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Effect of cysteine on bakery products from wheat–sorghum blends

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Abstract

Sorghum flour was added to wheat flour with or without cysteine for preparation of breads and biscuits having 5, 10 and 15% and 10, 20 and 30% addition of sorghum, respectively. Breads were prepared by two different methods. Results showed that 5% sorghum with 30 ppm cysteine gave acceptable bread using a straight-dough method. Using a chemical-dough development method for bread preparation, 10% sorghum, along with 60 ppm cysteine, may be added to wheat flour to give a bread of high quality. A high quality biscuit can be prepared by addition of 20% sorghum flour and cysteine (60 ppm/100 g flour) to wheat flour.

Keywords: Cysteine; Sorghum-wheat blends; Breads; Biscuits

1. Introduction

Grain sorghum ranks third among cereals for human consumption and is a staple food in Africa, India and China, superseded only by rice and wheat. It is the most important cereal crop in Sudan. Bakery products have become an essential food for a large segment of the Sudanese population. The bakery industry in Sudan has been in existence for a long time; contributing factors, such as urbanization, has resulted in increased demand for ready-to-eat, convenient food products, such as bread or biscuits. The main problem facing the bakery industry in Sudan is the non-availability of wheat flour, so any effort made to substitute part of the wheat flour by other kinds of available flours, e.g. sorghum, will contribute to lowering of cost.

Use of non-wheat flours for extending wheat supplies has been investigated with composite flours in bakery products (Bhatia, Chakraborthy, Mathur, Siddiah, & Raghavan, 1968). However, only processed flours from white sorghum, cassava, maize and other oil-seed flours, have been tried along with wheat. Many studies have shown that sorghum flour can replace wheat in bread, but the loaf volume is reduced and the crumb texture softened at higher concentrations of sorghum (Bhatia et al., 1968; Perten, 1977).

It has been reported that addition of cysteine to wheat flour accelerates stress relaxation and structural relaxation (Frater, Hird, & Moss, 1961). Pomeranz (1988) reported that cysteine reduces the mixing time of the dough and it reacts with wheat proteins by splitting disulphide bonds rapidly and thus aiding faster dough development. No work has been published on the use of cysteine with sorghum–wheat blends. The objective of this investigation was to study the effect of using cysteine with sorghum–wheat blends in preparation of breads and biscuits.

2. Materials and methods

A low-tannin sorghum cultivar M-35-1 was used in this study. The material was cleaned and ground to pass through a 0.4-mm screen.

Sorghum flour was mixed with wheat flour at 5, 10 and 15% levels for preparation of breads and at 10, 20 and 30% for the preparation of biscuits. L-cysteine hydrochloride was added to the blends, according to the level of the sorghum flour (15 ppm for each 5% sorghum), and the pH was adjusted to 4.5 by ammonium carbonate.

2.1. Farinograph characteristics

The farinograph of wheat flour (control) and the blends with or without cysteine were determined according to the method of AACC (1983).

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2.2. Preparation of breads

Breads were prepared by a straight-dough method and by the chemical-dough development method according to AACC (1983).

2.3. Physical characteristics of breads

Breads were evaluated for their physical characteristics. The parameters evaluated were: weight (g), loaf volume (ml) and specific volume (ml/g).

2.4. Texture of breads

Breads were analyzed for textural measurement of firmness by compression force in kg on a Instron Universal Texturometer, model 1140 (Instron Ltd., UK), using a compression load cell of 550 kg max and plunger of 36 mm diameter made of stainless steel, according to the AACC (1983) procedure.

2.5. Preparation of biscuits

Biscuits were prepared according to the Vatsala and Haridas Rao (1991) method.

2.6. Physical characteristics of biscuits

Biscuits were evaluated for weight (g), thickness (cm), width (cm), density (g/cm), spread ratio and spread factor. Spread ratio and spread factor were calculated using the following equation:

$$\text{Spread ratio} = \frac{\text{Width}}{\text{thickness}}$$

$$\text{Spread factor} = \frac{\text{Spread ratio of sample}}{\text{Spread ratio of control}} \times 100$$

Five biscuits were used for the evaluation and the average was noted.

2.7. Texture measurement

The breaking force of biscuits were measured following the triple beam snap technique of Gains (1991) using Instron Universal Testing Instrument (Instron Ltd., UK).

2.8. Sensory evaluation of biscuits

A panel of six members, composed of adult males and females, was used to determine preference of wheat–sorghum, biscuits with or without cysteine, against wheat biscuits (control) for colour, surface character, crumb colour, texture, taste and mouth feel. The order of presentation of the samples was randomized. To determine if the observed differences were statistically significant the mean total scores were analyzed by Duncan's multiple range test (Duncan, 1955).

Table 1
Farinogram characteristics of wheat–sorghum flour blends with and without cysteine

Treatment	Water absorption (%)	Dough development time (min)	Stability (min)	Mixing tolerance index (BU)
Wheat flour (control)	61.0	4.5	6.0	60
5% Sorghum	61.0	5.0	7.5	70
10% Sorghum	66.4	5.0	5.5	70
15% Sorghum	59.8	3.0	4.5	80
5% Sorghum + cysteine[a]	62.0	2.0	2.0	170
10% Sorghum + cysteine[b]	64.0	2.0	2.0	200
15% Sorghum + cysteine[c]	63.0	2.0	1.5	200

[a] Cysteine 15 ppm/100 g blend.
[b] Cysteine 30 ppm/100 g blend.
[c] Cysteine 45 ppm/100 g blend.

2.9. Statistical analysis

Three separate batches for a particular treatment were taken and analyzed separately and the figures were then averaged. Data was assessed by analysis of variance (Snedecor & Cochran, 1987) and Duncan's multiple range test with a probability $P \leqslant 0.05$ (Duncan, 1955).

3. Results and discussion

3.1. Farinograph characteristics

The farinograph characteristics of wheat flour and sorghum wheat blends, as influenced by addition of varying amounts of cysteine, are presented in Table 1. The

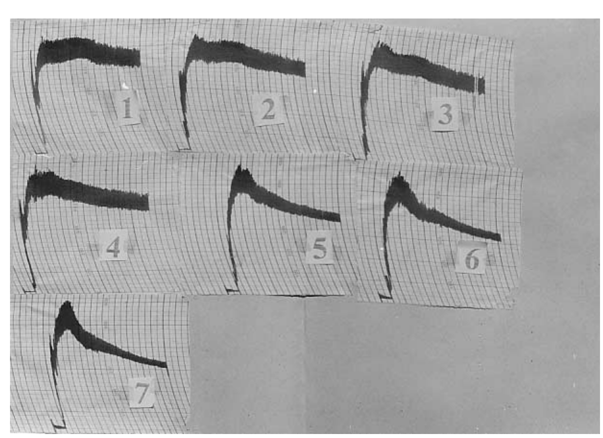

Fig. 1. Farinograms of wheat-sorghum blends with or without cysteine. (1) Wheat flour control; (2) 5% blend; (3) 10% blend; (4) 15% blend; (5) 5% blend + cysteine; (6) 10% blend + cysteine; (7) 15% blend + cysteine.

Table 2
Physical characteristics of breads made by straight dough method[a]

Bread	Weight (g)	Loaf volume (ml)	Specific volume (ml/g)	Compressibility (g)
Control	133.81 (±0.35)bc	677.5 (±0.43)a	5.07 (±0.03)a	872.58 (±111.80)b
5% Sorghum	134.16 (±0.43)bc	652.5 (±1.70)b	4.86 (±0.00)a	781.9 (±90.65)b
10% Sorghum	137.24 (±0.87)ac	620.0 (±10.07) c	4.52 (±0.04)b	825.6 (±81.03)b
15% Sorghum	137.53 (±0.11)ab	582.0 (±7.60)d	4.24 (±0.05)bc	872.58 (±65.40)b
5% Sorghum + cysteine[b]	136.70 (±0.93)a	615.0 (±5.00)c	4.5 (±0.11)b	604.0 (±17.70)b
10% Sorghum + cysteine[c]	140.72 (±0.17)a	545.0 (±5.00)e	3.87 (±0.04)cd	909.5 (±46.35)b
15% Sorghum + cystein[d]	140.21 (±0.17)a	472.0 (±12.50)f	3.37 (±0.10)d	1305.33 (±118.56)a

[a] Values are means (±S.E.). Means not sharing a common following letter in a column are significantly different at $P \leqslant 0.05$ as assessed by Duncan's multiple range test.
[b] Cysteine 30 ppm/100 g blend.
[c] Cysteine 60 ppm/100 g blend.
[d] Cysteine 90 ppm/100g blend

Table 3
Physical characteristics of bread made by chemical dough method[a]

Bread	Weight (g)	Loaf volume (ml)	Specific volume (ml/g)	Compressibility (g)
Control	136.93 (±0.09)a	732.5 (±12.50)a	5.35 (±0.l0)a	802.03 (±50.35)a
5% Sorghum	136.50 (±0.94)a	715.0 (±5.00)a	5.24 (±0.07)a	626.43 (±3.16)a
10% Sorghum	137.05 (±0.26)a	657.5 (±7.50)a	4.80 (±0.06)a	765.10 (±44.86)a
15% Sorghum	138.13 (±0.77)a	627.5 (±l2.50)a	4.55 (±0.12)a	761.78 (±64.00)a

[a] Values are means (±S.E.). Means not sharing a common following letter in a column are significantly different at $P \leqslant 0.05$ as assessed by Duncan's multiple range test.

farmnograms are given in Fig. 1. The data obtained with wheat flour showed relatively strong characteristics.

There was a decrease in water absorption with the addition of 15% sorghum flour but an increase with the 10% sorghum, while the 5% sorghum blend gave the same water absorption as the control. Increase in the level of sorghum to 15% lowered the dough development time from 4.5 to 3.0 min. The dough-mixing tolerance index value increased with all types of blends, indicating weakening of dough.

Generally, addition of cysteine led to increase in water absorption, decrease in dough development time by 2.5 min. and a decrease in dough stability, while the mixing tolerance index increased by 110, 140 and 160 BU for 5, 10 and 15% blends, respectively; it increased by 100, 130 and 140 BU with the corresponding no-cysteine blends. Babu (1995) reported that addition of L-cysteine hydrochloride (0.1%) increased water absorption, but decreased dough development time and dough stability. Pomeranz (1988) reported that cysteine reduces the mixing time of the dough and facilitates the unfolding of protein molecules during mixing, thus aiding faster dough development.

3.2. Bread preparation

3.2.1. Straight dough method

The physical characteristics of breads are listed in Table 2. There was an increase in the weight of the bread with increasing percentages of sorghum in the blends but the increase was not statistically significant; the volume of the bread decreased gradually as the level of sorghum increased. Significant decrease in bread volume occurred with the addition of cysteine (5 ppm/100 g blend), mainly at the 15% sorghum level. The specific volume of bread also decreased gradually, due to increased weight as well as decreased volume, as the level of sorghum or cysteine increased in the blend.

Texture of bread is influenced by addition of sorghum flour. Addition of sorghum had no effect on the force required to compress the crumb by 25% (Table 2). Addition of cysteine at high levels increased the compressibility, indicating a decrease in crumb softness. At low levels of cysteine (15 ppm, 5% blend), there was a decrease in the compressibility, indicating that at this level of cysteine made the crumb softer.

3.2.2. Chemical dough development method

The physical characteristics of breads made by the chemical dough development method are presented in Table 3. There was a slight increase in the weight of the bread with increasing sorghum levels in the blends. The volume decreased gradually with increasing sorghum percentage. The specific volume decreased due to the increase in weight and decrease in volume. The compressibility of the crumb, for all blends, was less than that of the control, which indicated that the crumb became softer.

Table 4
Physical characteristic of biscuits[a]

Biscuits	Weight (g)	Width (cm)	Thickness (cm)	Density (g/cm)	Spread ratio	Spread factor	Breaking force (g)
Control	8.29 (±0.01)c	5.53 (±0.01)1,	0.74 (±0.02)b	0.47 (±0.02)a	7.47 (±0.15)a	100.00 (±0.00)a	2420 (±86.35)a
10% Sorghum	8.05 (±0.01)d	5.49 (±0.01)b	0.72 (±0.01)b	0.47 (±0.03)a	7.63 (±0.08)a	102.14 (±4.02)a	2447 (±87.86)a
20% Sorghum	8.24 (±0.0l)c	5.56 (±0.03)ab	0.74 (±0.01)b	0.46 (±0.02)ab	7.51 (±0.08)a	100.54 (±1.10)ab	2472 (±111.97)a
30% Sorghum	9.18 (±0.03)a	5.70 (±0.01)a	0.82 (±0.02)a	0.44 (±0.01)bc	6.95 (±0.16)ab	93.22 (±4.70)b	2542 (±116.30)a
10% Sorghum + cysteine[b]	8.8 (±0.03)b	5.61 (±0.01)ab	0.84 (±0.01)a	0.42 (±0.01)c	6.68 (±0.11)c	89.43 (±0.11)c	1803 (±92.05)b
20% Sorghum + cysteine[c]	9.06 (±0.04)ab	5.70 (±0.02)a	0.84 (±0.04)a	0.42 (±0.01)c	6.80 (±0.32)b	91.18 (±6.70)bc	1493 (±92.05)b
30% Sorghum + cysteine[d]	9.27 (±0.03)a	5.67 (±0.02)a	0.86 (±0.01)a	0.43 (±0.01)c	6.59 (±0.06)d	88.32 (±0.85)c	1544 (±63.90)b

[a] Values are means (±S.E.). Means not sharing a common following letter in a column are significantly different at $P \leqslant 0.05$ as assessed by Duncan's multiple range test.
[b] Cysteine 30 ppm/100 g blend.
[c] Cysteine 60 ppm/100 g blend.
[d] Cysteine 90 ppm/l00g blend.

Table 5
Sensory evaluation of biscuits[a]

Biscuits	Colour (10)	Surface character (10)	Crumb colour (10	Texture (20)	Taste (20)	Mouthfeel (10)	Total score (80)
Control	8.5 (±0.32)	8 (±0.25)	9.0 (±0.45)	18 (±0.95)	18 (±0.85)	8 (±0.36)	69.6 (±1.03)a
10% Sorghum	8.5 (±0.25)	8 (±0.18)	9.0 (±0.36)	18 (±0.36)	18 (±0.71)	7 (±0.42)	68.5 (±1.03)ab
20% Sorghum	8.5 (±0.25)	8 (±0.26)	8.5 (±0.36)	b7 (±0.45)	18 (±0.36)	7 (±0.37)	67.0 (±0.95)b
30% Sorghum	8.5 (±0.16)	8 (±0.25)	8.0 (±0.32)	16 (±0.78)	17 (±0.36)	7 (±0.32)	63.5 (±b.85)c
10% Sorghum + cysteine[b]	8.5 (±0.42)	8 (±0.32)	9.0 (±0.25)	18 (±0.75)	18 (±0.36)	7 (±0.32)	68.5 (±1.83)a
20% Sorghum + cysteine[c]	8.5 (±0.32)	8 (±0.27)	9.0 (±0.25)	19 (±0.41)	18 (±0.36)	7 (±0.32)	69.5 (±1.70)a
30% Sorghum + cysteine[d]	7.5 (±0.25)	8 (±0.25)	8.0 (±0.25)	l8 (±0.4b)	17 (±0.36)	6 (±0.36)	64.5 (±0.92)c

[a] Values are means (±S.E.). Means not sharing a common following letter in a column are significantly different at $P \leqslant 0.05$ as assessed by Duncan's multiple range test.
[b] Cysteine 30 ppm/100 gm blend.
[c] Cysteine 60 ppm/100 gm blend.
[d] Cysteune 90 ppm/100 gm blend.

Comparing the results of the two methods for bread-making, the chemical dough development method gave bread with higher loaf volume, even for the control bread. The method also gave bread with a high specific volume and soft texture. Results indicate that sorghum can be added at the 10% level to wheat flour, using the chemical dough development method to produce good and acceptable bread. Several studies have indicated the possibility of incorporating sorghum in wheat flour for producing bread, biscuits and other snacks (Badi, Hoseney, & Casady, 1976; Hart, Graham, Gee, & Jorgan, 1976; Hulse, Laing, & Pearson, 1980). Jyothsna Rao and Vekateswara Rao (1997) reported that replacement of wheat flour by up to 15 and 10% with 75 and 85% extraction rate of sorghum flours, respectively, produced acceptable bread.

3.3. Biscuits

3.3.1. Physical characteristics

Widths of the biscuits were larger in those prepared from sorghum plus cysteine, while the thickness of the biscuits was increased in all blends by the addition of cysteine (Table 4). This increase in the thickness of the biscuits containing cysteine is probably due to greater development of gluten proteins. During the backing process, the gluten proteins expand due to formation of leavening gases, which results in an increase in the biscuit thickness.

The density of biscuits decreased with addition of sorghum, suggesting an increase in aeration (Table 4). Adding cysteine, decreased biscuit density still further, to an approximately constant value, relatively independent of the amount of cysteine added.

The spread ratio and spread factor decreased for all types of biscuits expcept biscuits made from 10 to 20% blends. This is due to the decrease in width and thickness of these two types of biscuits; the increase in the other types could be explained by the fact that the spread ratio is the ratio of width of biscuits to the thickness of biscuits. Babu (1995) reported that when cysteine was added to wheat flour for use in cream crackers, it affects the physical characteristics of the product by reducing the thickness and the weight of the crackers.

The texture of the biscuits was not affected by incorporation of sorghum, but addition of cysteine to the blends resulted in softer biscuits; there was a decrease in the texture of the three blends by 26, 40 and 39% for 10, 20 and 30% blends, respectively.

Earlier studies showed that using reducing agents, such as sodium metabisuphite in biscuit formulation, reduce the consistency and hardness of the biscuit dough (Oliver, Thocker, & Wheeler, 1995).

3.3.2. Sensory evaluation of biscuits

The sensory evaluation of different types of biscuits is shown in Table 5. The colours and surfaces of the different types of biscuits were not affected by the incorporation of sorghum flour or by the addition of cysteine.

Addition of sorghum to wheat flour made the crumb colour dull white but, when cysteine was added to those blends, this effect was eliminated. The texture of the biscuits became harder in the 20 and 30% blends, but addition of cysteine made the biscuits softer. Generally, the mouthfeel of the biscuits was affected by the presence of sorghum, which leads to a residual taste in the mouth.

Addition of cysteine to the blends did not affect the mouthfeel. The overall quality of the biscuits was reduced by addition of sorghum flour but the presence of cysteine in the blend improved the quality, mainly in the blend containing 20% sorghum; the total score of such biscuits was similar to the control biscuits.

Addition of cysteine results in the improvement of physical and sensory characteristics of biscuits made from wheat and sorghum blends. Twenty percent of sorghum flour with 60 ppm cysteine could be used with practically no adverse effect on the overall quality or taste of the biscuits.

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References

AACC (1983). *Approved methods of the American Association of Cereal Chemists*. St. Paul, MN, USA: AACC.

Babu, K. S. (1995). Influence of reducing agents emulsifiers on the quality of cream crackers. MSc thesis, University of Mysore, Mysore, India.

Badi, S. M., Hoseney, R. C., & Casady, A. J. (1976). Pearl millet 1. Characterization by SEM, amino acid analysis, lipid composition and prolamin solubility. *Cereal Chemistry, 53*, 478–487.

Bhatia, B. S., Chakraborthy, T. K., Mathur, U. F., Siddiah, C. H., & Raghavan, P. K. V. (1968). Use of maize and milo flours for the preparation of bread. *Ind. Food Packer, 22*, 33.

Duncan, B. D. (1955). Multiple range and multiple F tests. *Biometrics, 11*, 1–42.

Frater, R., Hird, F. J., & Moss, H. J. (1961). Role of disulphide exchange reactions in the relaxation of strains introduced in dough. *Journal of the Science of Food and Agriculture, 12*, 269–273.

Gains, C. S. (1991). Instrumental measurement of the hardness of cookies and crackers. *Cereal Foods World, 36*, 989–996.

Hart, J. H., Graham, R. P., Gee, M., & Jorgan Jr., A. I. (1976). Bread from sorghum and barley flours. *Journal of Food Science, 35*, 661–665.

Hulse, J. H., Laing, E. M., & Pearson, O. E. (1980). *Sorghum and millets: their composition and nutritive value*. London: Academic Press Inc.

Jyothsan Rao, S., & Venkateswara Rao, G. (1997). Effect of incorporation of sorghum flour to wheat flour on chemical, rheological and bread characteristics. *Journal of Food Science and Technolgy, 34*, 251-254.

Oliver, G., Thocker, D., & Wheeler, R. J. (1980). Semi-sweet biscuits. 1. The influence of sodium metabisuiphite on dough rheology and baking performance. *Journal of the Science of Food and Agriculture, 69*, 141–150.

Perten, H. (1977). UNDP/FAO sorghum processing project in Sudan. In: *Proceeding of Symposium on Sorghum and Millets for Human Food*. Tropical Products Institute, London.

Pomeranz, Y. (1988). *Wheat: chemistry and technology* (3rd ed., Vol. 11), St. Paul, Minnesota, USA: American Association of Cereal Chemists Inc.

Snedecor, G. W., & Cochran, W. G. (1987). *Statistical methods* (7th ed.). Ames, IA: The Iowa State University Press.

Vatsala, C. N., & Harids Rao, P. (1991). Studies on invert syrup for use in biscuits. *Journal of Food Science and Technology, 28*, 149–152.