

QUALITY OF TOFU AND OTHER SOY PRODUCTS

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A cooperative study by The Connecticut Agricultural Experiment Station
and the Connecticut Department of Consumer Protection

People in Asian countries long have used fresh and fermented soybean products such as tofu, but those in Western countries have only recently begun to use them in substantial amounts. Their popularity, however, appears to be rising. Included among fresh or fermented soy products are tofu, miso, tempeh, soy milk, and soy pastes which require refrigeration as compared to roasted soybeans, soy flour, and soy sauce which do not require refrigeration. Although variations may be used, a general description of each process for the manufacture of the soy products can be given.

Soybean milk, which is used to prepare tofu, is made by soaking soybeans in water, grinding and crushing the soaked beans, diluting the mixture about three-fold with water, and then heating to boiling. The liquid milk is removed by straining.

Tofu, or soybean curd, is the protein precipitated from soybean milk by acids or salts. When salts or acids are added to the soy milk, the protein flocculates. The precipitated protein or curd is allowed to settle and the water removed. The curd is placed on trays and more water is expelled by pressing. Tofu with more water may be labelled soft style and tofu with less, firm style.

Miso is a fermented mixture of soybeans and rice, although barley is sometimes used. The beans are steamed about 24 hours and then ground into a paste fermented by a fungus, usually *Aspergillus oryzae*. Miso is used principally in soups and in vegetable dishes.

Tempeh is made by fermenting dehulled, partially-cooked soybeans with fungi, generally

of the genus *Rhizopus*. The cake that forms usually is thinly sliced and fried or used in soups. For the American market it is sometimes made into "burgers".

There are no specific State regulations for the soy products described. They must, however, comply with general Connecticut regulations, which require they be prepared from wholesome ingredients, additives must conform to levels established by the U.S. Food and Drug Administration, and labelling must comply with State regulations (8).

Since the soy products described above, however, are made and packaged in a manner similar to dairy foods, especially cottage cheese, comparing the number of microbes in the soy products with the number permitted and present in dairy products allows an assessment of the quality of soy foods.

MATERIALS AND METHODS

Seventeen samples of fresh soy products sold in Connecticut were examined. Of these, 15 were collected at retail stores and two from a manufacturing plant by inspectors of the Department of Consumer Protection. All samples were packaged by the manufacturer except samples 5, 16, and 17, which were taken from a bulk supply. Samples were placed on ice for delivery to the laboratory, and microbial analyses begun within 24 hours of collection. Samples were analyzed by methods for cottage cheese in Standard Methods for the Examination of Dairy Products (7). Standard Methods Casein Agar (1) was used to determine the total number

of microbes as well as proteolytic bacteria. Coliform bacteria were enumerated on Violet Red Bile Agar (Difco), and yeasts and molds on Potato Dextrose Agar (Difco) to which chloramphenicol and chlortetracycline were added to suppress bacterial growth (5). All counts are reported as number per gram of sample. Chemical analyses were made by Standard Methods (6).

The samples, manufacturers, and ingredients follow:

New England Soy Dairy, Greenfield, MA

1. *Tofu, firm style*: water, organic soybeans, nigari (magnesium chloride).
2. *Tofu, soft style*: ingredients same as sample 1.
3. *Tofu, spice garden in broth for oriental cooking*: water soybeans grown with natural methods, spices, herbs, bell peppers, carrots, onions, garlic, hydrolyzed vegetable protein, nigari (magnesium chloride).
4. *Tofu, herb garden for salads*: water, soybeans grown with natural methods, herbs, spices, celery, onions, garlic, nigari.
5. *Tofu, bulk at a retail store*.

NaSoya Foods, Leominster, MA

6. *Tofu, organic style, firm*: deep well water, organically grown soybeans, natural nigari/solidifier (desalted seawater).
7. *Tofu slices, marinated and broiled*: tofu (water, soybeans, nigari), natural soy sauce (whole soybeans, salt, water), honey, herbs, spices.

Health Valley Natural Foods, Montebello, CA

8. *Soy Moo, non-dairy soy milk*: pure filtered water, organic soybeans, soya oil, honey.

Soyfoods Unlimited, San Leandro, CA

9. *Tempeh Burgers*: soy tempeh, natural soy sauce, herbs, spices.

Pacific Tempeh, Emeryville, CA

10. *Tempeh burger*: soy tempeh, shoyu, lemon juice, safflower oil, garlic, paprika, thyme.

Legume, Inc., Bloomfield, NJ

11. *Tofu Lasagna with sauce*: crushed tomatoes, organic tofu, whole wheat flour, water, soy and peanut oil, garlic, onion, oregano, basil, parsley, salt, pepper. Pasta ingredients: unbleached fancy Durum semolina, soy flour, 'DeBoles' American (Jerusalem) artichoke flour, wheat germ, wheat gluten.

Tempeh Works, Greenfield, MA

12. *Tempeh*: organically grown soybeans, water, Rhizopus culture, vinegar.

Erehon, Inc., Cambridge, MA

13. *Soybean paste with rice (Genmai Miso), product of Japan*: soybeans, brown rice, water, sea salt.

Tree of Life, St. Augustine, FL

14. *Kome Miso, product of Japan*: soybeans, rice, water, sea salt.

The Bridge, Middletown, CT

15. *Tofu from factory*: filtered water, prize organic soybeans, nigari (a natural coagulant from sea water).
16. *Tofu, bulk at the factory*: ingredients same as 15.
17. *Tofu, bulk at a retail store*: ingredients same as 15.

RESULTS AND DISCUSSION

Microbes

The number of microbes in the soy products are shown in Table 1. Microorganisms shown in Table 1 can be understood if they are compared to the numbers of microorganisms allowed and found in dairy foods. In Connecticut a total aerobic bacterial count of not more than 25,000 per milliliter and a coliform count of less than 5 are required for pasteurized milk. For other dairy products, a coliform count of 10 or less and a yeast and mold count of less than 10 per gram is generally required. In Table 2 we show the percentage of soy and dairy products meeting the specifications for dairy foods. The data in Table 2 for cottage and ricotta cheeses, chip dips, and sour creams and sour dressings are from recent Station Bulletins (2, 3, 4).

Generally all the dairy products had fewer microbes than the soy products. For all dairy foods, 84% met the coliform standard, 62% the yeast standard, 91% the mold standard, and 98% the standard for total bacterial count. For the soy products, 41% met the coliform standard, 29% the yeast standard, 41% the mold standard, and 12% the standard for total bacterial count. The number of gram negative bacteria in the cheeses is compared to the total aerobic count of soy products. Bacterial colonies growing on Standard Methods Casein Agar inoculated with the soy foods were short, motile rods, not of a type used in food manufacturing.

In dairy foods, organisms able to produce proteolytic enzymes could produce off-flavors and off-odors if their proteolytic enzymes degrade the protein or casein in the product. Many bacteria able to produce proteolytic enzymes were found in the soy products and could degrade the curd. Off-flavors and off-odors were not noted, although the products were not stored to the end of their code periods.

Nutrients

The fat, protein, carbohydrate, sodium, and calories in each sample is shown in Table 1. The nine tofu samples averaged 9.2% fat.

TABLE 1. MICROBIAL AND NUTRIENT ANALYSES OF SOY PRODUCTS

Sample	Total Aerobic count, thousands /g ^a		Coliform Bacteria, no./g	Yeasts, no./g	Molds, no./g	Fat, %		Protein, %		Carbohydrate, %		Calories/100g		Sodium, mg/100g		Sample
	claim	found				claim	found	claim	found	claim	found	claim	found	claim	found	
1. Tofu, firm, Soy Dairy	>3,000 ^b	>30,000	5	>10	7.1	10.7	11.5	16.1	0.9	1.5	113	164	7.1	9.0	1	
2. Tofu, soft, Soy Dairy	>3,000	900	10	>10	5.3	11.9	8.8	18.1	0.9	4.2	80	194	5.3	6.9	2	
3. Tofu, spice, Soy Dairy	>3,000	1	1,900	200	7.1	9.4	11.5	14.3	1.8	6.3	124	165	124	117	3	
4. Tofu, herb, Soy Dairy	>3,000	>30,000	200	40	7.1	9.4	11.5	13.7	1.8	1.5	120	143	<10.0	6.3	4	
5. Tofu (bulk), Soy Dairy	>3,000	>30,000	2,700	100	-- ^d	10.3	--	16.9	--	1.6	--	165	--	6.8	5	
6. Tofu, firm NaSoya ^c	>3,000	2,800	40	15	6.1	7.4	13.2	19.3	4.0	4.5	124	160	2.2	15.6	6	
7. Tofu slices, NaSoya	32	<1	<10	1,000	8.8	8.2	15.0	14.4	4.4	5.8	159	152	--	318	7	
8. Soy Mbo, Health Valley	>300	2,300	500	40	2.0	2.7	0.8	1.6	7.0	4.9	53	49	20.0	13.5	8	
9. Tempeh burgers, Soy Foods	>3,000	<1	<10	800	--	5.4	--	13.6	--	8.2	--	135	--	391	9	
10. Tempeh burger, Pacific	2,400	<1	<10	<10	--	19.9	--	25.7	--	18.0	--	350	--	237	10	
11. Tofu Lasagna, Legume	>3,000	1,300	40	2,200	4.0	7.3	5.8	7.3	16.8	16.9	127	161	270	202	11	
12. Tempeh, Tempeh Works	>3,000	<1	1,200	10	11.5	5.2	19.5	21.1	6.2	7.6	204	160	13.7	10.7	12	
13. Soybean paste, Erewhon	31	<1	15	<10	--	5.9	--	11.7	--	18.6	--	173	--	1,135	13	
14. Miso, Tree of Life	16	<1	1,100	500	--	6.1	--	11.8	--	17.5	--	171	--	1,154	14	
15. Tofu, The Bridge	12	110	240	10	--	8.6	--	18.1	--	6.4	--	174	--	6.4	15	
16. Tofu (bulk), The Bridge	91	120	110	<10	--	7.6	--	16.4	--	3.2	--	145	--	7.7	16	
17. Tofu (bulk), The Bridge	>3,000	>30,000	350	400	--	7.7	--	16.8	--	6.8	--	162	--	5.4	17	

^a g = grams, mg = milligrams

^b > = greater than, < = less than

^c This sample claimed 51 mg calcium per 100 g; 83 mg found

^d dash (--) indicates no claim made

TABLE 2. PERCENTAGE OF SOY AND DAIRY FOODS^a MEETING CONNECTICUT REGULATIONS FOR MICROORGANISMS IN DAIRY PRODUCTS.

Percent of samples meeting dairy regulations

Product	No. Samples	coliform bacteria >10/g	yeasts, >10/g	molds, >10/g	Gram negative bacteria, >25,000/g	Total aerobic count, >25,000/g
Soy foods	17	41	29	41	--	12
Cottage cheese	141	85	62	92	91	--
Ricotta cheese	19	89	100	89	95	--
Chip dips	38	82	63	97	--	82
Sour cream and sour dressing	28	54	68	82	--	89

^a Data for dairy foods from The Connecticut Agricultural Experiment Station Bulletins 791, 794, 795.

Fat ranged from 2.7% for soy milk (sample 8) to 19.9% for a tempeh burger (sample 10). Protein averaged 15.1%, but ranged from 1.6% for the soy milk (sample 8) to 21.1% for a tempeh product (sample 12). The calories per 100 grams ranged from 49 to 350, and they primarily depended on the fat content. Cottage cheese with 4% fat has about 110 calories per 100 grams. Samples 13 and 14, soy pastes, contained over 14% ash, indicating a high mineral content, probably from added sea salt.

Only nine of the 17 samples made a claim on the label for specific amounts of nutrients. In these nine samples the average for fat was 135% of claim, for protein 141%, for carbohydrate 178%, and for calories 129%.

Sodium in the soy products ranged from 5.4 to 1154 milligrams per 100 grams. All tofu samples except sample 3 contained little sodium, less than 16 milligrams per 100 grams. The most was found in soy pastes (samples 13 and 14).

CONCLUSIONS

The 17 soy products tested contained many microorganisms. Although Connecticut has no specific standards for microbes in fresh soy products, State Dairy Regulations provide a measure of the quality of soy products. Fifty-four to 100% of the dairy foods met the microbial standards for dairy products, while for soy products only 12 to 41% met these standards.

Soy foods generally contained more fat than claimed. Sodium content conformed to label declarations. Tofu had little sodium, while soy pastes and miso had much.

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