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Improvement of Nutritive Value in Corn for Human Nutrition

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ABSTRACT

Corn was steam cooked at a pressure of 5 psig (108·3°C) for 15, 30 and 60 min and the cooked grain was dried, ground and analysed chemically. Reducing sugars, sucrose, starch, lysine and niacin were altered by the cooking procedure.

The same corn variety was germinated at 25°C for 5 days. Germinated and non-germinated seeds were not separated but were dried and analysed together. Protein, ether extract, free fatty acids, crude fibre, starch, sucrose, reducing sugars, thiamin, riboflavin, niacin, lysine and tryptophan were altered significantly. Germination improved the nutritional quality of corn and is less expensive than heat treatment.

INTRODUCTION

In many developing countries, corn is the staple diet of low income families. The protein quality of corn is low because corn protein lacks quantities of lysine and tryptophan. Economical ways to correct those deficiencies are highly desirable (FAO, 1970).

Bressani *et al.* (1962) found that simple boiling of maize improved its nutritive value, because heat affected the protein and released bound niacin.

Hassim & Fields (1979), Tsai *et al.* (1975) and Wang & Fields (1978)

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suggested that germination of corn is a procedure that can be used at home to produce a more nutritious food, since there was evidence that this procedure could improve both amino acid balance and vitamin content.

The present work was undertaken with the intent of establishing the influence of either thermal treatment of corn or germination on its nutritive value.

MATERIALS AND METHODS

Corn (variety Giza) was obtained from the Ministry of Agriculture, Cairo, Egypt. The clean dry whole corn was steamed cooked at a pressure of 5 psig (108·3 °C) for 15, 30 and 60 min. The cooked grain was dried overnight at 50 °C, then ground to 100 mesh in a Wiley mill. The dried ground corn was placed in glass jars and stored in a refrigerator prior to analysis.

Prior to germination of seeds, the cleaned corn was soaked in 4–5 volumes of water at room temperature for 16–18 h. Soaking prior to incubating gave more uniform germination. After soaking, the corn seeds were surface sterilized by treatment with 70 % ethanol for 5 min, followed by three rinses in distilled water. Batches of 50 seeds were then placed in 15-cm Petri dishes, embryo down and seed base toward the centre of the plate. The plates were incubated for 5 days at 25 °C in darkness, but without controlling the occasional brief exposure to light during sampling times. The germinated seeds were not separated. They were dried and analysed together. The germination percentage was determined as a measure of the germination process.

The seeds were dried overnight at 50 °C and non-soaked, non-germinated seeds served as the control. The dried seeds were ground and stored in the same way as the cooked seeds.

Moisture, nitrogen, ether extract, crude fibre, ash, calcium, iron and free fatty acid contents of the samples were determined according to the methods of the AOAC (1965). Phosphorus was determined colorimetrically according to the technique of Allen (1940). Starch, reducing sugars, sucrose, riboflavin, thiamin, niacin and lysine were determined according to the methods of the American Association of Cereal Chemists (1969). Tryptophan was determined according to the method of Dalby & Tsai (1975).

Statistical analysis was carried out according to Ostle (1964).

RESULTS AND DISCUSSION

Moisture, protein, ether extract, crude fibre, ash, free fatty acids, starch, sugars and reducing sugars contents of heat treated corn and untreated corn are presented in Table 1. The results are the average of two determinations on a dry weight basis (dwb). The changes in moisture, protein, ether extract and free fatty acids were not significant, but the changes in crude fibre, starch and sugars were significant.

Table 2 shows the values of calcium, iron, phosphorus, thiamin, riboflavin, niacin, lysine and tryptophan of untreated and heat treated corn (dwb). The values of calcium, iron, phosphorus and riboflavin were stable. Thiamin, tryptophan and lysine change as a result of heating.

Table 3 shows the percentage of germination, protein, ether extract, free fatty acids, crude fibre, ash, starch, sucrose and reducing sugars of the examined corn. The germination percentage was 20–30 after 2 days, then increased to 70–80 after 4 days, and did not change on the fifth day. Protein, ether extract, free fatty acids, ash, sucrose and reducing sugars did not change significantly. Starch changed significantly and crude fibre changed highly significantly ($p < 0{\cdot}001$). The changes in the chemical constituents of the germinated corn were due to the biological deterioration inside the seeds during germination.

Table 4 shows that calcium, iron and phosphorus did not change during germination, but riboflavin, tryptophan, niacin, thiamin and lysine were changed significantly.

It should be noted from the present results that heat caused minor changes in the nutritive value of corn, e.g. lysine, the most limiting essential amino acid in corn, increased significantly. Also, niacin increased significantly. Germination was less expensive than the heating process and the nutritive value of germinating corn was higher than that of heat-treated corn. Germination caused major changes. Thiamin, riboflavin, niacin, lysine and tryptophan were increased. Tsai *et al.* (1975), in their study of germinated corn, found that starch decreased about 50% in 5 days at 28 °C. Meanwhile reducing sugars and sucrose increased about 60-fold and 3-fold, respectively. Lysine and tryptophan increased more than 50% over the ungerminated corn. Wang & Fields (1978) found that lysine increased 2·5 times in the germinated corn at 30 °C for 3–4 days and, under the same conditions, tryptophan increased 6·5 times.

The present study shows that germination of corn could improve both amino acid and vitamin contents. The results demonstrate that this is a

TABLE 1
Chemical Constituents of Untreated and Heat Treated Corn
(Components other than moisture expressed on a dry weight basis)

Treatment	*Moisture* (%)	*Protein* (%)	*Ether extract* (%)	*Free fatty acids* (%)	*Crude fibre* (%)	*Ash* (%)	*Starch* (%)	*Sucrose* (%)	*Reducing sugars* (%)
Untreated	10·4	9·50	4·25	0·61	2·25	1·43	70·26	2·47	0·32
Autoclaved at 5 psig/15 min	12·1	9·49	4·28	0·54	2·25	1·44	72·75	2·62	0·44
Autoclaved at 5 psig/30 min	12·2	9·43	4·23	0·53	2·19	1·44	72·04	2·64	0·46
Autoclaved at 5 psig/60 min	11·8	9·46	4·24	0·51	2·08	1·43	72·89	3·11	0·69

TABLE 2

Calcium, Iron, Phosphorus, Thiamin, Riboflavin, Niacin, Lysine and Tryptophan Contents of Untreated and Heat Treated Corn (Dry weight basis)

Treatment	*Calcium*	*Iron*	*Phosphorus*	*Thiamin*	*Riboflavin*	*Niacin*	*Lysine*	*Tryptophan*
			(mg/100 g)				*(g/gN)*	
Untreated	6·40	3·0	323	0·39	0·12	1·77	0·195	0·033
Autoclaved at 5 psig/15 min	6·40	3·0	324	0·38	0·12	1·82	0·219	0·034
Autoclaved at 5 psig/30 min	6·40	3·0	326	0·37	0·12	1·83	0·240	0·035
Autoclaved at 5 psig/60 min	6·40	3·0	325	0·36	0·12	1·88	0·238	0·034

TABLE 3
Germination Changes and Chemical Constituents of Corn During Germination at 25 °C
(Dry weight basis)

Time (days)	*Germination (%)*	*Protein (%)*	*Ether extract (%)*	*Free fatty acids (%)*	*Crude fibre (%)*	*Ash (%)*	*Starch (%)*	*Sucrose (%)*	*Reducing sugars (%)*
0	—	9·50	4·25	0·6	2·25	1·43	70·26	2·47	0·32
2	20–30	9·45	4·20	0·6	2·24	1·43	70·00	2·90	2·10
3	30–40	9·41	4·16	1·1	2·20	1·43	60·10	4·05	4·06
4	70–80	9·32	4·15	1·8	2·08	1·43	48·40	5·75	5·75
5	70–80	9·24	4·10	3·1	1·81	1·43	38·40	7·78	7·78

TABLE 4
Germination Changes and Calcium, Iron, Phosphorus, Thiamin, Riboflavin, Niacin, Lysine and Tryptophan Contents of Corn During Germination at 25 °C
(Dry weight basis)

Time (days)	*Germination %*	*Calcium*	*Iron*	*Phosphorus (mg/100 g)*	*Thiamin*	*Riboflavin*	*Niacin*	*Lysine (g/gN)*	*Tryptophan (g/gN)*
0	—	6·40	3·00	323	0·39	0·12	1·77	0·195	0·033
2	20–30	6·40	3·00	323	0·40	0·16	1·86	0·205	0·063
3	30–40	6·40	3·00	323	0·44	0·26	2·16	0·288	0·131
4	70–80	6·40	3·00	323	0·50	0·41	3·32	0·420	0·230
5	70–80	6·40	3·00	323	0·51	0·42	3·34	0·421	0·230

valid and valuable approach to increasing the world supply of high grade protein and is a procedure that can be used by farmers in developing countries to produce a more nutritious food.

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