effect on loaf volume and bread scores for these blends (data not shown).

Having established that the results were positive for the incorporation of SSL and ascorbic acid separately, we also studied the effect of SSL and ascorbic acid used together. Bread from 25:75 and 50:50 durum flour blends with added SSL plus ascorbic acid gave loaf volumes that were higher than any of the other blends or the control. The loaf volume of the 25:75 durum first clear flour blend with added SSL plus ascorbic acid was higher than that of the remaining blends or the control. The loaf volume of the 50:50 durum first clear flour blend was comparable to that of the control. No improving effect was noted in semolina blends with the use of SSL and ascorbic acid together, and none of the blends had a loaf volume higher than that of the control (data not shown).

Based on the results of previous breadmaking studies, the level of oxidizing agents was reduced, and effects on bread properties noted. A combination of potassium bromate (5 ppm) and ascorbic acid (50 ppm) was used with each of the 25:75 blends (durum flour, durum first clear flour, and semolina with untreated bread flour). Because slightly overoxidized bread properties were observed with 100 ppm of ascorbic acid, bread also was made with 0.5% SSL and 75 ppm of ascorbic acid.

Table VIII shows the effect of additives on bread containing 25% durum. Bread from the 25% blends of durum flour or durum first clear flour had a higher loaf volume than that of the other samples; bread from these blends also had higher grain and texture scores. Crumb color was not appreciably affected with the addition of 25% durum flour or durum first clear flour to the bread. According to Duncan's multiple range test, the combination of SSL and ascorbic acid had a more significant positive effect on loaf volume and internal bread characteristics than did the combination of potassium bromate and ascorbic acid (Table IX).

Our conclusion, based on the results of this study, is that given the introduction of durum wheat cultivars with strong gluten

TABLE VI
Comparison of Mean Values for the Effect of Additives on Loaf Volumes and Bread Property Scores[a] of Semolina Blends[b]

Additive	Loaf Volume (cm^3)	Bread Properties: External Appearance	Crust Color	Grain and Texture	Crumb Color
Control	609.0 d	7.8 b	9.6 a	6.5 b	6.3 c
Ascorbic acid	643.5 c	8.6 a	9.6 a	7.1 a	7.1 a
Sodium stearoyl lactylate	681.0 a	8.6 a	9.6 a	6.8 ab	6.6 bc
Vital wheat gluten	662.0 b	8.2 ab	9.6 a	7.0 a	6.9 ab

[a]Score of 1–10 with 10 being the highest score.
[b]Means followed by the same letter in columns are not significantly different at $P = 0.05$ according to Duncan's multiple range test ($n = 10$).

TABLE VII
Comparison of Loaf Volumes and Bread Evaluation Scores[a] for the Effects of Potassium Bromate and Ascorbic Acid on Bread Properties of Durum Flour Blends[b]

Additives	Bread Formula[c]	Loaf Volume (cm^3)	Bread Properties: External Appearance	Crust Color	Grain and Texture	Crumb Color
Control	0:100	775	9.0	10.0	8.5	9.0
	25:75	755	9.0	10.0	8.0	8.0
	50:50	725	8.0	10.0	7.5	6.5
	75:25	710	7.0	9.0	6.0	5.0
	100:0	625	6.0	7.5	5.0	3.0
Potassium bromate	0:100	785	10.0	10.0	9.5	10.0
	25:75	850	10.0	10.0	9.5	9.5
	50:50	845	10.0	10.0	9.0	8.0
	75:25	760	9.0	8.5	8.0	6.0
	100:0	680	7.0	7.0	6.0	4.0
Potassium bromate + ascorbic acid	0:100	740	9.0	10.0	9.5	10.0
	25:75	840	10.0	10.0	9.5	9.0
	50:50	840	10.0	10.0	8.5	7.0
	75:25	750	8.0	9.0	8.0	5.5
	100:0	685	7.0	7.5	6.0	4.0

[a]Score of 1–10 with 10 being the highest score.
[b]Values represent the mean of two replicates.
[c]Ratio of durum flour to untreated bread wheat flour in blend samples.

TABLE VIII
Comparision of Loaf Volumes and Bread Evaluation Scores[a] for the Effects of Combined Additives on Bread Properties of All 25% Blend Samples[b]

Additive	Bread Formula[c]	Loaf Volume (cm^3)	Bread Properties: External Appearance	Crust Color	Grain and Texture	Crumb Color
Control	0:100	850	10.0	10.0	8.5	9.0
	25:75 DF	850	10.0	10.0	8.5	8.0
	25:75 DFCF	805	9.0	10.0	7.5	8.0
	25:75 S	760	9.0	10.0	7.5	8.0
Potassium bromate + ascorbic acid	0:100	890	10.0	10.0	9.5	8.5
	25:75 DF	920	10.0	10.0	8.5	8.5
	25:75 DFCF	880	10.0	10.0	8.0	8.5
	25:75 S	760	9.0	10.0	8.0	8.0
Sodium stearoyl lactylate + ascorbic acid	0:100	910	10.0	10.0	9.5	9.5
	25:75 DF	945	10.0	10.0	9.0	8.5
	25:75 DFCF	945	10.0	10.0	9.0	9.0
	25:75 S	830	10.0	10.0	8.5	8.0

[a]Score of 1–10 with 10 being the highest score.
[b]Values represent the mean of two replicates.
[c]Ratio of sample flour to untreated bread wheat flour. DF = durum flour, DFCF = durum first clear flour, S = semolina.

TABLE IX
Comparison of Mean Values for the Effect of Additives on Loaf Volumes and Bread Property Scores[a] of All 25% Blend Samples[b,c]

Additive	Loaf Volume (cm^3)	Bread Properties: External Appearance	Crust Color	Grain and Texture	Crumb Color
Control	816.3 c	9.5 b	10.0 a	8.0 c	8.3 b
Potassium bromate + ascorbic acid	862.5 b	9.8 ab	10.0 a	8.4 b	8.4 b
Sodium stearoyl lactylate + ascorbic acid	907.5 a	10.0 a	10.0 a	9.0 a	8.8 a

[a]Score of 1–10 with 10 being the highest score.
[b]Durum flour, durum first clear flour, and semolina blended with untreated bread wheat flour.
[c]Means followed by the same letter in columns are not significantly different at $P = 0.05$ according to Duncan's multiple range test ($n = 8$).

properties, there is no longer any validity to the claim that durum wheat is not suitable for breadmaking. The present study has shown that bread with acceptable characteristics can be obtained by blending 25% durum flour or durum first clear flour with 75% bread wheat flour and adding SSL (0.5%) and ascorbic acid (75 ppm).

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