

## **The Effect of Environmental Conditions on the Chemical Composition of Soybean Seeds: Deactivation of Trypsin Inhibitor and Effect of Microwave on Some Components of Soybean Seeds**

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### *ABSTRACT*

*The effects of microwave treatment are investigated on trypsin inhibitor activity (TIA) and chemical composition of soybean seeds. TIA could be largely destroyed by microwave treatment; concentrations of water-soluble protein and lysine were also determined.*

### INTRODUCTION

A considerable amount of work has been carried out on the effect of different heat treatments on the trypsin inhibitor of soybeans (McNaughton & Reece, 1980; Collins & Beaty, 1980; Baintner, 1981; Liener & Tomlinson, 1981; Soetrisno *et al.*, 1982).

Hafez *et al.* (1983) studied the effect of microwave heating on nutritional quality of soybeans and stated that trypsin inhibitor activity of defatted sample decreased as microwaving time increased.

Bandemer & Evans (1963) reported that heating soybean meal and seeds resulted in small losses for most of the amino acids but mainly for tyrosine

and the basic acids. Taira *et al.* (1965) and Taira (1973) found that lysine, cystine, arginine, tryptophan and serine were partially lost during heating of soybean products. Wing & Alexander (1975) reported that microwave radiation treatment of full-fat soybeans for up to 6 min resulted in no destruction of fatty acids. Microwave processing can yield beans of high nutritive value compared with conventional heating techniques. Schingoethe & Ahrar (1979) showed that heat treatment of soybeans reduced solubility of nitrogen. Bekric & Bozovic (1979) reported that heat treatment decreased the trypsin inhibitor activity from 55.8–64.7 to 3.3–6.3 units and water solubility of the protein was decreased from 78.4–85.7 to 8–14%. No essential changes occurred in the oil fraction.

Mai *et al.* (1980) stated that microwave treatment neither changed the fatty acid pattern of lipids nor caused isomerization of the unsaturated fatty acids. Pour-El *et al.* (1981) investigated microwave-heated whole soybeans at natural moisture levels and found that trypsin inhibitor activity was reduced to a low level, indicating that maximum nutritional quality had been reached.

## MATERIALS AND METHODS

Samples of soybean seeds are the same as used in Part I. Whole soybean seeds (Clark, Woodworth and Williams varieties) were microwaved for 0, 2, 4, 6 and 8 min. A domestic size white Westinghouse microwave oven Model KM 50 V (USA) at frequency 2450 MHz was used.

Determination of moisture content was carried out by oven method at 105°C for 3 h; extraction of fat was carried out with petroleum ether; identification and determination of fatty acids by gas-liquid chromatography and total nitrogen by Kjeldahl's method according to the AOAC (1970). Water-soluble nitrogen was carried out according to the method of Eldridge *et al.* (1966). Determination of amino acids was carried out by the descending one-dimensional paper chromatographic technique according to Alexander & Block (1960). Tryptophan was determined by the colorimetric method according to Hernandez & Bates (1969).

## RESULTS AND DISCUSSION

The effect of microwave treatments on the trypsin inhibitor content of three different varieties of soybean seeds grown in Egypt is reported in Table 1. It is observed that, after exposure for 4 min, about 60–68% of the trypsin inhibitor activity is destroyed. Prolonging the exposure period to 6 and

**TABLE 1**

The Effect of Microwave Treatment on the Trypsin Inhibitor Activity (TIA) in Different Varieties of Soybean

| Microwave time<br>(min) | Varieties   |   |   |
|-------------------------|---|---|---|
|                         | Clark (Giza)<br>(TIA destroyed) <sup>a</sup><br>(%) | Woodwort (Giza)<br>(TIA destroyed)<br>(%) | Williams (Giza)<br>(TIA destroyed)<br>(%) |
| 0.0                     | 0.0   | 0.0                                       | 0.0                                       |
| 2                       | 10.1  | 13.8                                      | 15.0                                      |
| 4                       | 60.1  | 67.9                                      | 68.1                                      |
| 6                       | 98.9  | 97.0                                      | 98.9                                      |
| 8                       | 99.1  | 98.6                                      | 99.2                                      |

<sup>a</sup> Percentage of trypsin inhibitor activity destroyed using zero time as the control.

8 min destroyed 96–99% of the activity but it was observed that the colour of the seeds turned slightly brown. For this reason the 4 min period was taken as optimum. In the same way, Pour-El *et al.* (1981) has investigated microwave heated soybean at natural moisture levels and found it efficient in improving the nutritional value of soybean.

It was found that the moisture content was very slightly affected by exposure for 4 min; it decreased from 8.36% in the unheated sample to 8.20% in the treated sample (Clark) which is a insignificant change. Prolonging the exposure period to 8 min reduced the moisture content to 7.54% (Table 2).

The effect of microwave treatment on the fatty acid content of the oil is reported in Table 3. At first, seeds of the Clark variety were microwaved for 4 and 6 min; no change in free acidity was observed. In another experiment the fatty acids were separated and subjected to GLC analysis. It was found that

**TABLE 2**

Percentage of Moisture in Different Varieties of Soybean after Microwave Treatment

| Treatment time<br>(min) | Moisture (%) |           |          |
|-------------------------|--------------|-----------|----------|
|                         | Clark        | Woodworth | Williams |
| 0.0                     | 8.36         | 8.46      | 8.36     |
| 2                       | 8.29         | 8.20      | 8.25     |
| 4                       | 8.20         | 8.06      | 8.10     |
| 6                       | 7.88         | 7.85      | 7.82     |
| 8                       | 7.54         | 7.60      | 7.50     |

TABLE 3

The Effect of Microwave Treatment for Different Periods on the Relative Percentage of Fatty Acids in Soybean (Clark variety)

| Treatment time (min) | Relative percentage of fatty acids <sup>a</sup> |                               |                               |                              |                            |                               |                                |
|----------------------|---|-------------------------------|-------------------------------|------------------------------|----------------------------|-------------------------------|--------------------------------|
|                      | Lauric<br>C <sub>12:0</sub>                     | Myristic<br>C <sub>14:0</sub> | Palmitic<br>C <sub>16:0</sub> | Stearic<br>C <sub>18:0</sub> | Oleic<br>C <sub>18:1</sub> | Linoleic<br>C <sub>18:2</sub> | Linolenic<br>C <sub>18:3</sub> |
| 0·0                  | tr  | 0·22                          | 14·5                          | 1·74                         | 24·1                       | 54·6                          | 4·94                           |
| 4                    | 0·16  | 0·32                          | 20·8                          | 2·40                         | 19·0                       | 51·8                          | 4·31                           |
| 6                    | 1·12  | 0·25                          | 21·8                          | 3·24                         | 16·5                       | 51·4                          | 3·99                           |

<sup>a</sup> Relative percentage according to the amount of fatty acid determined.

The relative percentage composition of individual fatty acids = area of each peak/area of all peaks × 100.

tr = Trace.

linoleic and oleic acids were the most affected acids; the relative percentage of linoleic acid decreased from 54·6 to 51·8 and 51·4 while that of oleic acid decreased from 24·1 to 19·0 and 16·5% after 4 and 6 min of microwave treatment. Some saturated fatty acids were formed, especially palmitic and lauric acids. This is not in agreement with Mai *et al.* (1980) who stated that microwave cooking does not change the fatty acid pattern of lipids nor cause isomerization of the unsaturated fatty acids. This disagreement is probably due to the fact that Mai *et al.* (1980) used pure oil but in our experiment the whole beans were used which may contain some components active as catalysts for the conversion of fatty acids by microwaves.

The effect of microwave treatment on the percentage of soluble protein is reported in Table 4. It is observed that the percentage of soluble protein is decreased, probably due to denaturation. The percentage of water-soluble protein decreased from 13·1% in an untreated sample to 4·57% after exposure to the microwave for 6 min. Schingoethe & Ahrar (1979) showed that heat treatment reduced solubility of nitrogen.

TABLE 4

The Effect of Microwave Treatment on Total and Water-Soluble Proteins

| Treatment time (min) | Total proteins (%) | Water-soluble proteins (%) | Decrease in solubility (%) |
|----------------------|--------------------|----------------------------|----------------------------|
| 0·0 <sup>a</sup>     | 40·3               | 13·1                       | 0·0                        |
| 4·0                  | 39·8               | 6·17                       | 52·9                       |
| 6·0                  | 39·3               | 4·57                       | 65·2                       |

<sup>a</sup> Change by using zero time as a control.

TABLE 5

The Effect of Microwave Treatment on Amino Acid Composition (g per 100 g protein) of Soybean (Clark Variety)

| Amino acids            | Treatment time (min) |       |          |       |                       |
|------------------------|----------------------|-------|----------|-------|-----------------------|
|                        | 0                    | 4 min | ± change | 6 min | ± change <sup>a</sup> |
| Cysteine               | 2.73                 | 2.22  | -0.62    | 2.04  | -0.69                 |
| Lysine                 | 6.34                 | 5.91  | -0.43    | 5.55  | -0.79                 |
| Histidine              | 1.96                 | 2.14  | +0.18    | 1.35  | -0.61                 |
| Arginine               | 7.43                 | 7.42  | -0.01    | 6.85  | -0.58                 |
| Aspartic acid          | 8.10                 | 7.52  | -0.58    | 6.72  | -1.38                 |
| Serine and glycine     | 8.52                 | 8.62  | +0.10    | 8.53  | +0.01                 |
| Glutamic acid          | 13.34                | 14.56 | +1.22    | 14.92 | +1.58                 |
| Threonine              | 4.15                 | 4.88  | +0.73    | 4.71  | +0.56                 |
| Alanine                | 4.60                 | 4.42  | -0.18    | 3.82  | -0.78                 |
| Proline                | 3.83                 | 3.97  | +0.14    | 3.87  | +0.04                 |
| Tyrosine               | 1.54                 | 1.56  | +0.02    | 1.91  | +0.73                 |
| Valine                 | 5.24                 | 5.30  | +0.06    | 5.04  | -0.20                 |
| Methionine             | 2.29                 | 2.21  | -0.08    | 2.34  | +0.05                 |
| Phenylalanine          | 2.73                 | 2.87  | +0.14    | 2.90  | +0.17                 |
| Leucine and Isoleucine | 8.65                 | 8.62  | -0.03    | 8.73  | +0.08                 |
| Tryptophan             | 0.97                 | 0.98  | +0.01    | 0.76  | -0.21                 |

<sup>a</sup> Change by using zero time as a control.

The sensitivity of the methods was about  $\pm 7\%$  and the results were insignificant.

The influence of the microwave treatment on the amino acid composition is reported in Table 5. The microwave treatment slightly affected percentage; e.g. after 4 and 6 min, microwave lysine decreased (from 6.34) to 5.91 and 5.55 g/100 g protein, respectively. Taira *et al.* (1965) and Taira (1973) reported that decreases in cystine, lysine, arginine, tryptophan and serine were noticed under heat treatment.

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