Cottonseed Flour's Functionality in Egyptian Baladi Bread[1]

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ABSTRACT

The functionality of liquid cyclone-processed cottonseed flour was studied in an Egyptian "baladi" bread system. Bread baked with 0, 4, 8, 12, and 16% cottonseed flour showed a decrease in bread volume as the cottonseed substitution level increased. Sensory data indicated that bread was acceptable even at the 12% level of substitution. The protein and lysine contents of bread increased as the level of the cottonseed increased. The protein and lysine added at the 0.5% level affected the rheological (or mixograph) properties of the dough. Egyptian bread baked with Tandem 552 retained its softness after three days of storage, whereas bread baked with Tween 20 retained softness for six days.

Wheat in bread constitutes a daily staple in the Egyptian diet. Baladi bread is a very popular type of bread consumed in Egypt as well as in the Middle East in general. This bread has been reported by some investigators (Arafah et al 1980; Hussein et al 1973, 1974; Shehata and Fryer 1970) to be deficient in the amino acid lysine. The studies on the substitution of Arabic bread with protein sources are few (Dalby 1969, Maleki and Djazayeri 1968, Shakir et al 1960, Shehata and Fryer 1970).

The objectives of this study were to investigate the effect of liquid cyclone-processed (LCP) cottonseed flour on the physical properties of hard red winter (HRW) wheat flour dough and on the quality of the baladi bread baked with different levels of cottonseed flour. The effect of four dough conditioners on maintenance of bread freshness after three and six days of storage was evaluated.

MATERIALS AND METHODS

Flour Samples

HRW untreated wheat flours of 74.5% extraction (straight grade) and 85% extraction were purchased from the Department of Grain Science, Manhattan, KS. On a 14% moisture basis, protein and ash of the first flour were 11.4 and 0.27%, respectively, and of the second, 11.9 and 0.75%, respectively. LCP cottonseed flour with a protein content of 59.4% and a moisture content of 2.03% (Sample No. 85400-A) was supplied by the Southern Regional Research Center, New Orleans, LA. LCP cottonseed flour was blended with HRW wheat flour at levels of 4, 8, 12, and 16%.

Dough Conditioners

Polyoxysorbate 20 (Tween 20) and polyoxyethylene sorbitan monostearate (Tandem 552) were supplied by ICI United States, Inc., Specialty Chemical Division, Wilmington, DE. Polysorbitan monoglycerides and diglycerides polysorbate 60 (36%) (Tween 60), and polyoxyethylene 10 stearyl ether (POESE) were purchased from Sigma Chemical Company, St. Louis, MO.

Physical Dough Tests

Straight-grade HRW flour was used in all blends for these tests. The AACC constant dough weight farinograph procedure was followed, using a 300-g bowl maintained at 30 ± 0.1°C (86 ± 0.2°F) to determine water absorption, peak time, and mixing tolerance index data of dough with cottonseed substitution. For the study of the effect of conditioners on doughs substituted with cottonseed, a 35-g bowl mixograph (National Mfg. Co.) was used to measure rheological properties after absorption had been determined with the farinograph. Room temperature for the mixograph studies was maintained at 21 ± 0.5°C (70 ± 1°F). Peak time, peak height, curve height after 9 min of mixing, and area under the curve were determined using the AACC procedure.

Baking Formula and Preparation

The bread formula was 200 g of 85%-extracted wheat flour or blend of 85%-extracted flour and LCP cottonseed, 3 g of salt, 9 g of dry yeast, and distilled water (21°C, 70°F) included at levels of 40 ml more than the absorption as determined by a farinograph.

All ingredients were at 21°C (70°F) when used, and mixing was done at room temperature (21 ± 0.5°C, 70 ± 1°F). Dry yeast was hydrated for 5 min in the bowl of a Hobart Kitchenaid K5-a mixer; then the dry ingredients were added and mixed at speed 2 for 1 min. The bowl sides were scraped down with a rubber spatula. Mixing was continued, using a dough hook attatchment, on speed 6 for 7 min. The dough was then transferred to a lightly greased stainless steel bowl and fermented at 31 ± 1°C (88 ± 2°F) for 4 hr. The fermented dough was scaled into two 150-g loaves, which were put on a cookie sheet previously dusted with shorts. The loaves were patted by hand to a round loaf 18 cm in diameter and 1 cm high. Loaves were proofed for 30 min at 32°C (90°F) and 88% rh. Bread was baked at 288°C (550°F) in an electric reel oven for 5 min.

Bread Evaluation

Volume was measured by rapeseed displacement. The Instron, model TT-B, equipped with a single-blade tenderness test cell (model CA-1, Food Technology Corporation) was used to evaluate tenderness. Bread was cut into a round slice 5 cm in diameter and was sheared with the single-blade cell. Tenderness was expressed as grams of force needed to shear the 5-cm sample diameter.

Six Middle Eastern panelists who had been trained in the sensory procedure for consistantly scoring control and protein-supplemented baladi bread, evaluated the bread 1 hr after baking. Taste paneling was conducted in a room with individual booths equipped with daylight lighting. Bread was evaluated for crust color, crumb color, flavor, texture, aroma, and general acceptability, using a seven-point descriptive scale. Comments on each sensory characteristic were also solicitated.

Chemical Analyses

Moisture and ash were determined according to AACC methods. Nitrogen was measured by the micro-Kjeldahl method as outlined by MacKenzie (1970). Protein was calculated as N × 5.7 for wheat flour and N × 6.25 for cottonseed flour. Lipid was determined as crude fat according to the AACC (1967) method.

A Beckman Amino Acid Analyzer, model 120C, was used to determine amino acids after acid hydrolyses of the samples. Performic acid oxidation was used to oxidize methionine to methionine sulfone and cysteine to cysteic acid to stabilize these amino acids for acid hydrolysis (Lewis 1966, Schram et al 1954).

All rheological and baking tests were evaluated three times. Proximate analyses were determined in duplicate. Farinograph data and characteristics of the baladi bread without conditioners, were analyzed for variance due to cottonseed level. Mixograph data was analyzed for variance due to cottonseed level, conditioner, and their interaction. A 4^3 factorial design was used to test the effect of four conditioners at three levels each on Egyptian bread

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character after three periods of storage. Duncan's new studentized range test (1957) was used to sort out significant differences among means.

RESULTS AND DISCUSSION

Farinograph studies presented in Table I show that water absorption increased with increasing levels of cottonseed flour substitution. Khan et al (1976) reported similar results with cottonseed protein concentrates prepared by wet extraction followed by spray-drying or freeze-drying at different pHs. With the substitution of cottonseed, the doughs tended to decrease in stability, as can be seen from the increased values of the mixing tolerance indices (Table I). The level of drop was not linear with increasing levels of cottonseed substitution, however. This same destabilizing effect has been reported by other workers (Lawhon et al 1972, Matthews et al 1970, Sidwell and Hammerle 1970).

TABLE I
Farinograph Data[a] for Hard Red Winter Wheat Flour Dough Substituted with Liquid Cyclone Processed Cottonseed Flour

Cottonseed Flour (%)	Absorption[b] (%)	Peak Time (min)	Mixing Tolerance Index (BU)
0.0	58.7 ± 0.5	3.6 ± 0.1	33.0 ± 4.8
4.0	60.9 ± 0.6	3.2 ± 0.2	117.0 ± 4.9
8.0	62.3 ± 0.6	3.6 ± 0.3	82.0 ± 10.6
12.0	63.0 ± 0.6	3.5 ± 0.1	107.0 ± 2.8
16.0	62.9 ± 0.7	3.7 ± 0.1	135.0 ± 10.8

[a]Mean and standard deviation of the mean for three replications.
[b]Expressed on a 14% mb.

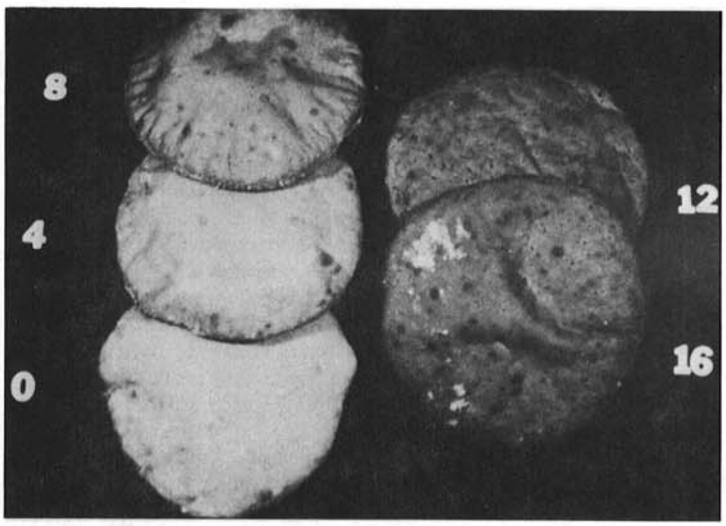

Fig. 1. Egyptian baladi bread prepared with 0, 4, 8, 12, and 16% cottonseed flour substitutions.

Egyptian bread was baked using 0, 4, 8, 12, and 16% cottonseed flour substitutions (Fig. 1). Loaf volume and specific volume decreased when 12 or 16% levels of cottonseed flour were substituted for wheat flour (Table II). At the levels of 4 and 8% cottonseed substitution, the volume increased, indicating that a better product than the unsubstituted loaf had been produced.

Sensory evaluations of the Egyptian bread are also presented in Table II. Crust and crumb color ratings decreased significantly as the level of cottonseed substitution increased; thus a darker bread was produced with higher levels of cottonseed flour. Significant decreases were also found in flavor, texture, aroma, and general acceptability scores for baladi bread with the high levels of cottonseed flour. Nevertheless, the baladi bread prepared with 4 and 8% LCP cottonseed flour was scored in the acceptable range for all sensory characteristic tested except crumb color.

The protein level of the Egyptian bread substantially increased with all levels of cottonseed substitution. The protein content of the control bread was 12.52%, whereas those of the breads substituted with 4, 8, 12, and 16% cottonseed were 14.70, 17.72, 19.03, and 20.58%, respectively. Fat and ash levels also increased slightly from 2.0 to 2.7 and from 1.8 to 2.7%, respectively, as the level of cottonseed substitution in the Egyptian bread increased.

The essential amino acids of 85%-extract wheat flour and LCP cottonseed-wheat flour combinations are presented in Table III. Lysine is the first limiting amino acid in wheat flour. The substitution of 16% LCP cottonseed flour increased the lysine content from 2.53 to 3.90 g/100 g of protein. Fisher (1965) used chick growth studies to determine that the first limiting amino acid in cottonseed is also lysine and that methionine is the second. Comparison of the essential amino acid composition of all wheat-cottonseed flour mixes to the Food and Agriculture Organization/World Health Organization's suggested pattern of amino acid requirements for the infant, school child, and adult (cited by Castro et al 1976) indicated that all the mixtures contained adequate quantities of essential amino acids to meet the requirements of an adult. However, the amounts of lysine, leucine, and isoleucine were lower than those required to support the normal growth of an infant.

Effect of Dough Conditioners

Both the type of dough conditioner and its level signficantly affected the mixograph properties of control and substituted dough systems. Average affects of the dough conditioner on mixograph properties are given in Table IV. Peak time increased with the addition of all conditioner treatments except for Tween 20 or 1.5% POESE. Peak height tended to decrease with the addition of all conditioners, but the decrease was only significant for doughs containing Tandem 552 or 1.5% Tween 60. Work or area under the curve tended to decrease with higher levels of dough conditioners, but few significant differences existed. The dough conditioners are surfactants that possess the ability to strengthen the gluten structure of dough and thus improve its gas-retaining ability. Langhans and Thalheimer (1971) found that the addition of 0.2% polysorbate 60 imparted a dry consistency to dough as measured by the

TABLE II
Effect of Liquid Cyclone Processed Cottonseed Flour on Loaf Volume and Sensory Evaluation of Egyptian Bread

Cottonseed Level (%)	Loaf Volume (g)	Sensory Characteristics					
		Crust[a] Color	Crumb[b] Color	Flavor[c]	Texture[c]	Aroma[c]	General Acceptability[c]
0	581 ± 45 c	6.8 ± 0.1 a[d]	6.0 ± 0.4 a	5.5 ± 0.1 a	5.3 ± 0.1 a	5.4 ± 0.3 a	5.7 ± 0.1 a
4	641 ± 31 c	4.9 ± 0.7 b	3.8 ± 2.5 b	4.4 ± 1.0 b	3.9 ± 1.2 c	4.3 ± 0.9 b	4.4 ± 0.8 b
8	595 ± 45 d	4.0 ± 0.5 bc	3.3 ± 0.4 ab	4.3 ± 1.1 b	4.4 ± 1.1 b	4.1 ± 0.9 b	4.2 ± 0.6 bc
12	550 ± 31 a	3.7 ± 0.2 cd	3.3 ± 1.5 bc	4.0 ± 0.7 bc	4.4 ± 1.4 b	4.0 ± 1.1 b	4.0 ± 1.5 bc
16	556 ± 36 b	2.8 ± 1.5 d	2.8 ± 1.1 c	3.5 ± 0.8 c	3.7 ± 0.8 c	3.3 ± 1.2 c	3.4 ± 0.9 c

[a]Scale: 1 = very dark brown, 7 = light tan.
[b]Scale: 1 = greenish dark yellow, 7 = oatmeal color.
[c]Scale: 1 = very poor, 7 = excellent.
[d]Values in a column followed by the same letter are not significantly different at $P < 0.05$ (Duncan 1957).

TABLE III
Essential Amino Acid Content[a] of Wheat-Liquid Cyclone Processed (LCP) Cottonseed Flour Mixtures and the FAO/WHO Suggested Pattern of Amino Acid Requirement[b]

Amino Acids	Cottonseed in Mixture (%)					Suggested FAO/WHO Patterns		
	0	4	8	12	16	Infant	School Child	Adult
Histidine	2.36	2.54	2.62	2.73	2.77	1.4		
Isoleucine	3.79	3.34	3.00	2.73	2.57	3.5	3.7	1.8
Leucine	7.16	7.04	7.02	6.94	6.93	8.0	5.6	2.5
Lysine	2.53	2.98	3.32	3.47	3.90	5.2	7.5	2.2
Methionine	1.60	2.40	3.06	3.53	3.90	···	···	···
Half-cystine	2.53	2.83	3.00	3.19	3.29	···	···	···
Total sulfur amino acids	···	···	···	···	···	2.9	3.4	2.4
Phenylalanine	5.14	5.37	5.55	5.69	5.80	···	···	···
Tyrosine	3.12	3.20	3.25	3.30	3.34	···	···	···
Total aromatic amino acids	···	···	···	···	···	6.3	3.4	2.5
Threonine	2.78	4.07	5.04	5.86	6.47	4.4	4.4	1.3
Valine	6.23	5.81	5.55	5.29	5.08	4.7	4.1	1.8

[a]g/100 g of protein.
[b]Castro et al (1976).

TABLE IV
Average Effect[a] of Dough Conditioners on Mixograph Properties of Hard Red Winter Wheat-Liquid Cyclone Processed Cottonseed Flour Doughs

Dough Conditioners[b]	Level of Conditioner (%)	Peak Time (min)	Peak Height (cm)	Area (cm^2)
No Conditioner	0.0	3.72 e	6.08 a	81.86 a
Tween 60	0.5	4.14 bc	5.77 ab	82.52 a
	1.5	4.27 b	5.51 bc	74.41 b
Polyoxyethylene 10 stearyl ether	0.5	4.00 cd	5.89 ab	80.77 ab
	1.5	3.90 cde	5.64 abc	78.94 ab
Tween 20	0.5	3.71 e	5.94 ab	80.87 ab
	1.5	3.86 de	5.70 ab	76.51 ab
Tandem 552	0.5	4.73 a	5.48 bc	77.65 ab
	1.5	4.87 a	5.24 c	76.50 ab

[a]Values followed by the same letter are not significantly different at $P = 0.05$ (Duncan 1957).
[b]Tween 60 = polysorbitan monoglycerides and diglycerides polysorbate 60, Tween 20 = polysorbate 20, Tandem 552 = polyoxyethylene sorbitan monostearate.

farinograph. Earlier, Knightly[2] had reported a similar effect using polyoxyethylene sorbitan.

Table V shows that the inclusion of Tween 20 and Tandem 552 in Egyptian bread with 8% cottonseed significantly increased loaf volume over bread made with POESE or without conditioner. At the 12% level of cottonseed, Tween 20 at the 0.5% level was very effective in increasing bread volume, and at the 16% cottonseed level, all conditioners except POESE were effective in increasing volume.

Bread Staling Study

In Egypt, bread has traditionally been baked and bought daily. However, commercial bakeries are increasing, and therefore maintaining bread freshness is desirable. Tenderness evaluations of the Egyptian bread (Fig. 2) indicated that all of the cottonseed-substitution bread was less crisp and more leatherly than the control and that all breads lost their crisp crust on storage. The lower rate of staling in bread with cottonseed flour substitution could result from dilution of the starch content of flour by the substitution of cottonseed, which is higher in protein, or to the slightly higher fat content in the bread with cottonseed flour. When

[2]W. H. Knightly. Monoglyceride performance in bread as a function of chemical composition. Presented at the 47th AACC Annual Meeting, St. Louis, MO, May, 1962.

TABLE V
Effect[a] of Conditioners on Loaf Volume (cc) of Egyptian Bread Made with 0, 4, 8, 12, and 16% Liquid Cyclone Processed Cottonseed Flour

Dough Conditioner[b]	Level of Conditioner (%)	Cottonseed Flour Level (%)				
		0	4	8	12	16
No Conditioner	0.0	635 a	733 a	550 d	585 ab	539 cb
Tween 60	0.5	578 b	692 a	604 bcd	560 b	553 bcd
	1.5	612 ab	672 b	584 bcd	579 ab	612 ab
Polyoxyethylene 10 stearyl ether	0.5	538 c	522 c	472 e	464 c	442 e
	1.5	510 d	506 c	564 cd	541 b	514 d
Tween 20	0.5	656 a	652 b	680 a	628 a	579 abc
	1.5	660 a	698 ab	618 bc	542 b	596 abc
Tandem 552	0.5	520 c	612 c	640 ab	542 b	617 a
	1.5	520 c	674 b	640 ab	527 b	565 abcd

[a]Means followed by the same letter are not significantly different at $P = 0.05$ (Duncan 1957).
[b]Tween 60 = polysorbitan monoglycerides and diglycerides polysorbate 60, Tween 20 = polysorbate 20, Tandem 552 = polyoxyethylene sorbitan monostearate.

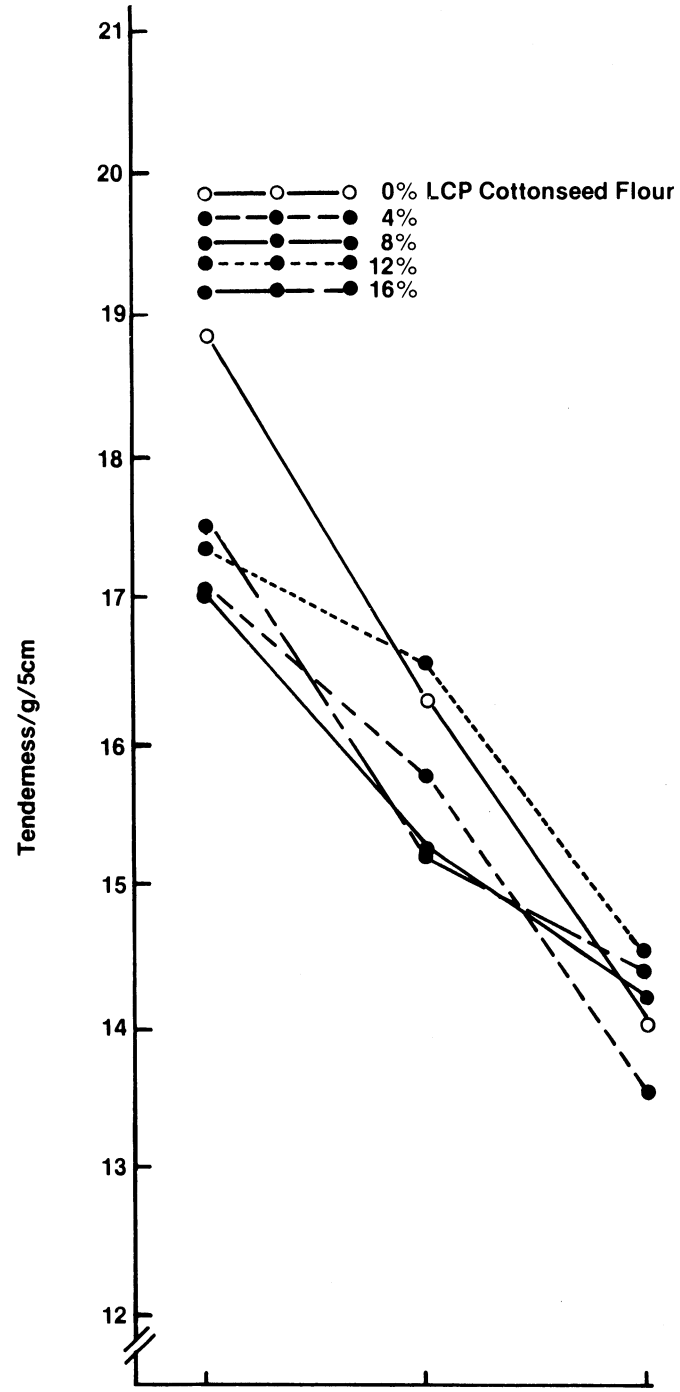

Fig. 2. Tenderness of Egyptian bread substituted with liquid cyclone processed (LCP) cottonseed flour after zero, three, and six days of storage. Low scores = less crisp, more leathery.

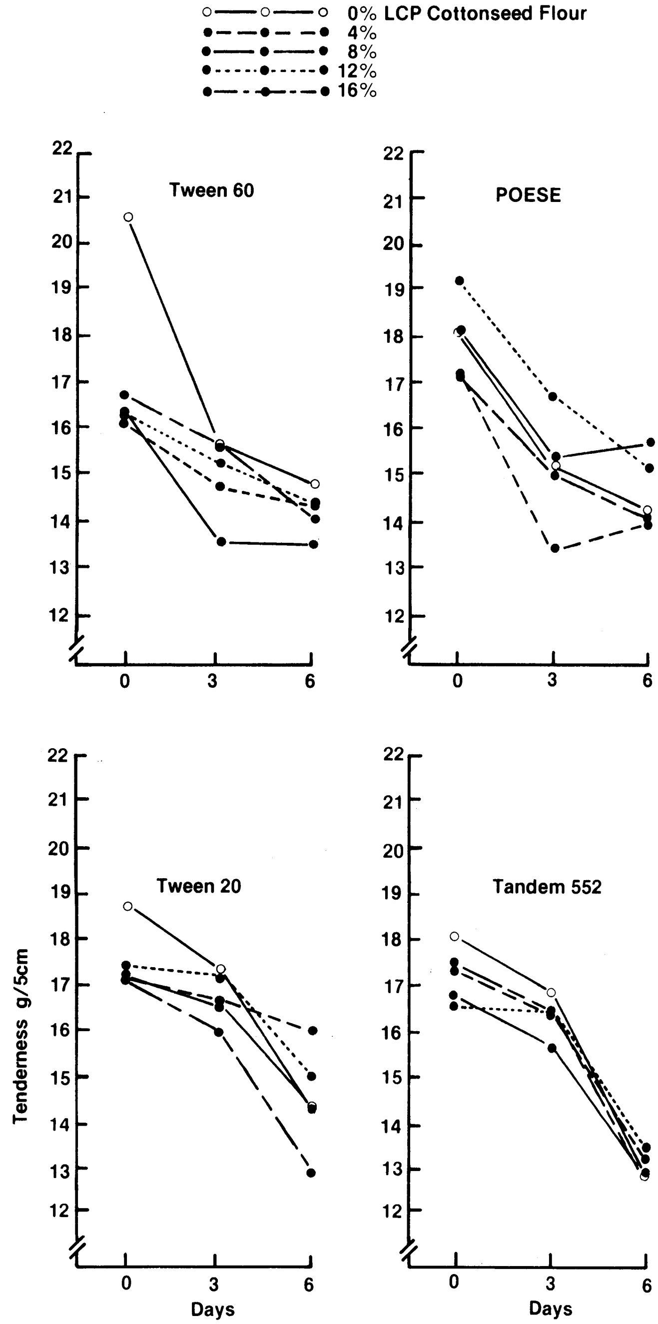

Fig. 3. Effect of dough conditioners on the tenderness after zero, three, and six days of storage of Egyptian bread prepared with 0, 4, 8, 12, and 16% liquid cyclone processed (LCP) cottonseed flour substitutions. Tween 60 = polysorbitan monoglycerides and diglycerides polysorbate 60, POESE = polyoxyethylene 10 stearyl ether, Tween 20 = polysorbate 20, Tandem 552 = polyoxyethylene sorbitan monostearate.

dough conditioners were added to the bread, the rate of staling significantly decreased (Fig. 3). Tween 20 and Tandem 552 were the most effective as antistaling factors.

CONCLUSIONS

Egyptian bread made with up to 8% LCP cottonseed flour was acceptable and its protein content was 41% higher than that of the all-wheat bread. Use of this level of cottonseed substitution also improved the lysine content. Conditioners Tween 20, Tween 60, and Tandem 552 counteracted the deleterious effect of high levels of cottonseed flour (12 and 16%) on bread volume, and their incorporation maintained bread freshness, as measured by tenderness after three and six days of storage.

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Mineral Components of Grain Dust[1]

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ABSTRACT

Particle size distribution patterns, protein and ash contents, and P, K, Mg, Ca, Zn, Fe, Mn, and Cu levels were determined in bin, belt, and cyclone grain dusts collected during handling of wheat, corn, grain sorghum, and soybeans in four commercial grain elevators. Generally, in the 2–125 μm particle size range, Gaussian size distribution was skewed, with particles in the 10–22 μm range making up the single largest fraction. Amounts of large particles (above 125 μm) were substantially larger in settled belt dusts than in airborne bin dusts. Relatively large differences in size distribution patterns were obtained for the tailing dust (collected by cyclone), which is the main dust source. Protein contents in grain dust were the same as for wheat and grain sorghum grains but lower than for whole corn and soybean. Ash levels in dusts had high coefficients of variability and were substantially higher than in whole grains by a factor of 8.0–19.0 for wheat, 4.0–15.9 for corn, 4.5–9.1 for grain sorghum, and 4.0–4.5 for soybeans. Compared with whole grains, dusts were relatively low in P and high in other minerals, especially the minor ones present in trace amounts. Wheat cyclone dust contained less protein and ash and less of most mineral components than did bin or belt wheat dusts. Several statistically significant associations between dust components are recorded.

Several studies from our laboratories have been concerned with the composition of grain dust, including the potentially toxic and otherwise deleterious components (Martin and Lai,[4] Martin and Sauer 1976). The minerals in grain dust are of interest to animal nutritionists as mineral components of rations or as possible toxic or deleterious components. Such information is needed to characterize grain dust and thus to improve its utilization. This is a continuation of those studies.

[1]Cooperative investigations, Agricultural Research, Science and Education Administration, U.S. Department of Agriculture, and the Department of Grain Science and Industry, Kansas State University.

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Mention of firm names or products does not constitute endorsement by the USDA over others of a similar nature.

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[4]C. R. Martin and F. S. Lai. 1979. Physical and chemical composition of grain dust. Presented at the summer meeting of American Society of Agricultural Engineers, University of Manitoba, Winnipeg, Canada. Paper No. 79-3089, June 1979.

The specific objectives of this study were to 1) compare the mineral contents (total ash and individual elements) in dusts from various grains, 2) compare dusts and cereal grains as sources of minerals, 3) compare the mineral composition and particle size of dusts from various locations in an elevator, 4) determine variability in mineral contents of dusts from various grains and locations in the elevator, and 5) determine associations between these characteristics.

MATERIALS AND METHODS

Samples

Samples of grain dust were collected from wheat (predominantly hard red winter), corn, grain sorghum, and soybeans in four commercial grain elevators in central and eastern Kansas. One elevator did not handle soybeans. About 1 kg of dust discharged from the dust control systems on their bucket elevators (cyclone dust) were obtained. Dust samples were also collected from the dust settled around the belt (belt dust) and suspended in the bin overspace (bin dust). The cyclone dust made up by far the largest amount of dust in the elevators; the fine, airborne bin dust and the coarser, settled belt dust each made up a small portion of the total.

Determination of Particle Size Distribution

Particle size distributions of each type of grain dust were determined by sieving and the Whitby centrifugal sedimentation