# Agricultural Processing and Utilization Research

B.L. D'Appolonia, N. Hettiarachchy and K. Khan

Utilization-type research may have different meanings to different people. Much research in progress or conducted in the past in the Department of Cereal Science and Food Technology can be classified as being related to the general area of utilization. In almost all cases the emphasis has centered on food utilization of various agricultural commodities. In this article we would like to review briefly some of the utilization research work that has been conducted by faculty and staff in the department and some of the research in progress or being planned.

Although studies on the biochemical components found in cereals and in northern grown crops might not be readily considered utilization research, it is essential to know the chemicl composition and basic structure of the starting material before being able to proceed further to investigate food and non-food uses.

Investigative studies on the biochemical components present in wheat, barley, sunflower, and edible beans have been and continue to be conducted. In many instances attempts have been made to relate a particular component to end-use properties, be it bread, pasta, beer or some other product.

Research to develop correlations between biochemical components, such as wheat proteins, and various quality parameters including flour mixing strength and bread loaf volume continues. Instrumental techniques as polyacrylamide gel electrophroesis (PAGE), sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) and reversed phase-high performance liquid chromatography (RP-HPLC) are three tools used to separate the various classes of wheat proteins in attempts to relate a particular protein component to a specific quality factor.

Considerable effort has been expended in the department in the area of bread staling. The changes which occur in a load of bread after removal of the bread from the oven and placement in an air-tight container are referred to as bread staling. Economic losses to the baker as a result of this phenomenon are extremely great. The major factor contributing to the staling process has been attributed to changes occurring in the starch or to the process of starch retrogradation. Agains, such research is related to utilization.

*Hettiarachchy and Khan are associate professors and D'Appolonia is professor and chairman, Department of Cereal Science and Food Technology.*

Besides the proteins and carbohydrates, cereal lipids and enzymes have been studied in terms of their role in end-product functionality.

Numerous publications in the department have dealt with composite flours. In these studies a certain percentage of the flour is replaced with flour obtained from either a crop indigenous to this or another country or with a protein concentrate, isolate, or high fiber-type material. The major objectives in composite flour studies are to be able to either utilize a material from some other source to produce a particular end-product such as bread, beer or pasta, or to improve the nutritional quality of the end-product. Department faculty and staff have investigated the use of flour derived from crops such as sunflower, legumes, tubers and other cereals in both bread and pasta products. Addition of materials such as brewer's spent grain, potato peel, various bran sources, protein concentrates and isolates from different cereals and other northern grown crops in various products have been studied with the intent of improving nutritional quality.

One of the major functions in the department has been the quality evaluation programs for hard red spring and durum wheat and malting barley. Quality evaluation of any one of these three crops involves the measurement of many parameters. For hard red spring wheat, factors related to wheat kernel quality, milling and flour quality, physical dough properties and baking quality are assessed. Similarly, numerous measurements are conducted on durum wheat and barley to meet the needs of the pasta processing and malting industries. In addition to the qulaity evaluation of breeders samples in the development of new varieties, the quality evaluation of breeders samples in the development of new varieties, the quality of the wheat and barley crops is evaluated each year at harvest time. Also, the quality of wheat cargos being exported from the three major ports is tested on a regular basis. The net result of these programs has been to maintain or increase the utilization of these crops in either the domestic or export markets through quality.

Numerous blending-type studies have been conducted. Blending of United States hard wheat flours with Australian wheat flours on physical dough and baking properties was investigated. Blending capacity of hard red spring wheats at different protein levels with different European wheats, compared to the blending capacity of Canadian hard wheats at comparable protein levels with the same European wheats on milling and baking performance, also has been studied. Again, we note the utilization implications of such activities.

Milling, baking, pasta processing, and malting and brewing research studies have been an on-going effort in the department. Much of this work is again geared to the utilization aspect. Work on stability of frozen doughs or use of mutant barleys to produce beer are just two examples implicating utilization.

Other examples of utilization-type research can be cited. Introduction of amaranth as a commercially viable cereal grain depends largely upon the elucidation of its food value and the potential for it to be transformed into products which possess functional, nutritional, and/or economic properties that would enhance the quality of the food to which it would be added. In research conducted on amaranth, its milling potential was evaluated as well as the functional and nutritional quality of protein isolates derived from it.

Many types of noodles are consumed in East and Southeast Asia. A large market for wheat to manufacture these various noodle types exists. However, in many instances the flour specifications for producing a specific type of noodle has not been well defined. A study to examine the formulation and quality for Chinese wet noodles was conducted.

The effects of processing conditions utilizing different corn types on the production of arepas and on the preparation of masa for making tortillas were investigated.

Although hard red spring wheat, durum wheat and barley have been the major crops studied in our department, recent research has also centered on edible beans and sunflower.

## EDIBLE BEAN UTILIZATION RESEARCH

Traditionally, dry edible beans such as navy and pinto beans, the major bean classes grown in the Red River Valley regions of North Dakota and Minnesota, have been utilized for canning and dry packaging. Research is being conducted in our department to expand the utilization of dry edible beans.

For example, we have developed a fortified spaghetti made from blends of bean protein concentrate and durum semolina (Bahnassey et al., 1986). This fortified spaghetti had acceptable quality properties (Table 1) and was acceptable to taste panelists in sensory evaluation studies. Also, shelf-life stability evaluations after six months of storage at ambient temperatures showed no adverse effects on quality parameters (Table 2) and sensory properties (Duszkiewicz-Reinhard et al., 1988). This specialty product of at least 20 percent protein (13 percent moisture basis) can be targeted to specific groups such as nutrition-conscious consumers, institutional food services (schools, hospitals, prisons), athletes, and developing countries. This specialty product would expand utilization of both dry beans and durum semolina.

In our ongoing efforts to expand utilization of dry beans, navy bean protein concentrate (NBPC) was used as a meat extender (Duszkiewicz-Reinhard et al., 1988). Blends of NBPC and retail ground beef were made and stored for various time intervals. Then the growth patterns of different groups of microorganisms that are important in food hygiene and food processing were evaluated (Figs. 1 and 2). These data show that the aerobic plate counts (APC) and the numbers of psychrophiles, coliforms, and yeasts and molds increased during six days of storage. This type of information is important to the food processor in order to determine the shelf-life stability and safety of a new food product.

Another means of expanding dry bean utilization is the development of ingredients from beans for food product for-

**Table 1. Quality Components of Spaghetti Containing 15% Legume Flour or 15% Protein Concentrate[1].**

| Sample Description | Moisture (%) | Protein (%) | Ash (%) | Fiber (%) | Fat (%) | Color |
|---|---|---|---|---|---|---|
| Control | 8.8 | 13.9 | 0.81 | 1.28 | 2.4 | 8.5 |
| Nonroasted, flour | | | | | | |
| Navy bean | 7.4 | 19.7 | 1.31 | 1.86 | 2.2 | 7.0 |
| Pinto bean | 8.0 | 20.2 | 1.30 | 1.99 | 2.1 | 7.0 |
| Lentil | 8.2 | 20.1 | 1.02 | 1.87 | 2.1 | 7.5 |
| Roasted, flour | | | | | | |
| Navy bean | 7.3 | 19.6 | 1.33 | 1.79 | 2.2 | 7.5 |
| Pinto bean | 7.8 | 19.8 | 1.33 | 1.97 | 2.1 | 7.0 |
| Lentil | 8.3 | 19.6 | 1.16 | 1.86 | 2.1 | 7.5 |
| Nonroasted, protein concentrate | | | | | | |
| Navy bean | 6.6 | 27.1 | 1.52 | 1.37 | 2.8 | 5.5 |
| Pinto bean | 7.7 | 26.2 | 1.45 | 1.38 | 2.5 | 6.0 |
| Lentil | 8.3 | 26.6 | 1.10 | 1.30 | 2.5 | 7.0 |
| Roasted, protein concentrate | | | | | | |
| Navy bean | 6.3 | 26.9 | 1.74 | 1.35 | 2.7 | 6.0 |
| Pinto bean | 7.5 | 27.0 | 1.47 | 1.35 | 2.2 | 7.0 |
| Lentil | 8.1 | 28.3 | 1.32 | 1.29 | 2.1 | 6.5 |

[1]Values reported are an average of two determinations and expressed on a dry weight basis.

Table 2. Duncan Multiple Range Test for Different Quality Parameters of Cooked Spaghetti made of Semolina-Legume Blends after Various Storage Times.

| | Storage Time (months) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | 0 | 1 | 3 | 6 | 0 | 1 | 3 | 6 | 0 | 1 | 3 | 6 |
| | Cooked Weight (g) (Mean)[1] | | | | Cooking Loss (%) (Mean) | | | | Firmness (g.cm) (Mean) | | | |
| **Legume Effect** | | | | | | | | | | | | |
| Control No. 1 | 30.83a | 30.65a | 31.61a | 32.61a | 7.33a | 6.85a | 7.02a | 6.80a | 6.22b | 6.91b | 6.54c | 6.89b |
| Control No. 2 | 30.35a | 30.98a | 30.88a | 32.80a | 7.43b | 6.78a | 6.68cb | 6.52b | 6.40b | 7.00b | 7.17b | 7.08b |
| Spaghetti with NF and NC[2] | 29.85ab | 29.30b | 29.93b | 30.81b | 7.55ab | 6.45b | 6.63c | 6.45b | 7.92a | 7.93a | 8.46a | 8.29a |
| Spahgetti with PF and PC | 29.25b | 28.84b | 29.69b | 30.23b | 7.88a | 6.79a | 6.98ab | 6.49b | 7.81a | 7.74a | 8.12a | 8.40a |
| **Flour Effect** | | | | | | | | | | | | |
| Control No. 1 and No. 2 | 30.59a | 30.81a | 31.25a | 32.71a | 7.38b | 6.81a | 6.85ab | 6.66a | 6.31c | 6.96c | 6.85c | 6.99c |
| Spaghetti with NF and PF | 30.18a | 29.70b | 30.62a | 31.29b | 7.88a | 6.64a | 6.98a | 6.83a | 7.60b | 7.66b | 8.04b | 7.98b |
| Spaghetti with NC and PC | 28.93b | 28.45c | 28.99b | 29.75c | 7.55b | 6.60a | 6.63b | 6.26b | 8.13a | 8.00a | 8.53a | 8.71a |
| **Cooking Time Effect** | | | | | | | | | | | | |
| Optimum | 26.07c | 26.08c | 26.34c | 27.45c | 6.53c | 5.56c | 5.71c | 5.43c | 8.17a | 8.33a | 9.00a | 8.99a |
| 5 min over optimum | 30.17b | 39.80b | 30.56b | 31.55b | 7.83b | 7.05b | 6.98b | 6.54b | 7.32b | 7.63b | 7.66b | 7.83b |
| 10 min over optimum | 33.45a | 33.80a | 33.97a | 34.74a | 8.46a | 7.45a | 7.78a | 7.63a | 6.55c | 6.65c | 6.76c | 6.86c |

[1]Means having the same letter in columns are not significantly different ($\alpha = 0.05$).
[2]NF = navy flour, NC = navy protein concentrate, PF = pinto flour and PC = pinto protein concentrate.

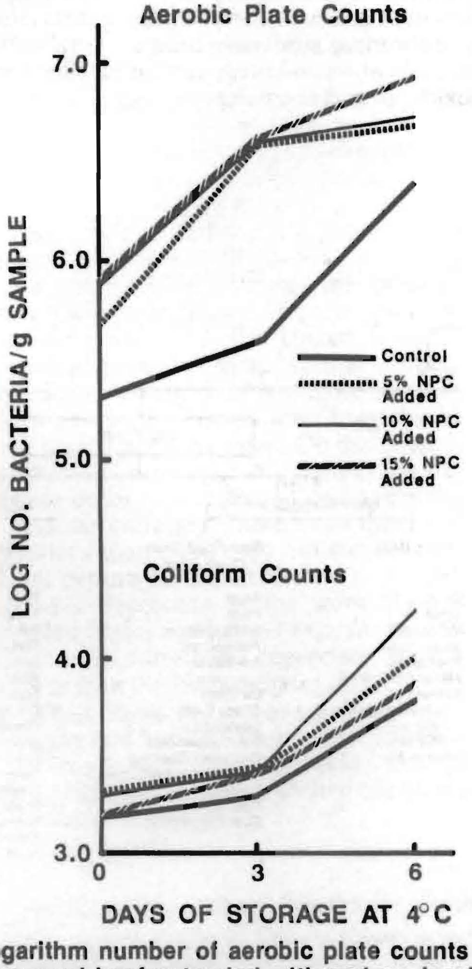


Figure 1. Logarithm number of aerobic plate counts and coliforms in ground beef extended with various levels of navy bean protein concentrate.

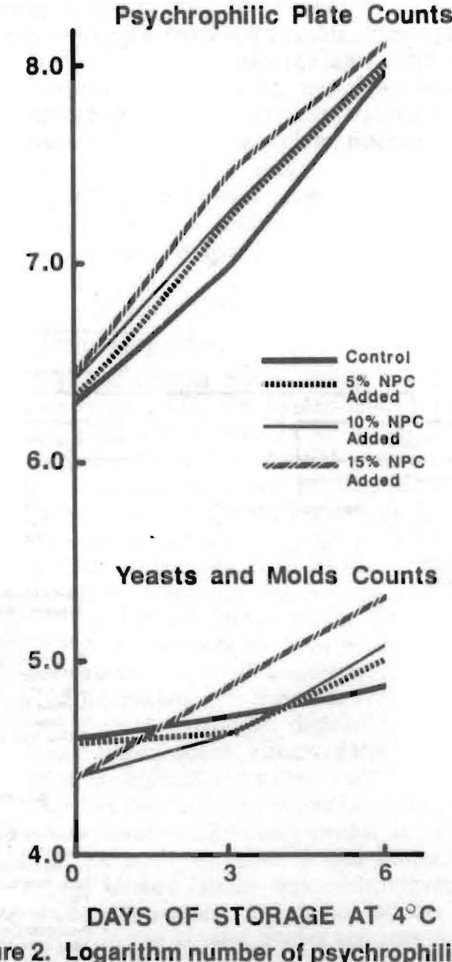


Figure 2. Logarithm number of psychrophilic plate counts, and yeast and molds in ground beef extended with various levels of navy bean protein concentrate.

mulations. Pin-milling and air-classification techniques are currently being used to isolate high protein, high starch and high fiber fractions. The properties of these fractions are being evaluated to provide information on chemical properties such as moisture, ash, protein, fat, and fiber contents, and functional properties such as nitrogen solubility index, water holding capacity, foaming, emulsifying and pasting properties. This type of information is essential to the food processor for utilization of the various fractions in specific food formulations.

Another challenging research project on utilization that our department is presently undertaking is the application of thermal extrusion, that is, high temperature-short time (HT/ST) extrusion, on dry edible beans and their fractions. With the extrusion technique the food processor can vary many conditions in order to obtain products of various sizes, shapes, colors, porosities, densities, and textures, and of various functional and nutritional qualities. It is said that the only limitation to utilization of the extrusion technology is one's own imagination. This technology, therefore, can also be used to develop food ingredients. Other products can be developed, such as quick-cooking bean products. These quick-cooking products would be most welcomed by today's consumers who are accustomed to convenience foods.

## SUNFLOWER UTILIZATION RESEARCH

Sunflower is a major oilseed crop with North Dakota ranking first in the United States in production. The Department of Cereal Science and Food Technology has a project devoted to sunflower research which includes both fundamental and applied research. One objective is to increase sunflower utilization in various food and non-food products. The numerous possible uses of this crop are shown in Figure 3. The protein, lipid, total carbohydrate, crude fiber and ash content values of sunflower nutmeats are given in Table 3. Table 4 shows selected vitamin and mineral compositions. Fatty acid composition of lipids of sunflower nutmeats is shown in Table 5. Values for other nutmeats are also included in Tables 3, 4 and 5 for comparison. The sunflower lipid consists primarily of polyunsaturated fatty acids (PUFA) which make up about 80 percent of the lipid weight. Linoleic and oleic acid contribute about 70 percent and 15 percent, respectively, of the total fatty acids. These values indicate that confectionary sunflower nutmeats are a valuable source of quality protein and unsaturated fatty acids, and that they are a food source of vitamins (Like A and E) and minerals (iron and calcium).

Sunflower nutmeats can be used in a variety of products, including bakery items, snacks, trail mixes, ice cream toppings, cereals, salads and candies. However, the utilization of sunflower in various food products will largely depend upon the shelf-life stability of the nutmeats.

In general, the sunflower nutmeats contain naturally occurring antioxidant compounds that inhibit deterioration caused by lipid breakdown, excessive heat, and the presence of moisture and atmospheric oxygen. After a certain storage period, however, a large part of the natural stability is lost, and the oil can undergo changes such as hydrolysis and autooxidation. This may lead to rancidity and reduce the shelf-life of nutmeats.

Studies have demonstrated that roasted confectionary sunflower nutmeats may have a relatively short shelf-life because of high oil content and high proportions of PUFA. Oxidative deterioration of PUFA produces off-flavors resulting in racidity.

Research in the Cereal Science and Food Technology Department is focused on four major areas: shelf-life stability of confectionary sunflower nutmeats; utilization in cookies, bread, tofu and sun sauce; protein functionality, and natural antioxidants and red colorant.

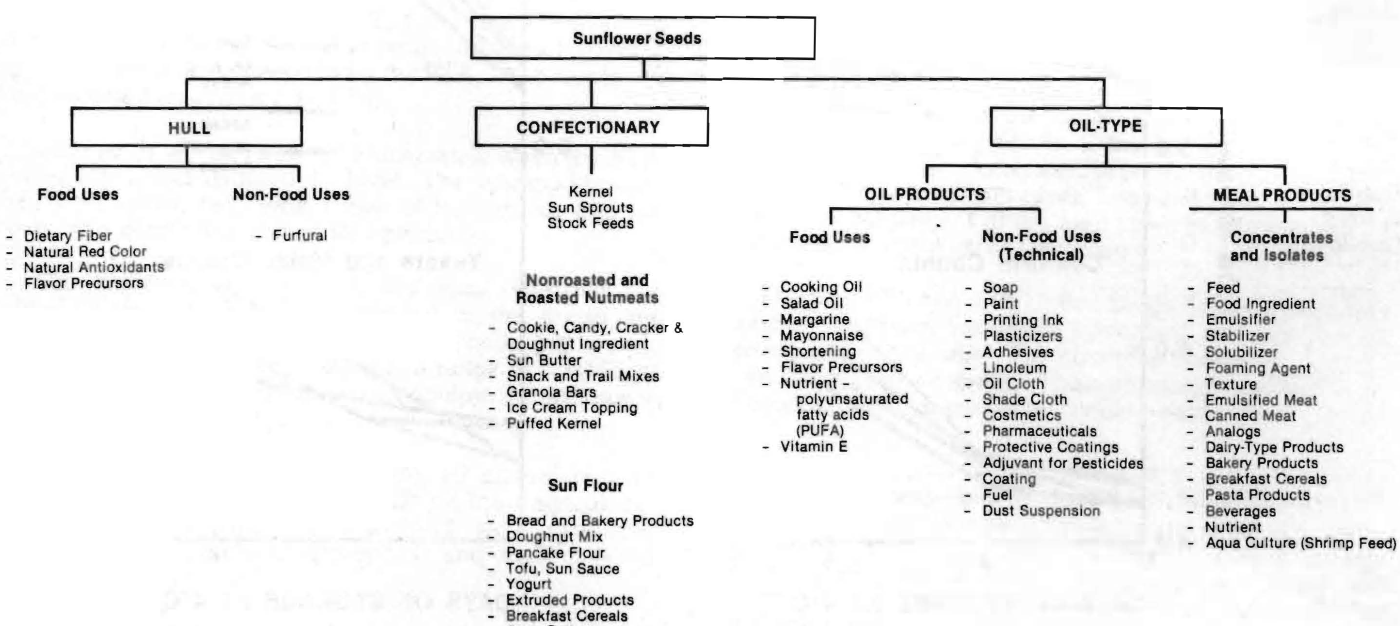


**Figure 3. Sunflower Utilization Chart.**

Table 3. Chemical Composition of Nuts (g/100 g edible portion).

| Nutmeat | Moisture | Protein | Lipid | Carbohydrate | Crude Fiber | Ash |
|---|---|---|---|---|---|---|
| Almond | 4.7 | 18.6 | 54.2 | 19.5 | 2.6 | 3.0 |
| Cashew | 5.2 | 17.2 | 45.7 | 29.3 | 1.4 | 2.6 |
| Peanut | 1.8 | 26.2 | 48.7 | 20.6 | 2.7 | 2.7 |
| Pine nut | 5.6 | 31.1 | 47.4 | 11.6 | 0.9 | 4.3 |
| Pistachio | 5.3 | 19.3 | 53.7 | 19.0 | 1.9 | 2.7 |
| Pumpkin | 4.4 | 29.0 | 46.7 | 15.0 | 1.9 | 4.9 |
| Walnut | 3.1 | 20.5 | 59.3 | 14.8 | 1.7 | 2.3 |
| Sunflower | 5.4 | 21.8 | 55.8 | 19.9 | 3.8 | 4.0 |

USDA. 1975. Handbook of the Nutritional Contents of Foods. Dover Publications, Inc. NY.

Table 4. Selected Vitamin and Mineral Composition of Nuts (mg/100 g edible portion).

| Nutmeat | Thiamin | Niacin | Carotene | Vitamin A | Vitamin E | Iron | Calcium |
|---|---|---|---|---|---|---|---|
| | | | | (i.u.) | | | |
| Almond | 0.24 | 3.5 | 0.12 | | 26.1 | 4.7 | 234 |
| Cashew | 0.43 | 1.8 | 0.06 | | 5.8 | 3.8 | 38 |
| Peanut | 0.32 | 17.1 | | | 16.4 | 1.3 | 43 |
| Pine nut | 0.62 | | | 2.1 | | | |
| Pistachio | 0.67 | 1.7 | 0.15 | | 5.2 | 7.3 | 131 |
| Pumpkin | 0.24 | 2.4 | 1.96 | | | 11.2 | 51 |
| Walnut | 0.22 | 1.0 | 0.048 | | 24.7 | 6.0 | Trace |
| Sunflower | 1.96 | 5.4 | | 72.5 | 18.6 | 7.1 | 120 |

1. USDA. 1975. Handbook of the Nutritional Contents of Foods. Dover Publications, Inc., NY.
2. Vitamins. Sonci et al. 1981. Food Composition and Nutritional Tables, 1981/82.

Table 5. Fatty Acid Composition of Lipids (g/100 g lipid).

| Nutmeat | Saturated Fatty Acids | Polyunsaturated Fat | Oleic Acid | Linoleic Acid |
|---|---|---|---|---|
| Almond | 4.3 | 10.5 | 36.5 | 9.9 |
| Cashew | 9.2 | 7.7 | 26.2 | 7.3 |
| Peanut | 8.6 | 13.3 | 22.9 | 13.3 |
| Pine nut | 6.2 | 22.8 | 19.0 | 22.2 |
| Pistachio | 7.4 | 7.3 | 36.0 | 6.8 |
| Pumpkin | 8.0 | — | 17.0 | 20.0 |
| Walnut | 5.1 | 40.9 | 9.7 | 36.8 |
| Sunflower | 9.1 | 82.3 | 14.7 | 67.6 |

Ensminger et al. 1986. Food for Health. A Nutrition Encyclopedia. Pergus Press, Clovis, CA.

## Shelf-Life Stability of Sunflower Nutmeats

Various studies have been done to extend the shelf-life stability of roasted sunflower nutmeats. One of these studies has shown that the shelf-life stability of chocolate bars containing roasted confectionary sunflower nutmeats can be extended by packaging in an atmosphere of nitrogen. These findings suggest that oxygen plays a key role in the deterioration of quality of roasted sunflower nutmeats.

Based on this observation, a hydrocolloid film coat was developed on the nutmeats to act as an oxygen barrier, and the efficacy of the film coat in extending the shelf-life stability of roasted sunflower nutmeats was investigated.

The coated nonroasted and roasted nutmeats were packaged in polethylene and Alure bags and stored at room temperature (25°C) for a period of eight months. The uncoated roasted and nonroasted nutmeats were also included in this study for comparison. Lipids were extracted at zero time and thereafter every four weeks up to a period of eight months. Peroxide values, total fatty acids, and sensory evaluation were used as indicators to monitor rancidity. Fatty acid composition and peroxide values of sunflower lipids from sunflower nutmeats stored at room temperature for eight months are shown in Table 6 (Hettiarachchy et al., 1988).

The total oleic and linoleic acid values and the peroxide values of lipids from sunflower nutmeats indicated that:

1. The nonroasted nutmeats were relatively stable without a film coat.
2. Rancidity developed in roasted nutmeats packaged in polyethylene bags (rancidity developed only after four months).
3. Rancidity observed in roasted nutmeats packaged in polyethylene bags can be delayed with the hydrocolloid film coat.

4. Shelf-life stability of roasted nutmeats can be extended by packaging in Alure bags instead of in polyethylene bags.
5. Packaging the film-coated roasted nutmeats in Alure bags gives the best extended stability.
6. No appreciable change occurred in palmitic and stearic acids.

Sensory evaluation indicated rancidity only in nutmeats packaged in polyethylene bags.

The significant findings and their implications of these studies are that the shelf-life stability of the roasted nutmeats can be extended by:

1. Packaging under nitrogen.
2. Packaging in Alure bags.
3. Coating with hydrocolloid film.

Further, the hydrocolloid coated nutmeats have the following advantages:

1. A crunchier texture and a better mouthfeel.
2. Potential for increased utilization in products where packaging is not required (salad bar).

**Shelf-Life Stability of Roasted Sunflower Nutmeats in Chocolate Cookies**

Two studies were conducted to examine the shelf-life stability of roasted sunflower nutmeats in chocolate cookies.

A total of five treatments was included in these studies. The first study consisted of two treatments which included incorporation of 1) roasted sunflower nutmeats and 2) roasted sunflower nutmeats with vitamin E in the cookie mix. The cookies were packaged in polyethylene bags and stored at room temperature. A triangle test was used to organoleptically evaluate chocolate sunflower-containing cookies for rancidity. Twenty-five subjects participated in the testing. Each treatment was tested every two weeks. The panelists detected off-flavor in cookies containing vitamin E (after six weeks storage) and without it (after four weeks storage).

The second study consisted of three treatments. In Treatment 1, the roasted nutmeats were coated with hydrocolloid film. Treatment 2 was the same as Treatment 1 except that the coating solution also contained vitamin C. Treatment 3 consisted of tenox addition to the cookie mix.

The cookies were organoleptically tested as described in the first study. The testing was done up to 95 days.

The results of this study indicated that the shelf-life stability of roasted nutmeats in cookies can be extended by:

1. Coating the nutmeats with hydrocolloid, or
2. Tenox incorporation in cookies containing nutmeats (Hettiarachchy et al., 1987).

Another study is in progress to measure shelf-life stability of hydrocolloid coated, roasted nutmeats. When chemically and organoleptically tested at eight months of room temperature storage, rancidity was not apparent. This observation indicated that the shelf-life stability of hydrocolloid coated sunflower nutmeats in chocolate cookies may be extended well over 95 days.

**Utilization Research of Sunflower Flour Derived from Nonroasted and Roasted Nutmeats in Breadmaking**

Numerous studies on the use of composite flours in bread baking are reported in the literature.

**Table 6. Fatty Acid Composition and Peroxide Value of Sunflower Lipids from Sunflower Nutmeats Stored at Room Temperature for Eight Months (g/100 g lipid).**

| Treatment* | Palmitic | Stearic | Oleic | Linoleic | Peroxide Value (meq/kg) |
|---|---|---|---|---|---|
| SF (zero time) | 5.5 | 3.6 | 14.7 | 67.6 | 1.5 |
| RSF (zero time) | 5.0 | 2.7 | 15.7 | 51.5 | 1.6 |
| PSF | 5.2 | 3.5 | 13.7 | 59.6 | 14.4 |
| ASF | 6.8 | 3.7 | 15.0 | 67.5 | 3.8 |
| PSF-G | 5.0 | 3.2 | 13.0 | 58.4 | 3.0 |
| ASF-G | 5.4 | 3.4 | 14.1 | 64.0 | 2.6 |
| PRSF | 5.3 | 3.0 | 12.9 | 35.9 | 235.4 |
| ARSF | 5.4 | 3.3 | 17.1 | 42.0 | 54.1 |
| PRSF-G | 5.5 | 3.2 | 15.5 | 41.4 | 41.0 |
| ARSF-G | 5.0 | 2.9 | 15.0 | 47.5 | 20.1 |

*SF = unroasted sunflower nutmeats
RSF = roasted sunflower nutmeats
PSF = sunflower nutmeats in polyethylene packaging material
ASF = in Alure packaging material
PSF-G and ASF-G = nutmeats coated with hydrocolloid film
PRSF = roasted nutmeats in polyethylene packaging material
ARSF = roasted nutmeats in Alure packaging material

Hettiarachchy, N.S., D'Appolonia, B.L., Jacobsen, A. and Henderson, J. 1987

D'Appolonia and MacArthur (1979) baked bread substituting 5, 10, 15 and 20 percent of wheat flour with defatted, untreated and roasted sunflower flour and studied the baking properties.

Figures 4 and 5 show the appearance of bread containing untreated and roasted sunflower flour.

Table 7 gives data for bread containing various levels of untreated and roasted sunflower flour. This study showed that the loaf volume, crust color, grain and texture were better in the bread containing roasted than the untreated flour. The results indicate the sunflower flour supplementation at the 10 percent level gave desirable characteristics.

### Tofu

Research has demonstrated that an acceptable tofu can be produced using sunflower flour alone. The tofu prepared had higher protein and lower fat content than soybean tofu on a dry weight basis (Table 8). The low fat content will contribute to a longer shelf-life of the products. This is the first report on the successful preparation of sunflower tofu from skim milk (Liu, 1988).

### Sun Sauce

Work is in progress to prepare sun sauce (similar to soy sauce) from sunflower meal using cultures and proteolytic enzymes.

## PROTEIN FUNCTIONALITY

Functional properties denote characteristics that govern the behavior of proteins in foods during processing, storage, and preparation as they affect food quality and acceptance. Sunflower meal contains about 63 percent protein on a dry weight basis. The protein concentrates and isolates from

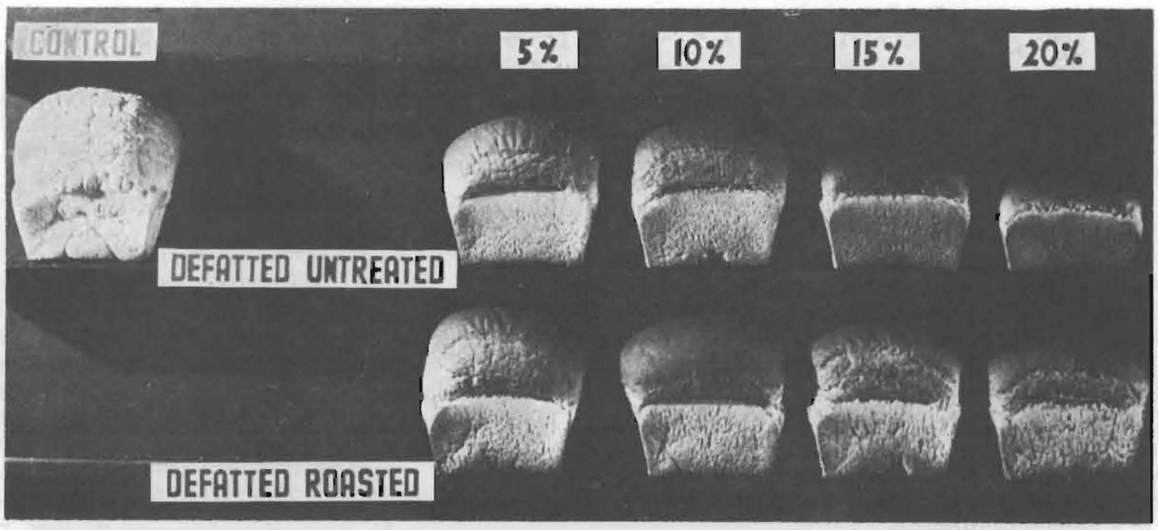


**Figure 4. External appearance of bread containing untreated and roasted sunflower flour.**

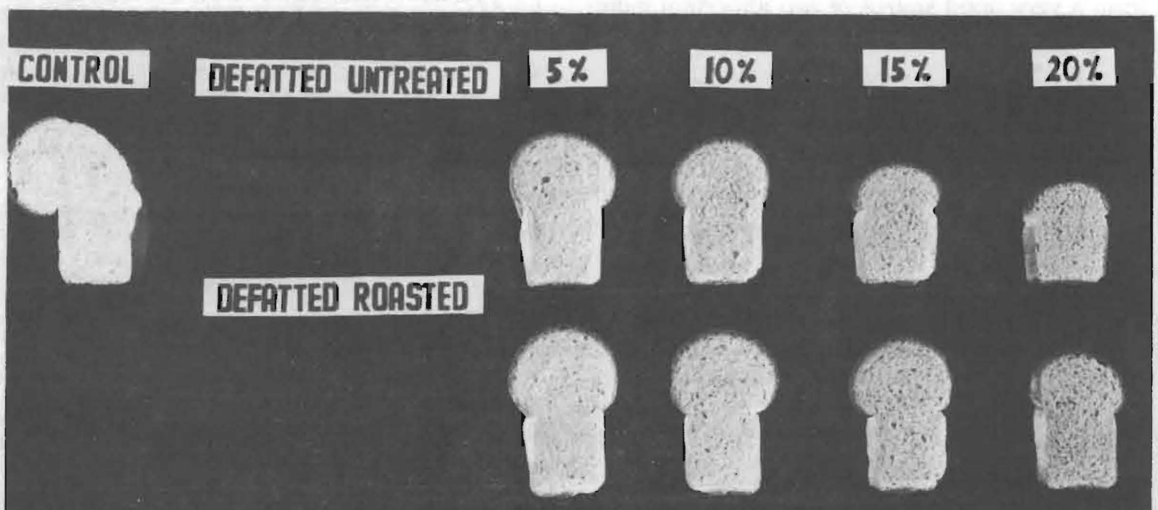


**Figure 5. Internal appearance of bread containing untreated and roasted sunflower flour.**

**Table 7. Baking Data of Bread Containing Various Levels of Nonroasted and Roasted Sunflower Flour[1].**

| Blend | Nonroasted | | | | Roasted | | | |
|---|---|---|---|---|---|---|---|---|
| Sunflower | Loaf Volume | Crust Color[2] | Crumb Color[2] | Grain and Texture[2] | Loaf Volume | Crumb Color[2] | Crust Color[2] | Grain and Texture |
| Control | 975 | 10.0 | 10.0 | 10.0 | — | 10.0 | 10.0 | 10.0 |
| 5 | 843 | 10.0 | 8.0 | 8.0 | 897 | 8.0 | 10.0 | 9.0 |
| 10 | 723 | 9.5 | 7.0 | 7.5 | 825 | 6.5 | 10.0 | 8.5 |
| 15 | 557 | 9.0 | 5.0 | 4.0 | 772 | 5.0 | 10.0 | 8.0 |
| 20 | 475 | 8.5 | 4.0 | 3.0 | 688 | 4.0 | 9.0 | 6.0 |

[1]Results expressed are an average of duplicate values.
[2]Values are based on a score of 1-10 with 10 being the best score.

D'Appolonia, B.L. and MacArthur, L.A. 1979. Bakers Digest, 53(1):32-36.

**Table 8. Chemical Composition of Sunflower and Soybean Curds.**

| Source | Moisture % | Protein % | Fat % | Ash % | NDF % | Carbohydrate % |
|---|---|---|---|---|---|---|
| Sunflower Curd | 4.4 | 73.2 | 8.1 | 3.9 | 2.4 | 11.3 |
| Soybean Curd | 1.2 | 46.5 | 31.8 | 5.1 | 0.94 | 7.5 |

Values are means of duplicate determination.
Protein = Nitrogen × 6.25.
NDF = Neutral Detergent Fiber.
Values on protein, fat, ash, NDF and carbohydrate are on dry weight basis.

sunflower meal can have 75-95 percent protein. Currently, work is in progress to enzymatically modify sun proteins and to obtain fractions that will have various functional properties. These protein fractions can be used as a food ingredient in various appications. Table 9 shows possible functional properties that the modified protein fractions can have and their use in a variety of products.

## NATURAL COLORANT AND ANTIOXIDANT

Thirty percent of the sunflower seed is made up of hull. Currently hulls are being burned as a source of energy. The hulls can form a very good source of two important ingredients that are largely used in foods, natural red color and antioxidants. Fundamental research is in progress to investigate these possibilities and the preliminary findings appear promising.

**Table 9. Functional Property of Food Systems.**

| Property | Food System |
|---|---|
| 1. Solubility | beverages |
| 2. Water absorption, water activity binding | meat, sausages |
| 3. Viscosity | soups, gravies |
| 4. Gelation | meats, curds, cheese |
| 5. Elasticity | meats, bakery |
| 6. emulsification | sausages, bologna, soup, cakes |
| 7. Fat absorption | meat, sausage, donut |
| 8. Flavor binding | meat analogs |
| 9. Foaming | whipped topping, angel cakes |
| 10. Foam stabilizing | beer |

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