# Characterization and Use of Samah in the Production of Flat Bread

AYED S. AMR[1]

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**ABSTRACT**

Samah (*Mesembryanthemum forsskalii*) seeds were characterized in respect to their test weight and 1,000-kernel weight. Analysis revealed that their meal is nonglutenous and contains starch, about 20.50% protein, 5.20% fat, 4.25% ash, and 1.98% fiber (db). Compared with cereal grains, it is rich in iron but low in calcium. Amino acid analysis proved that the protein of samah seeds is high in glutamic acid, arginine, and methionine but limited in leucine and lysine. Amylograph and falling number tests showed that samah meal forms a soft gel at 74°C; mild roasting resulted in increased paste viscosity after holding at 95°C for 15 min and after cooling to 50°C. The brownish, bland-tasting meal was used to produce flat bread by blending it with wheat flour at levels of 5, 10, 15, and 20%. The bread obtained from combinations containing up to 10% meal was acceptable. Higher levels resulted in soggy, dull, and disintegrating loaves of bread.

The search for new food sources has been advocated by a number of international organizations and research institutions (FAO 1989). Amaranth and jojoba seeds are just two examples of recently developed plant food sources, and their nutritional value and potential uses as foods have received a great deal of attention (BOSTID 1984a, 1984b).

Among the traditional foods common to some areas of the Middle East is a dish based on the meal of a wild seed known by its Arabic name, *samah*. The plant grows in the deserts of the Middle East and North Africa. It belongs to the family Aizoaceae and has the Latin name *Mesembryanthemum forsskalii* (Hochst. ex Boiss). Its importance lies in the fact that it is highly tolerant to dry conditions and soil salinity (Zohary 1966).

Samah seeds are known to bedouins (nomadic people of the desert), who have used them as a food for centuries. The meal is usually mixed with sheep ghee and sugar or honey and is consumed without cooking or heating. Some people, however, claim that roasting the seeds enhances the flavor of the meal.

The objective of this work was to document some of the important physical and chemical properties of samah seeds and meal from a cereal chemistry perspective and to study their suitability for use in the production of flat bread.

[1]Associate Professor, Department of Nutrition and Food Technology, College of Agriculture, University of Jordan, Amman.



## MATERIALS AND METHODS

### Samah Samples

Samah seeds collected in 1988 and 1989 were obtained through personal contacts from Krayat (a town in Saudi Arabia near the eastern border with Jordan) and Wadi Araba (in southwest Jordan). The four samples were pulverized separately on a hammer mill equipped with a 200-$\mu$ screen, and the meal of each was kept for further analysis. All tests were performed on duplicates of the four samples unless otherwise indicated.

### Physical Characteristics of the Seeds

*Test weight.* Bulk seed density was evaluated using a test weight apparatus according to AACC method 55-10 (AACC 1983). Results were expressed as pounds per Winchester bushel and converted to kilograms per hectoliter following the standard conversion formula (Orth and Shellenberger 1980).

*One-thousand-kernel weight.* One thousand kernels were counted manually, and their weight in grams was recorded. The average weight of two replicates from each sample was taken.

### Chemical Characteristics of the Meal

*Proximate composition.* Ash, fat, crude fiber, moisture, and protein (N $\times$ 5.7) were determined according to AACC methods 08-03, 30-10, 32-10, 44-15A, and 46-13, respectively (AACC 1983). Nitrogen-free extract was calculated by subtraction. Values were expressed on a dry matter basis.

*Mineral matter content.* The magnesium, manganese, iron, calcium, zinc, and potassium in samah meal were determined with atomic absorption spectrophotometry according to AOAC method 3.006 (AOAC 1984). Phosphorous was determined according to AOAC method 7.118 (AOAC 1984). Results were expressed as milligrams per 100 grams of dry matter.

*Gluten content, falling number, and starch isolation.* The gluten content and falling number of the meal were determined according to AACC methods 38-11 and 56-81B, respectively (AACC 1983). Starch was isolated by manually washing a stiff dough of the meal over a No. 14 XXX silk gauze screen (95 $\mu$). The presence of starch was confirmed by reaction with iodine and direct microscopic examination. The sample used for these three tests was from the 1989 Krayat crop.

*Amino acid analysis.* Protein hydrolysates were prepared according to AOAC methods 43.263 and 43.264 (AOAC 1984). An amino acid analyzer (LKB 4150, LKB Biochrom, Cambridge, England) was used to identify and quantify the amino acids. Scores for the essential amino acids were calculated according to the FAO/WHO/UNU method (FAO/WHO/UNU 1985) using requirements for infants as a base for calculation.

The two samples used for this test were from the 1988 crops from Krayat and Wadi Araba.

*Amylograph and farinograph data.* An amylograph test using an 18% slurry was performed on the meal according to AACC method 22-10 (AACC 1983). Amylograms were interpreted by calculating the criteria recommended by Tipples (1980).

Farinograph tests were run on different samah-wheat flour blends according to AACC method 54-21, using 300 g of flour (AACC 1983). Farinograms were evaluated according to the method described by Shuey (1972). The samah meal used in these two tests was from the 1989 Krayat crop.

*Baking and flat bread evaluation techniques.* Portions of the samah meal sample used in the farinograph test were blended with 78% extraction flour (milled from blends of U.S. red winter and Saudi hard wheats) at levels of 5, 10, 15, and 20%. To prepare thick kmaj-type flat bread (Amr 1988a), a lean formula was used, consisting of 200 g of flour, 1.5% salt, 2.0% compressed yeast, and 47% water. The bakes were replicated five times, using the straight-dough procedure practiced in local bakeries. This involved manual mixing, fermenting for 45 min at bakery temperature and relative humidity, dusting and mechanical sheeting, final resting (30 min), and baking at 400°C for about 2 min. Ten flat loaves (two from each bake) were obtained from each combination and the control.

The bread was scored subjectively (based on visual observation) using a scale of 1–10, in which 10 was excellent. Evaluation was based on crust color and crispness, pocket formation, crumb grain, and loaf integrity. Specific volume (cubic centimeters per gram) was determined by dividing the loaf volume in cubic centimeters (measured by samah seed displacement) by its weight in grams. Moisture content was determined according to the AACC two-stage method 44-18 (AACC 1983). The ratio of the upper layer to the lower layer was evaluated by weighing the respective layers of the loaves.

## RESULTS AND DISCUSSION

### Physical Characteristics of the Seeds

The average 1,000-kernel weight of samah seed is 0.082 g (Table I), which corresponds to about 12,000 seeds per gram. Thus, these seeds are smaller than teff millet seeds, which weigh 0.14–0.20 g/1,000 kernels (Kent 1983), and amaranth grain, which weighs 0.33–1.0 g/1,000 kernels (BOSTID 1984a).

The test weight of the seeds, on the other hand, averaged 80.6 kg/hl (Table I), which corresponds to 62.6 lb/bu. The high test weight is due to the uniform shape and size of the seeds, which allows them to be packed into the weight-testing apparatus with less void space. All kernels examined under the microscope were similar in size and shape (indented on the bottom, becoming narrower toward the germ end, with the germ portruding from the peak of the grain) (Fig. 1).

**Fig. 1.** Samah seeds (×50).

**TABLE I**
**Physical and Chemical Characteristics of Samah Meal and Seeds**

| Parameter | Average[a] | Range | Standard Deviation | Coefficient of Variation (%) |
|---|---|---|---|---|
| Physical Characteristics | | | | |
| Test weight of seeds (kg/h) | 80.6 | 79.6–81.4 | 0.65 | 0.01 |
| 1,000-kernel weight (g) | 0.08 | 0.078–0.086 | 0.003 | 0.03 |
| Number of seeds per gram | 12,172 | 11,627–12,820 | 428 | 0.03 |
| Proximate Composition (dm) | | | | |
| Protein | 20.5 | 19.8–21.3 | 0.53 | 2.5 |
| Ash | 4.2 | 3.5–5.3 | 0.71 | 16.7 |
| Fat | 5.2 | 5.0–5.3 | 0.14 | 2.6 |
| Crude fiber | 2.0 | 1.9–2.1 | 0.10 | 5.5 |
| Nitrogen-free extract | 62.6 | 49.4–66.5 | 2.77 | 4.4 |
| Mineral Content (mg/100 g, dm) | | | | |
| Calcium | 9.6 | 8.5–12.1 | 1.45 | 15.00 |
| Magnesium | 318.7 | 298.6–340.5 | 17.16 | 5.38 |
| Potassium | 343.8 | 310.3–387.8 | 29.02 | 8.44 |
| Iron | 13.3 | 12.2–14.9 | 0.99 | 7.44 |
| Zinc | 2.7 | 2.3–2.9 | 0.19 | 7.28 |
| Manganese | 9.6 | 9.2–19.9 | 0.75 | 7.88 |
| Phosphorous | 245.0 | 230.5–26.2 | 11.95 | 4.70 |
| Moisture | 6.1 | 4.0–7.5 | 1.34 | 0.22 |

[a] Values listed are averages of eight determinations, two from each sample.

## Proximate Composition

The major component of interest is protein (Table I), which at 20.5% is about twice the level of protein found in Jordanian durum wheat varieties (Amr 1988b). The levels of ash, fiber, and fat are very close to their levels in other cereal grains. The levels of potassium, magnesium, and phosphorous are higher than the levels of other minerals, which is typical of cereal grains. Iron content, however, is about 13.3 mg/100 g (db) compared with about 4.6 mg/100 g db in wheat, barley, and oat kernels (Kent 1983). The level of manganese also is higher than in other grains, while the calcium level is lower.

Table I also shows the amount of variation between the samples with respect to the parameters evaluated. Apart from the ash, the coefficient of variation was within reasonable limits. The high variability of the ash could be attributed to the different levels of dirt mixed in with the seeds.

## Amino Acid Composition

As in many cereal grains, glutamic acid is the predominant amino acid (17 g/16 g of $N_2$) in samah protein (Table II). However, histidine (8.02 g/16 g of $N_2$) is the second most predominant amino acid rather than proline as in the case of wheat, barley, rye, and triticale proteins (Tkachuk and Irvine 1969). The third most abundant amino acid is arginine (7.64 g/16 g of $N_2$). It is interesting that leucine is the least available essential amino acid in the samples analyzed, with a level of 2.55 g/16 g of $N_2$, compared with values above 6 g/16 g of $N_2$ in cereal grains (Deyoe and Shellenberger 1965, Busson et al 1966, Juliano et al 1964, Tkachuk and Irvine 1969). However, this result should not seem surprising, as we were dealing with a plant that belongs to a different botanical family. Lysine, too, is low in this product, with a level of 2.27 g/16 g of $N_2$, compared with a level that ranges between 0.7 and 3.7 g/16 g of $N_2$ in other grains (Kent 1983).

## Amino Acid Scores

The amino acid scores (Table II) for histidine and tryptophan are 286 and 174, respectively, which implies the superiority of samah protein (regarding these two amino acids) to the protein pattern reported by the FAO/WHO/UNU (1985). The score is also high (176) for the sulfur-containing amino acids, assuming that cysteine-cystine is present in amounts equal to those of methionine. It is also apparent that leucine and lysine, with scores of 39 and 49, respectively, are the most and second most limiting amino acids in this protein.

**TABLE II**
**Amino Acid Composition of Samah Protein**

| Amino Acid | Average (g/16 g of $N_2$) | Range (g/16 g of $N_2$) | FAO/WHO UNU (1985) Protein Pattern[a] | Amino Acid Score |
|---|---|---|---|---|
| Aspartic acid | 4.20 | 3.67–4.37 | ... | ... |
| Threonine | 1.74 | 1.69–1.79 | 3.41 | 51 |
| Serine | 3.58 | 3.28–3.88 | ... | ... |
| Glutamic acid | 17.04 | 14.26–19.47 | ... | ... |
| Proline | 4.25 | 4.35–4.70 | ... | ... |
| Glycine | 4.21 | 3.62–4.80 | ... | ... |
| Alanine | 2.63 | 2.61–2.66 | ... | ... |
| Valine | 3.16 | 2.98–3.34 | 3.50 | 74 |
| Methionine | 2.51 | 2.36–2.67 | 2.49[b] | 176[d] |
| Isoleucine | 1.50 | 1.45–1.55 | 2.80 | 53 |
| Leucine | 2.55 | 2.45–2.65 | 6.59 | 39 |
| Tryptophan | 1.92 | 1.81–2.03 | 1.10 | 174 |
| Phenylalanine | 3.00 | 2.87–3.14 | 6.30[c] | 86[e] |
| Histidine | 8.02 | 8.36–7.86 | 2.80 | 286 |
| Lysine | 2.87 | 2.63–3.11 | 5.80 | 49 |
| Arginine | 7.64 | 6.70–8.58 | ... | ... |

[a] Pattern for infant requirements.
[b,c] Values in the pattern represent the total sulfur-containing and total aromatic amino acids, respectively.
[d] Calculated on the assumption that cysteine-cystine is equal to methionine.
[e] Calculated on the assumption that tyrosine is equal to phenylalanine.

## Gluten and Starch

Gluten washing according to the standard AACC method 38-11 (AACC 1983) revealed that samah meal contains no gluten. Although this absence poses a problem when using the meal in the production of bread, it is not a problem in the production of cakes, where gluten strength is not of major importance.

The starchy nature of samah meal was demonstrated by the blue color produced when the the white slurry was reacted with iodine solution. Microscopic examination of the starch granules showed that they are simple, round, and minute.

## Amylograph Pattern

Table III shows the amylograph data obtained from raw and roasted samah meal at 74 and 76°C, respectively. The maximum viscosity was 260–280 BU. The roasting process had little effect on the gelatinization temperature of the meal. The low maximum viscosity obtained is consistent with the falling number data (< 100), which indicates the formation of a soft, weak gel. Roasting increased the peak viscosity obtained from the amylograph by about 20 BU, while the peak temperature did not change. When the temperature was held at 95°C for 15 min, the viscosity increased to 500 BU in the roasted meal, while it dropped slightly (to 240 BU) in the raw meal. This pattern is similar to that reported by Tipples (1980) for whole wheat meal given a mild hydrothermal treatment. It is attributed to the two-stage gelatinization of the starch, which was more apparent in heat-treated meal than in raw meal.

As with other starches, the setback period after cooling to 50°C resulted in increased paste viscosities, but the increase was much higher in the heat-treated sample. Increased paste viscosity at this stage is due to the retrogradation process upon cooling (Tipples 1980).

## Farinograph Data

Table IV shows the effect of blending various levels of unroasted samah meal with wheat flour on farinograms for this flour. The arrival time increased from 2.0 min in the control to 3.5 min in the blend that contained 20% samah meal. This may be due to the increased protein content, which consequently increases the time of flour hydration (Shuey 1972). Blending up to 20% samah meal with 10% protein flour would increase the protein level by 2%.

The farinograph absorption was not affected and remained about 63% regardless of samah meal level. Peak time increased considerably as the level of samah meal increased and reached about 8 min with the addition of 20% meal. With this addition, the stability of the flour decreased to about half its value in the control sample. The nonglutenous nature of the samah protein is the factor responsible for both the decrease in stability and the increase in the mechanical tolerance index. The meal had a diluting effect on the flour gluten, which explains the negative effect of blending samah meal on such parameters as time to break down, departure time, and valorimeter value.

## Bread Characteristics

The specific volume of flat bread baked from samah meal-wheat flour blends decreased as the level of meal increased in the formulation, and the bread became more dense and soggy (Table V). Pocket formation, which is important in the preparation of flat-bread sandwiches (Faridi and Rubenthaler 1983), was quite acceptable for all levels of samah meal. The ratio of the upper

**TABLE III**
**Effect of Roasting Samah Meal on Its Amylograph Data[a]**

| Treatment | Pasting Temperature (°C) | Peak Height (BU) | Peak Temperature (°C) | 15-min Height (BU) | Setback (BU) |
|---|---|---|---|---|---|
| Raw | 74 | 260 | 95 | 240 | 320 |
| Roasted | 76 | 280 | 95 | 500 | 780 |

[a] Values listed represent meal from the 1989 Krayat crop.

TABLE IV
Effect of Blending Samah Meal on the Farinogram Characteristics of Flour[a]

| Samah Meal Level in Flour (%) | Farinograph Absorption (%) | Arrival Time (min) | Peak Time (min) | Stability (min) | Mechanical Tolerance Index (BU) | Valorimeter Value | Time to Break Down (min) | Departure Time (min) |
|---|---|---|---|---|---|---|---|---|
| 5 | 63.0 | 2.0 | 7.0 | 21.0 | 30.0 | 74.0 | 18.5 | 23.0 |
| 10 | 63.0 | 3.0 | 7.0 | 16.5 | 30.0 | 72.0 | 12.0 | 19.5 |
| 15 | 63.0 | 3.0 | 7.0 | 13.0 | 40.0 | 68.0 | 11.0 | 16.0 |
| 20 | 63.0 | 3.5 | 8.0 | 12.0 | 50.0 | 64.0 | 3.0 | 15.5 |
| Control[b] | 63.0 | 2.0 | 4.0 | 24.0 | 10.0 | 78.0 | 18.5 | 27.0 |

[a] Samah sample from 1989 Krayat collection.
[b] 100% flour milled from a blend of U.S. red winter and Saudi hard wheat.

TABLE V
Characteristics of Flat Bread Baked with Four Combinations of Samah Meal[a] and Wheat Flour[b]

| Samah Meal (%) | Specific Volume (cc/gm) | Moisture (%) | Pocket[c] Formation | Ratio of Upper to Lower Layer | Crust[c] Color | Crust[c] Crispness | Loaf[c] Integrity |
|---|---|---|---|---|---|---|---|
| 0 (control) | 1.93 | 28.87 | 10 | 0.96 | 10 | 10 | 10 |
| 5 | 1.92 | 31.28 | 9 | 1.10 | 9 | 8 | 9 |
| 10 | 1.79 | 31.03 | 9 | 1.92 | 8 | 7 | 8 |
| 15 | 1.37 | 31.87 | 9 | 1.98 | 3 | 3 | 4 |
| 20 | 1.17 | 32.39 | 9 | 2.22 | 3 | 2 | 3 |

[a] Samah meal obtained from the 1989 Krayat collection.
[b] Each value is the average of the scores of 10 loaves representing five bakes (two loaves from each bake).
[c] On a scale of 1–10, using the wheat flour as a control.

layer to the lower layer, the importance of which is emphasized by Faridi and Rubenthaler (1983), is considered optimum at values near 1. This ratio increased to high levels as the percent of samah was increased. It reached 2.22 at the 20% replacement level.

The crust became duller and lost its appealing brown color as the samah levels reached 15%. Similarly, the crispness of the crust was also badly affected at samah levels above 10%. Also, at levels above 10%, the loaves started to fall apart and became hard to handle. They showed signs of disintegration in the form of cracks on the upper layer, which indicated weakening of the gluten. The taste of the bread, however, was not affected by samah blending, regardless of its level.

In addition to these characteristics, at samah meal levels above 10%, the dough took on a slack consistency and became hard to handle.

## CONCLUSIONS

Samah meal, although believed to have been known in the Middle East since biblical times, is of limited popularity. Its chemical composition is similar to that of cereal grains, but it is higher in iron, magnesium, and protein. The amino acid composition of its protein reveals a high content of glutamic acid, histidine, and arginine but a low content of leucine and lysine, which makes them the most limiting amino acids in its protein. The bland, starch-containing, nonglutenous, brown samah meal has a diluting effect on wheat gluten. It produces flat bread with acceptable properties when it is blended with wheat flour at levels up to 10%. Flour combinations above this level result in bread with poor properties.


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