Functional Properties of Yeast Grown on Ethyl Alcohol

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ABSTRACT

A new series of food ingredients, based on torula yeast (*Candida utilis*) grown on ethyl alcohol, offers unique functional properties and flavor effects in processed and fabricated foods. The new ingredients bind fat and water, act as emulsifiers, heighten meat, poultry, and seasoning flavors, improve texture of bakery products, and add crispness and tensile strength to wafers. At the same time, they contribute desirable nutrition to foods by increasing the quantity and improving the quality of protein in cereals.

INTRODUCTION

A substantial segment of food science is now devoted to the development of food ingredients intended to improve the flavor, safety, color, texture, shelf-life, sensory quality, or other properties of the finished foods, and concurrently to contribute to the nutritional quality of the foods (1-3). Among the newest of these ingredients is a family of torula yeast products, called TORUTEIN®, grown as a pure culture on food-grade ethyl alcohol (4) and suitable for the human diet. These yeast products are mild tasting and light tan in color with 50% protein content and a favorable contribution of B-vitamins.

Research on this product currently centers on the development of a variety of specially processed TORUTEIN products designated as TORUTEIN-LF and TORUTEIN-94 that fulfill specific funtions in foods, such as forming stable emulsions or retaining moisture. An essential part of the work involves the selection and adaptation of methods for evaluating these yeasts to determine how the properties of the yeasts effect taste, texture, and other subjective aspects of foods as well as the nutritional value of foods. In the remainder of this text, all TORUTEIN products are referred to as yeast products.

TABLE I

Typical Composition of Yeast Product

Composition	%
Protein	52
Carbohydrates	22
Minerals	8
Fat	7
Moisture	6
Crude Fiber	5
Vitamins	**mg/100g**
Thiamine	0.80
Riboflavin	4.50
Niacin	55.00
Folic Acid (Total)	0.40
Folic Acid (Free)	0.07
Pyridoxine HCl	8.30
Panthothenic Acid	9.40
Biotin	0.08
PABA	1.40
Choline Chloride	780.00
Inositol	460.00
Vitamin B-12	0.0004
Minerals	**mg/100g**
Phosphorus	2100
Potassium	2000
Magnesium	300
Sulfur	200
Sodium	100
Calcium	15
Iron	9.5
Zinc	9.3
Fluoride	1.2
Manganese	0.7

EXPERIMENTAL DETERMINATION OF COMPOSITION AND PHYSICAL PROPERTIES

Standard methods were used for proximate analysis (5) and determination of vitamins (5-12), minerals (13-15), amino acids (16), and total free fatty acids (17). Individual fatty acids were determined separately (18).

Fat composition was determined by ethyl alcohol extraction and fractionation followed by standard thin layer chromatography.

Soluble solids were determined from the weight loss of a sample of the yeast product that had been repeatedly suspended in water, centrifuged, and then dried.

Water absorption was determined by a chromatographic method in which a weighed sample of the yeast product was placed on a filter wetted with a wick that extended into a graduated cylinder of water. After this setup had been sealed in a water-tight beaker, water absorption was recorded at 1-hr intervals until no change was observed in three successive readings.

Oil absorption within the yeast cells was determined by the same method, except that salad oil was used as the liquid. To determine oil absorption within the total cell mass, 0.1-ml increments of oil were added to 1.0 g of the yeast product until the mass failed to retain additional oil.

Emulsion capacity was determined by a modification of a procedure reported by Swift et al. (19). To test material (the yeast product, dried egg yolk, nonfat dried milk, soy concentrate, soy isolate, or 90% tissue chuck beef) was dispersed in water to give a 2% suspension. Then 50 ml of the

TABLE II

Typical Amino Acid Profile of Yeast Product and FAO[a] Pattern

	g/16 g N	
Amino Acid	Yeast Product	FAO
Lysine	6.6	4.2
Leucine	7.1	4.8
Isoleucine	4.5	4.2
Methionine	1.4	2.2
Phenylalanine	4.1	2.8
Threonine	5.5	2.8
Tryptophan	1.2	1.4
Valine	5.7	4.2

[a]Food and Agricultural Organization of the United Nations.

TABLE III

Typical Fat Distribution of Yeast Product

Fat Type	Wt % of Yeast Product
Lecithin	5.42
Ergosterol	0.54
Lipoprotein, Glycolipids	0.25
Cephalins	0.25
Fatty Acids (Free)	0.40
Other nonsaponifiables	0.13

TABLE IV

Distribution of Fatty Acids of Yeast Product

Fatty acid	Composition, %		
	Total	Bound	Free
C-14	0.10	0.10	0.12
C-15	0.82	0.85	0.71
C-16	17.52	17.80	16.42
C-16:1	3.68	3.74	3.44
C-17	0.35	0.33	0.35
C-17:1	0.73	0.75	0.72
C-18	0.99	1.05	1.08
C-18:1	18.24	17.95	19.30
C-18:2	39.81	39.50	40.83
C-18:3	17.76	17.93	17.03

suspension and 50 ml of oil were added to a Waring blender cooled to 4 C and were blended at low speed until an emulsion formed. The low speed blending was continued as oil from a buret was added at 2-3 ml/sec rate until the emulsion inverted. The tests were run in triplicate and the results averaged.

Emulsion stability was determined by a method of Yasumatsu et al. (20).

To determine storage stability, the yeast product was heat sealed into polyethylene bags (2-mil thickness) and stored at 27 C and protein efficiency ratio, (PER) was determined after one and two years by a standard method (21). To determine vitamin stability, the product was stored similarly but at 35 C and then analyzed for thiamine (5), pantothenic aicd (8), and pyridoxine (7).

DETERMINATION OF NUTRITIONAL AND FUNCTIONAL PROPERTIES

Nutritional improvements in protein quality of commercially produced corn-based cereal were judged from PER determinations (21).

The fat-holding capacity of commercially produced tamales was determined by a standard method (5).

The tensile strength of commercially produced wafers was determined on 12 in. square samples by various empirical methods that permit rough comparisons only.

BASIC PRODUCTION AND CHARACTERISTICS

In the continuous process, torula yeast, ammonia, air, ethanol, and mineral nutrients are combined in a fermentor, where pH and temperature are controlled to promote rapid cell growth and to ensure a uniform product. The cells are continuously withdrawn, centrifuged, pasteurized, and spray dried.

Tables I, II, and III, respectively, list the composition, amino acid profile, and fat distribution of a typical ethanol-grown torula yeast. (Starting materials and process conditions can be controlled to yield products that meet specific nutritional and functional requirements.)

From both chemical and nutritional points of view, the components of yeasts are the same as those of other food – proteins, carbohydrates, fats, vitamins, and minerals. On a dry basis, this yeast product ranks as high as beef and egg in protein content (ca. 50%) and very much higher than wheat, which contains only ca. 15%. Beef and egg are high in fat–again, ca. 50%–whereas the yeast product has ca. 7% and wheat flour has practically none. In contrast, wheat has 85% carbohydrates, the yeast product has 22%, and beef and egg have practically none.

Like other food yeasts, ethanol-grown torula yeast is rich in B-vitamins, and it also contains nutritonally important minerals. Beef, egg, and most animal products tend to be well balanced in essential amino acids, whereas wheat and cereals are not well balanced because they are especially low in lysine. While this yeast product is high in lysine and threonine, it is deficient in methionine.

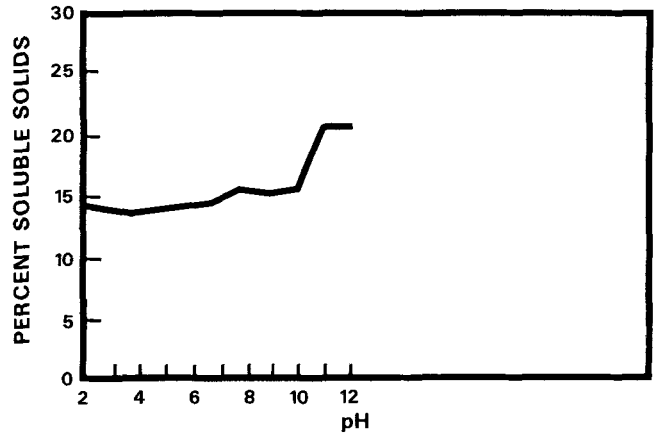

FIG. 1. Soluble solids of ethanol grown torula yeast.

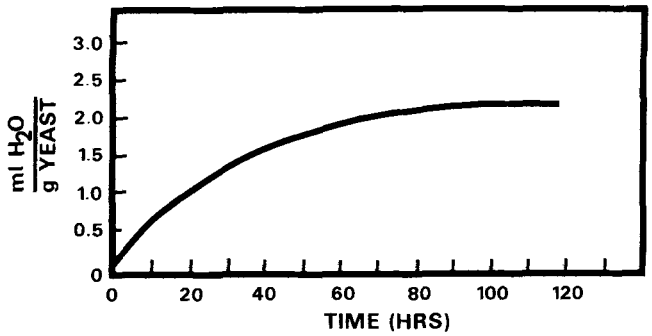

FIG. 2. Water absorption of ethanol grown torula yeast.

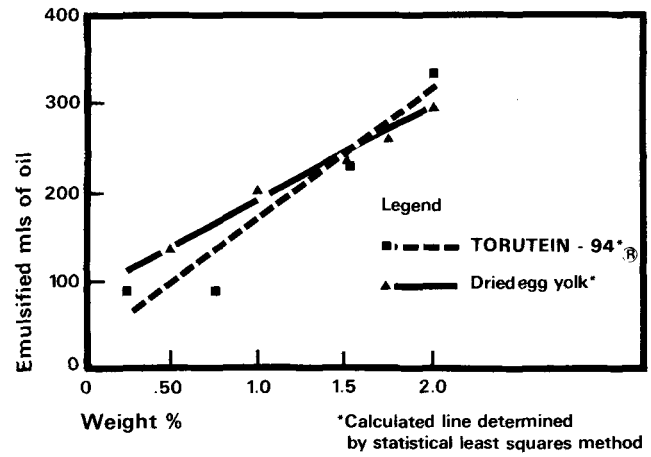

FIG. 3. Effect of specially processed yeast and dried egg yolk concentration on the amount of oil emulsified.

With respect to fats, ethanol-grown torula yeast contains ca. 5.5% lecithin, which amounts to ca. 80% of the lipid content. Table IV shows the distribution of fatty acids. Most of them are unsaturated, and ca. 20% are in the free fatty acid form. Linoleic acid, an essential fatty acid, accounts for ca. 40% of the total.

Despite the high amount of unsaturated fatty acids, the presence of natural antioxidants prevents the yeast product from becoming rancid on storage. The initial PER was 1.7 and did not change over a two-year storage period at 27 C. After 18 months of accelerated aging at 35 C, the thiamine content remained stable, and there were only minor losses in pyridoxine and approximately a 30% loss in pantothenic acid.

As shown in Figure 1, the yeast product contains about

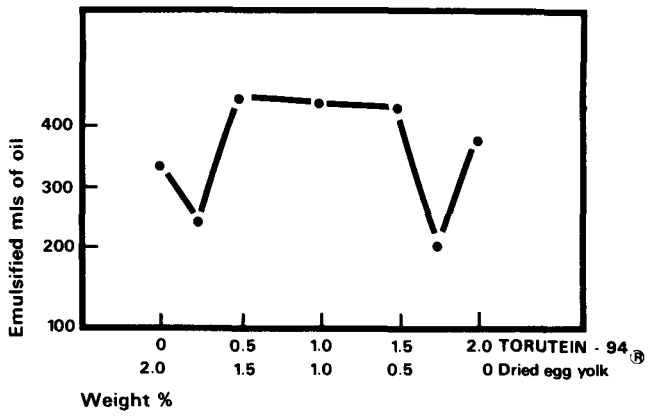

FIG. 4. Effects of combinations of specially processed yeast plus dried egg yolk on the amount of oil emulsified.

TABLE V

Effect of the Yeast Product on the Fat Holding of Tamales

Treatment	% fat	
	Control	Test
Uncooked filling	25.60	25.60
Uncooked shell	3.25	3.25
Cooked filling	21.90	24.60
Cooked shell	8.40	6.30
Fat in wrapper	+	–

14.5% soluble solids that includes minerals, amino acids, nucleotides, and carbohydrates. Otherwise, it is insoluble but easily dispersible in water and oil. Figure 2 shows that the yeast product absorbs about twice its weight in water at pH 6; although absorption varies somewhat with pH, it does not appear to change significantly within the normal pH range of food.

Individual dry yeast cells absorb ca. 37% of their weight in oil. The cell mass, however, can hold 90% of its weight in oil or fat within the intercellular space.

A specially processed form of yeast has an emulsion capacity slightly lower than that of egg yolk but has a much higher emulsion stability. Figure 3 indicates that egg yolk is a more effective emulsifier at concentrations below 1% in a water solution. However, between 1 and 2%, this yeast product and egg yolk are equivalent. Moreover, as shown in Figure 4, certain combinations of this yeast product and egg yolk have a higher emulsion capacity than either one alone.

EFFECTS OF ETHANOL-GROWN TORULA PRODUCTS IN COMMON FOODS

The soluble solids in the yeast product play a role in enhancing the flavor and functional properties of foods. For instance, the yeast product heightens meat, poultry, chocolate, cheese, and spice flavors, and it functionally replaces egg and nonfat dry milk.

TABLE VI

Comparison of the Emulsion Capacity of Yeast, Soy and Nonfat Dry Milk in Combination with Meat

Test product	Emulsion capacity: mls of oil emulsified by 0.25g test product + 0.75g meat
Yeast	236
Non fat dry milk	241
Soy concentrate	230
Soy isolate	232
All meat control	192

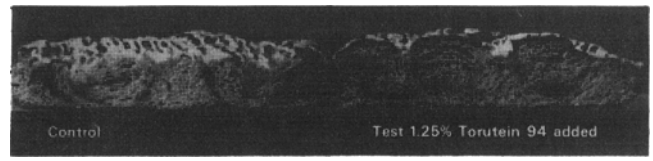

FIG. 5. Effect of yeast on the texture of Danish pastry.

Because of its high lysine and threonine content, the yeast product can be used to increase the protein efficiency ratio of cereal products. At the 5% level in corn-based breakfast cereals, it increases the PER of the cereal from 1.1 to 1.5. Recently we developed high protein macaroni and high protein donuts with a PER of 2.5 by using a combination of yeast and various protein ingredients.

The ability to hold water, fats, and oils in stable emulsions is an especially important functional property. Table V, for example, shows the effect of the yeast product added at the 1% level to the filling of a commercial tamale. Compared with the control, the tamale lost less fat from the filling into the shell.

When the emulsification ability of a blend of 75% yeast and 25% egg yolk were tested in a creamy garlic dressing, there was a decided increase in apparent viscosity, which was perceived as thickness and cling, compared with that of the control. Photomicrographs of these dressings along with a cell suspension of yeast at the same concentration, indicate that both the size and shape of the oil droplets and yeast cells influence the apparent viscosity and stability of the dressings. An important point is that there is a wide variation in the size of the oil droplets in the control. By contrast, the droplets in the dressing with the yeast product are more uniform in size and distribution, indicating that yeast exerts a milling action. In addition, the soluble components of the yeast cells act as stabilizers. Finally, as observed in the photomicrographs, yeast cells have a cylindrical shape that effectively increases the apparent viscosity of the emulsion.

Processed meats is another area in which the emulsifying property of the yeast product can play a key role. Table VI compares the emulsion capacity of a specially processed low flavored yeast with that of other high protein supplements that were used to replace 25% of a processed meat. In all tests the supplements increased the emulsion capacity of the meat, and the yeast product compared favorably

TABLE VII

Comparison of the Tensile Strength of Standard and 5% Yeast Added Wafers

	Standard	5% Yeast added
Wafer dropped from 12" high on edge	2" of edge broken away	0.75" of edge broken away
Ten gram weight dropped from measured distance	Weight broke through at 3"	Weight broke through at 5"
Wafer picked up by edge with weight at opposite edge	Wafer broke with 5 grams on edge	Wafer broke with 25 grams on edge
Cracking measured by Instron	267 grams	460 grams

with the other supplements. We have also found that combinations of this yeast product and nonfat dry milk increase the emulsion capacity of the meat to the same degree as either of these supplements alone.

The complementary effect of replacing some egg yolk with the yeast product in baked goods is shown in Figure 5. Addition of 1.25% of this yeast product produced a flakier structure and decreased the hard fat mouthfeel. The flaky appearance is not only a visual improvement, but it is also a sensory improvement which was identified by a taste panel and experienced bakers. The addition of 5% yeast to wafers resulted in a significant increase in crispiness and a decrease in gumminess preceived by a taste panel as increased freshness of the product. Also, as shown in Table VII, mechanical measurements indicated that the wafers had increased tensile strength, which gives better handling properties. In fact, most ethanol grown torula yeast products have improved the texture of cereals and other bakery products.

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