Zeitschrift für
**Ernährungswissenschaft** Z Ernährungswiss 26:100–106 (1987)

# Feasibility of Saudi wheat flour enriched with cottonseed flour for bread making

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*Summary:* Three samples of edible grade cottonseed flour (cosf) were utilized each in 5 %, 10 % and 15 % mixtures with Saudi wheat flour for bread making.

Addition of cosf increased water absorption of the dough. Times of dough mixing, stability and break-down were slightly increased at the low addition level, but adversely shortened at the higher levels, where mixing tolerance was doubled or tripled. Up to 5 %–10 % of cosf could be tolerated without deleterious effect on dough properties or bread quality, depending on the source of the additive and method of preparation. An increase of 25 %–50 % in protein content of bread was expected.

*Zusammenfassung:* Baumwollsaatmehl (eßbare Qualität) wurde in Anteilen von 5, 10 und 15 % einem saudiarabischen Weizenmehl zur Brotbereitung zugemischt. Dies führte zu einem Anstieg der Wasserbindung des Teiges. Die Zeiten zur Teigbereitung, die Teigstabilität und das Abreißverhalten wurden mit niedrigen Zusatzmengen geringfügig erhöht; die höheren Zusatzmengen hatten umgekehrte Wirkung. Ein Zusatz von 5–10 % Baumwollsaatmehl konnte bezüglich Teigeigenschaften und Brotqualität toleriert werden; die Qualität des zugesetzten Produktes war allerdings maßgebend. Auf diese Weise konnte eine Erhöhung des Proteingehaltes der Brote um 25–50 % erreicht werden.

*Key words:* cottonseed flour, wheat flour, bread making

## Introduction

Cottonseed forms the most important inedible oilseed produced in Arab countries (1), yet it is not well exploited, due to its inherent toxicity. Various methods have been presented to overcome the lysine and gossypol problems (2). Net edible cottonseed protein potentially produced in arab countries has been estimated to raise protein intake of the poorer sectors of the Arab population more than 50 % (3).

Edible grade cottonseed flour (cosf) has successfully been used in a host of food products including cereal flours, noodles, breakfast cereals, sausages, cheese and baby foods (4, 5, 6). Bread, being widely consumed, forms a good medium for enrichment. Addition of cosf in bread-making enhances both protein content and protein quality (7) therefore widely studied (8–13). This product is permitted as a food additive without limitations (14).

Saudi Arabia was declared self-sufficient in wheat production (15), and recently a resulting surplus has been donated to needy countries that happen to be cotton producers. Integration would therefore be of economic and nutritional value. This investigation studies rheological behaviour of doughs of Saudi wheat flour mixed with different types of cosf and properties of bread baked therefrom.

## Materials and Methods

*Materials*

Wheat flour of 75 % extraction (Saudi Mills Co. Dammam) was obtained from a local market.

Two food grades of cottonseed flour (cosf) samples were obtained from the Ministry of Agriculture, U.S.A. One (AAC) was prepared by the air classification method, whereas the other (ALC) by the liquid cyclone process (16). A third sample (ILC) was provided by the Regional Research Lab, Hyderabad, India, and produced by the LCP (17).

Sugar, salt, yeast, glycerol monostearate and ascorbic acid were also used for bread making.

*Methods*

Moisture, crude protein, fat, fibre and ash content were determined, as given in approved methods of the AACC (18).

Mixing properties of the dough were determined in triplicate in a Farinograph (Brabender, Duisburg; West Germany) by the AACC method (18).

Bread was prepared and baked as described earlier (19). All ingredients, including cottonseed flour in 5 %, 10 % and 15 % were well mixed with Saudi wheat flour in the Farinograph mixer where the amount of water to be added was also predetermined. Dough was left to ferment at 32 °C in a Fermentor (Natl. Mfg. Co. Lincoln, Nebr.) for 15 min, moulded in Al-moulds, then replaced in a fermenter to prove for 45 min, then baked at 218 °C. Specific loaf volume was computed from loaf weight (g) and loaf volume (ml) (19). Each result was an average determination of three loaves.

Organoleptic quality was assessed at two levels: firstly a panel of 15 members evaluated appearance, flavour and texture on a scale of nine points for each. Secondly, volume, colour, grain, symmetry, texture, break and shred were evaluated on a centigrade basis (19).

## Results and Discussion

Analysis of cosf samples (Table 1) shows that American cosfs, AAC and ALC, enjoy a much higher protein and fiber content, but a significantly lower content of moisture and oil, properties which would indicate better nutritive value and keeping qualities. Addition of 10 % cosf would thus raise protein content of the resulting bread by approximately 1.5 times.

The higher protein and much lower ash content of ALC compared to AAC flour must be in favour of the former. Analytical difference between the three samples attributed to preparation technique is evidently smaller than that due to seed derivation and variety.

Mixing properties of wheat-cosf mixtures are shown in Table 2. Cottonseed flour thus increases water absorption of the dough. This coincides

Table 1. Approximate analysis of cottonseed flours.

| Constituent | AAC | ALC | ILC |
|---|---|---|---|
| Moisture | 4.2 | 2.6 | 6.7 |
| Crude protein | 63.8 | 66.2 | 49.1 |
| Crude fat | 1.6 | 0.6 | 7.4 |
| Ash | 10.2 | 7.5 | 7.6 |
| Crude fibres | 2.3 | 2.2 | 1.3 |
| Carbohydrates (by difference) | 17.9 | 20.9 | 17.9 |

with earlier findings (11, 13). The increase is higher for the LC flours than for the AC product, and for ILC than ALC. Therefore, it is not the difference in protein content that causes the difference in water absorption, but rather the difference in the highly absorbent carbohydrates and in salts (19).

Other mixing properties were affected mainly by the level of cosf addition. Thus at 5% the mixing tolerance index of the dough was not affected. Times of mixing, stability and breakdown were either unaffected (sample ILC) or slightly increased (samples AAC and ALC). The higher levels of cosf adversely shortened these times and doubled or tripled the mixing tolerance indices, intensity of the effect depending on the type of flour. Thus ILC flour shows the strongest, followed by the AAC product. Once again, the influence of seed variety and derivation seems to be stronger than that of preparation technique. It is well known that gluten is the most important factor influencing dough mixing properties. Non-gluten protein admixture would therefore weaken these properties. However, this appears not to be the sole factor, since the effect of the lower protein ILC flour is stronger than the richer American types.

Table 2. Effect of cottonseed flour on mixing properties of Saudi wheat flour dough.

| Sample | % cosf added | Water absorption | | Mixing time | | Stability time | | Mixing tolerance index | | Break-down time | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | % | SD | Min | SD | Min | SD | B.U. | SD | Min | SD |
| Control | 0 | 69.1 | 0.1 | 11.0 | 0.1 | 23.5 | 0.1 | 30.0 | 0.0 | 27.5 | 0.1 |
| | 5 | 69.5 | 0.1 | 12.0 | 0.1 | 26.0 | 0.2 | 30.0 | 0.1 | 28.0 | 0.1 |
| AAC | 10 | 70.4 | 0.0 | 8.5 | 0.2 | 15.3 | 0.2 | 60.0 | 0.1 | 23.5 | 0.1 |
| | 15 | 73.0 | 0.1 | 7.0 | 0.2 | 8.5 | 0.2 | 85.0 | 0.2 | 13.5 | 0.1 |
| | 5 | 69.7 | 0.1 | 12.5 | 0.2 | 27.5 | 0.1 | 30.0 | 0.1 | 29.5 | 0.1 |
| ALC | 10 | 71.4 | 0.1 | 9.0 | 0.1 | 16.0 | 0.1 | 60.0 | 0.1 | 23.5 | 0.1 |
| | 15 | 73.2 | 0.1 | 7.5 | 0.1 | 9.3 | 0.1 | 80.0 | 0.1 | 16.5 | 0.1 |
| | 5 | 70.2 | 0.1 | 11.0 | 0.2 | 23.0 | 0.1 | 30.0 | 0.1 | 27.0 | 0.1 |
| ILC | 10 | 72.0 | 0.1 | 8.0 | 0.2 | 14.5 | 0.1 | 65.0 | 0.1 | 20.0 | 0.1 |
| | 15 | 75.1 | 0.1 | 6.3 | 0.2 | 6.5 | 0.1 | 95.0 | 0.1 | 12.8 | 0.1 |

SD: Standard deviation of three determinations

Table 3. Effect of cottonseed flour on bread dimensions.

| Sample | % cosf added | Loaf weight g | SD | % change | Loaf volume $cm^3$ | SD | % change | Specific volume $cm^3/g$ | SD | % change |
|---|---|---|---|---|---|---|---|---|---|---|
| Control | 0 | 143 | 2.3 | – | 362 | 3.4 | – | 2.5 | 0.1 | – |
| | 5 | 140 | 3.5 | –2 | 370 | 2.8 | 2 | 2.6 | 0.1 | 4 |
| AAC | 10 | 152 | 3.1 | 6 | 337 | 3.6 | –7 | 2.2 | 0.1 | –12 |
| | 15 | 162 | 3.5 | 13 | 325 | 3.2 | –10 | 2.0 | 0.1 | –21 |
| | 5 | 135 | 3.1 | –6 | 275 | 3.9 | 4 | 2.8 | 0.0 | 10 |
| ALC | 10 | 150 | 2.9 | 5 | 345 | 4.5 | –5 | 2.3 | 0.0 | –9 |
| | 15 | 155 | [illegible].2 | 8 | 330 | 2.9 | –9 | 2.1 | 0.1 | –16 |
| | 5 | 144 | 2.4 | 0 | 362 | 5.1 | 0 | 2.5 | 0.1 | 0 |
| ILC | 10 | 158 | 4.1 | 10 | 331 | 4.2 | –9 | 2.1 | 0.1 | –17 |
| | 15 | 166 | 3.2 | 16 | 321 | 2.7 | –11 | 1.9 | 0.1 | –24 |

SD: Standard deviation for three samples

Specific volume of bread, a positive quality criterion, is shown to be significantly enhanced by addition of 5 % of American cosf (Table 3), the influence being higher with ALC than with AAC, with the ILC sample showing no effect. This enhancement is a result of the increase in loaf volume with a concomitant decrease in loaf weight. Levels of 10 % and 15 % addition evidently decrease bread quality in terms of specific volume. Similar results have been reported for Iranian Sangak bread (11) and Egyptian Baladi bread (12, 13).

Flavour testing (Table 4) shows a general deterioration in quality with increasing addition of cosf. The 5 % level may be tolerated, particularly with American flours, regardless of preparation method. It may be note-

Table 4. Effect of cottonseed flour on bread quality.

| Sample | % cosf added | Scoring of sensory properties | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Appearance (9) | SD | Flavour (9) | SD | Texture (9) | SD | Total score 27 | SD |
| Control | – | 8.0 | 0.2 | 8.2 | 0.1 | 7.5 | 0.2 | 23.7 | 1.5 |
| | 5 | 8.0 | 0.5 | 7.3 | 0.2 | 7.9 | 0.3 | 23.2 | 1.2 |
| AAC | 10 | 7.1 | 0.3 | 5.9 | 0.3 | 6.9 | 0.3 | 19.9 | 1.3 |
| | 15 | 5.4 | 0.4 | 4.9 | 0.3 | 5.6 | 0.3 | 15.9 | 1.4 |
| | 5 | 8.0 | 0.3 | 7.1 | 0.2 | 8.0 | 0.2 | 23.1 | 1.2 |
| ALC | 10 | 7.0 | 0.3 | 6.0 | 0.3 | 7.1 | 0.2 | 20.1 | 1.3 |
| | 15 | 5.0 | 0.6 | 5.2 | 0.3 | 5.5 | 0.2 | 15.7 | 1.4 |
| | 5 | 7.5 | 0.1 | 7.0 | 0.2 | 7.0 | 0.3 | 21.5 | 1.2 |
| ILC | 10 | 5.4 | 0.1 | 5.5 | 0.3 | 5.9 | 0.4 | 16.8 | 1.1 |
| | 15 | 3.5 | 0.2 | 4.6 | 0.3 | 4.2 | 0.2 | 12.3 | 0.9 |

SD: Standard deviation of 15 panelists

Table 5. Sensory scoring of bread containing cottonseed flour.

| Cottonseed flour added | % | Loaf volume 20 | SD | Crust colour 10 | SD | Crumb colour 10 | SD | Grain 20 | SD | Texture 20 | SD | Break and shred 10 | SD | Symmetry 10 | SD | Total score 100 | SD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Control | – | 16 | 1.2 | 9 | 0.8 | 9 | 0.8 | 16 | 1.1 | 18 | 1.2 | 8 | 0.8 | 8 | 0.9 | 84 | 3.1 |
| | 5 | 17 | 0.7 | 9 | 1.3 | 8 | 1.1 | 18 | 0.9 | 18 | 1.5 | 9 | 0.4 | 9 | 1.0 | 88 | 3.1 |
| AAC | 10 | 14 | 1.5 | 8 | 1.1 | 8 | 0.9 | 16 | 0.8 | 17 | 1.3 | 8 | 0.7 | 9 | 1.0 | 80 | 1.7 |
| | 15 | 10 | 1.3 | 7 | 0.5 | 7 | 1.1 | 13 | 0.9 | 15 | 0.8 | 7 | 0.9 | 7 | 1.1 | 66 | 3.0 |
| | 5 | 17 | 2.1 | 9 | 1.0 | 9 | 0.8 | 17 | 1.4 | 18 | 1.7 | 9 | 0.4 | 9 | 0.7 | 88 | 3.1 |
| ALC | 10 | 14 | 1.1 | 8 | 0.9 | 9 | 0.7 | 16 | 0.7 | 16 | 1.2 | 8 | 0.7 | 8 | 1.3 | 79 | 3.3 |
| | 15 | 10 | 1.1 | 8 | 0.8 | 8 | 0.6 | 14 | 1.5 | 15 | 0.9 | 7 | 1.5 | 7 | 0.9 | 69 | 2.9 |
| | 5 | 16 | 1.5 | 8 | 0.8 | 8 | 0.3 | 16 | 1.2 | 17 | 0.9 | 8 | 1.3 | 8 | 1.1 | 81 | 3.1 |
| ILC | 10 | 13 | 1.9 | 6 | 2.1 | 6 | 0.9 | 12 | 1.4 | 13 | 1.1 | 6 | 1.3 | 6 | 1.2 | 62 | 2.8 |
| | 15 | 9 | 1.7 | 5 | 1.8 | 4 | 1.2 | 10 | 0.9 | 11 | 1.5 | 5 | 1.2 | 6 | 2.0 | 50 | 2.1 |

SD: Standard deviation of five experienced panelists worthy that the light brown Indian flour added to the undesirability of the darker bread produced more than the cream coloured American products. Moreover, at the 5 % level, the American cosfs have a slight effect on appearance, and enhance texture acceptability.

Critical scoring of bread quality attributes (Table 5) shows that at the 5 % level, American cosfs may enhance bread acceptability, whereas the Indian product is as tolerated as the American at 10 %. The 15 % level was rejected in all cases.

Closer examination of Table 5 confirms results mentioned above (Tables 3 and 4). Thus, at 5 % addition, cosfs do not seriously affect loaf volume, colour of crust or crumb, grain, texture, break and shred, nor symmetry. These parameters are little deteriorated by the addition of 10 % of American cosf, and strongly affected by the same level of Indian flour, or 15 % of all samples. As high as 10 % Indian cosf had been found to increase the spread of biscuits, without taste deterioration (20). Colour was darker than the control, and could be overcome in Cacao biscuits.

In conclusion, the use of cottonseed flour for bread making is advisible from nutritional aspects. At a level of 5 % addition bread quality is either unaffected or even enhanced. Up to 10 %, cosf may functionally and organoleptically be tolerated, depending on the source, hence properties of the flour. Such a level would increase protein content of bread by approximately 1.5 times. The American cosf tested was more favourable than the Indian sample in all aspects. The use of higher proportions of this protein-rich flour might prove suitable for biscuit production.

*Acknowledgements*

The authors wish to acknowledge the kind co-operation of scientists at SRRL, New Orleans, La, U.S.A., and RRL, Hyderabad, India, for providing the cosf samples.

*References*

1. FAO (1985) Production Yearbook 39
2. Maleki M, El-Shaarawy MI (1976) Oilseeds, their technical qualities as sources for oil and protein. 10th Iranian Oilseed Seminar, April 1986, College of Agriculture, Pahlavi University, Shiraz, Iran
3. El-Shaarawy MI (1984) Cottonseed and Arab food security. Lecture on World Food Day. College of Agriculture and Foods, KFU, October 1984
4. Anon (1974) Edible vegetable protein makes consumer gains as meat blends. Cill Mill Gazetter 79 (2):22
5. Martinez WH, Berardi LC, Goldblatt LA (1970) Potential of cottonseed. Third Interntl Congress on Food Science and Technol, Washington DC
6. Bressani R (1965) The use of cottonseed protein in human foods. Food Technol, November 1965, pp 51–58
7. El-Shaarawy MI (1975) Preparation of cottonseed protein for human consumption. Report (unpublished), to Pahlavi University Research Council, Shiraz, Iran
8. Bacijalupo A, Aguilar TS, Lunade Tafuenta R, Valla Riestra J (1967) Bread enrichment with Protal-Peruvial cottonseed flour. Cereal Sci Today 12:431
9. Mathews RH, Sharpe EJ, Clark WM (1970) The use of some oilseed flours in bread. Cereal Chem 47:181

10. Rooney LW, Gustafson CB, Clark SP, Cater CM (1972) Comparison of the baking properties of several oilseed flours. J Food Sci 37:14
11. El-Shaarawy MI, Badr HR (1976) Properties of wheat-cottonseed flour doughs for Iranian "Sangak" bread making. Unpublished study
12. El-Sayed KM, Salem AE, Bary A (1978) Utilization of cottonseed flour in human food. III. Bread and Biscuit supplemented with cottonseed flour. Alex J Agric Res 26 (3):619–631
13. Minyawi M, Zabik ME (1981). Cottonseed flour's functionality in Egyptian baladi bread. Cereal Chem 58 (5):413–417
14. Furia TE (1972) Handbook of food additives. CRC Press, 2nd ed
15. Anon (1985) FAO hails Saudi Arabia's Agricultural achievements. Middle East Agribusiness 5 (1):6
16. Gardner HK, Ron RJH, Vix HL (1973) Liquid Cyclone Process for edible cottonseed flour production. Oil Mill Gazetter, December 12–15
17. Afzalpurkar AB, Krishnamurthy A, Krishnamoorthi V (1970) A liquid cyclone process for preparation of low gossypol high-protein flour from cottonseed. Chemical Age of India 21 (8):712–715
18. AACC (1976) Approved Methods of the American Association of Cereal Chemists. Vol 2 AACC, Inc. St. Paul, Min, USA
19. Mesallam AS, El-Shaarawy MI, Mustafa AI (1987) Effect of water from different sources in Saudi Arabia on rheological properties of dough and bread quality. Acta Alimentaria 16 (1):45–53
20. El-Shaarawy MI (1983) Use of cottonseed flour in biscuit production. Unpublished results

Received February 4, 1987

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