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DRUM-DRIED MUSHROOM POWDER

A NEW PRODUCT

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CONTENTS

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ABSTRACT

A process is described for preparing a new dehydrated mushroom powder. It involves washing and pulping fresh mushrooms, drying the pulp on an atmospheric double-drum dryer, and grinding the dry flakes into powder.

The product is light brown in color and has an excellent flavor characteristic of Agaricus campestris mushrooms. It can be stored in air at room temperature for at least 9 months without significant change in flavor.

A commercial plant producing 253 pounds of the powder a day would require about $57,000 of fixed capital investment. Selling price of the powder would range from about $4.50 to $4.60 per pound when using mushrooms of good quality and condition, to about $3.10 to $3.30 per pound when using lower priced, lower quality "spots and opens"--so-called because of the dark spots and open veils.

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ERRATA

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Page 11, next-to-the-last paragraph. Replace with the following:

Each member of the panel was given a sample designated "standard." This corresponded to treatment No. 1 in table 2. Three coded samples were also presented, each corresponding to one of the treatments in table 2. Thus, one of the three was a hidden standard. The tasters were asked to compare each of the coded samples with a designated standard and to record the degree of difference on the following descriptive scale (3):

Page 12, para. 2, lines 4 and 6; para. 3, line 4. Delete the word "hidden" (the nitrogen-packed sample referred to is the one stored at 70° F.).

Para. 3, last two sentences. Replace with the following:

This showed that the apparent flavor inferiority of the air-packed sample with respect to the standard after 9 months' storage was biased by the slight difference in color. Thus, it can be concluded that mushroom powder packed in air can be stored at room temperature for at least 9 months without a significant change in flavor.

DRUM-DRIED MUSHROOM POWDER
A NEW PRODUCT

M. Komanowsky, V. A. Turkot, F. B. Talley, and R. K. Eskew

INTRODUCTION

The only commercially important variety of mushroom commonly cultivated in the United States is the Agaricus campestris. The annual crop is over 165 million pounds, of which about 60 percent is grown in Pennsylvania (2, 7).*

Fresh mushrooms are extremely perishable, and their supply is seasonal and depends to a large extent on weather conditions (4). Consequently, the mushroom industry is plagued with intermittent surpluses with resultant depressions in price. These surpluses are absorbed primarily by the canning industry; only limited quantities are sold frozen or dehydrated (8).

In the canning process, about 22 percent of the solids are lost in blanching and retorting (6). The loss of solids and the high temperature processing are responsible for the lack of mushroom flavor in the canned products. Air-dried Agaricus campestris is tough and chewy on reconstitution and has an off-flavor which is more pronounced at higher drying temperatures. If blanching precedes the drying step, the air-dried product is, in addition, quite dark in color. Freeze-drying yields a product of good initial flavor, but it quickly becomes dark on reconstitution because the enzymes have not been inactivated. Moreover, processing costs are high and the product is costly to package because of its friability.

Both canned and dehydrated mushrooms have lately encountered strong competition from imports which, although often poor in quality, are much cheaper. Research on mushroom processing has been undertaken at the Eastern Utilization Research and Development Division to develop products which could compete more successfully with imported processed mushrooms and which would help to ensure the continued growth of the United States mushroom market. One such development of this Laboratory is drum-dried mushroom powder--the subject of this report.

EXPERIMENTAL PROCESSING

Production of Powder

All mushrooms were the white type Agaricus campestris. They were obtained already trimmed either from local stores or from the American Mushroom Institute in Kennett Square, Pa. Their cap sizes ranged from 3/4 inch to about 3 inches in diameter. They were first washed by hand, using cold water to minimize browning, and then pulped. A Waring Blendor was used when small quantities

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* Underscored numbers in parentheses refer to Literature Cited, p. 15.

were pulped. Either a Fitzpatrick Mill (Model D) or a Rietz Disintegrator (Model RP-8-K111) was used with larger quantities. In the former, swinging hammers were used with the blunt edges facing the direction of motion, and the pulp was forced through a 1/32 inch screen. In the latter, the hammers were rigid and the screen had 1/16 inch holes. Both machines were operated at 5,400 r.p.m. The mushroom pulp was dehydrated on a double-drum dryer (6 inch diameter X 7-5/8 inch). The pulp was confined between the drums with two plastic end boards.

The dry sheet, which was doctored off, was permitted to fall by gravity into a receiver. The falling sheet tended to form at the doctor blade long thick "cigars," which eventually fell into the receiver, and took a long time to cool. This problem was eliminated by providing an inclined metal plate that extended from the doctor blade just far enough to permit the sheet to slide down without touching the drum.

The product was very thermoplastic as it was peeled from the drum and had to be cooled to about room temperature before it became sufficiently brittle to be ground in a Fitzpatrick Mill.

No bacteriological standards for dehydrated mushrooms are known to the authors. However, drum-dried mushroom powder appeared to be bacteriologically clean. When it was made from fresh mushrooms that contained approximately 3×10^6 bacteria per gram, a typical dry product had only 10,000 bacteria per gram.

The polyphenol oxidase in the dry product was completely inactivated. This was determined by a method described by Masure and Campbell (5) for measuring peroxidase activity. To test for polyphenol oxidase, the procedure was modified by omitting the addition of H_2O_2.

The effects of different drying conditions are shown in Table 1. From the standpoint of flavor and cost, the best results were obtained with a drum steam pressure of 50 p.s.i.g., a drum speed of 3.7 r.p.m., and a distance of 0.008 inch between drums. At these drying conditions, the output was 0.8 pound per hour per square foot of drum surface and the moisture content was about 5 percent. A higher output was obtained when the drum steam pressure was increased. However, when the dryer was operated at 60 p.s.i.g. drum steam pressure and 4.6 r.p.m. drum speed, the product had somewhat less mushroom flavor than the products obtained at the lower drum steam pressures, even though the moisture content was approximately the same.

Table 1.--Effect of drying conditions on product flavor and output

Drum steam pressure (p.s.i.g.)	Drum speed (r.p.m.)	Distance between drums (in.)	Drum output (lb./hr./ft.^{2})	Flavor
35	3.0	0.003	0.60	Very good.
50	3.7	.008	.80	Very good.
60	4.6	.008	1.0	Good but less mushroom flavor.

NOTE: The moisture content of all products ranged between 5 and 6 percent.

Factors Affecting Color and Flavor

A fresh mushroom has an exceedingly delicate structure that darkens gradually with time. This darkening is triggered by the oxidizing enzyme polyphenol oxidase, naturally present in the plant material. When the natural structure is disturbed, e.g., by pulping, darkening is greatly accelerated in the presence of air. Both the age of the mushrooms and the operating conditions affect the color of the final product. When young "buttons" were used, light brown flakes were obtained after dehydration, while the larger and older "flats" produced a golden to brown product. Storage of mushrooms at 35° F. for several days before pulping resulted in a product that was darker than that made from fresh mushrooms. A darker product also resulted when mushroom puree was permitted to stand at room temperature exposed to air for 5 hours before dehydration; but storage of whole mushrooms or mushroom puree did not have any effect on flavor. A considerable loss in flavor was observed, however, when sulfite was added to mushroom puree to reduce discoloration. Blanching was not used because of the concomitant loss in solids and flavor. Moreover, it is unnecessary if processing is prompt and continuous.

COMMERCIAL PRODUCTION

Basic Assumptions

In order to determine the cost of manufacturing the powder commercially and its approximate factory selling price, a hypothetical commercial plant has been designed with certain basic assumptions. The plant is assumed to be built and operated as an adjunct to an existing mushroom processing (canning) plant. Some facilities already present are assumed to be shared, such as the steam boiler. Part-time use is also made of existing supervisors and office help. Charges are included for such shared use. Location of the plant is assumed to be in the Kennett Square area of southeastern Pennsylvania, where mushroom growing and processing are concentrated. Estimates were made of the cost of processing equipment, the fixed capital investment, the working capital, and daily operating costs. By assuming figures for selling expense and return on investment, a factory selling price for the powder was obtained.

Processing Steps

Figure 1 depicts the processing steps for commercial operation. The numbers refer to the items given in the section on Equipment Summary. Feed to the plant is "cuts," that is, mushrooms with the root portion already trimmed off by the grower, and delivered in 9-pound baskets. These are dumped by hand into the hopper (1) (fig. 1). The hoppers (1) and (3) are large enough to hold at least a half-hour's supply. Both hoppers have variable speed drives for controlling feed rate. The rod-reel washer (2) uses cold water sprays within a rotating reel to wash the mushrooms. The disintegrator (4) pulps them continuously. Pump (5), with variable speed drive, supplies pulp to the double-drum dryer (6) at the required rate. The dryer discharges the product into bulk containers in which it is allowed to cool to room temperature before it is ground batchwise in grinder (7). The powder is weighed by hand into No. 10 cans, which hold 3.5 pounds net. The cans are sealed, cased six to a carton, and trucked to

storage. Two men will operate the plant on a schedule of 9 hours per day, six days a week. Eight hours of actual production per day is assumed.

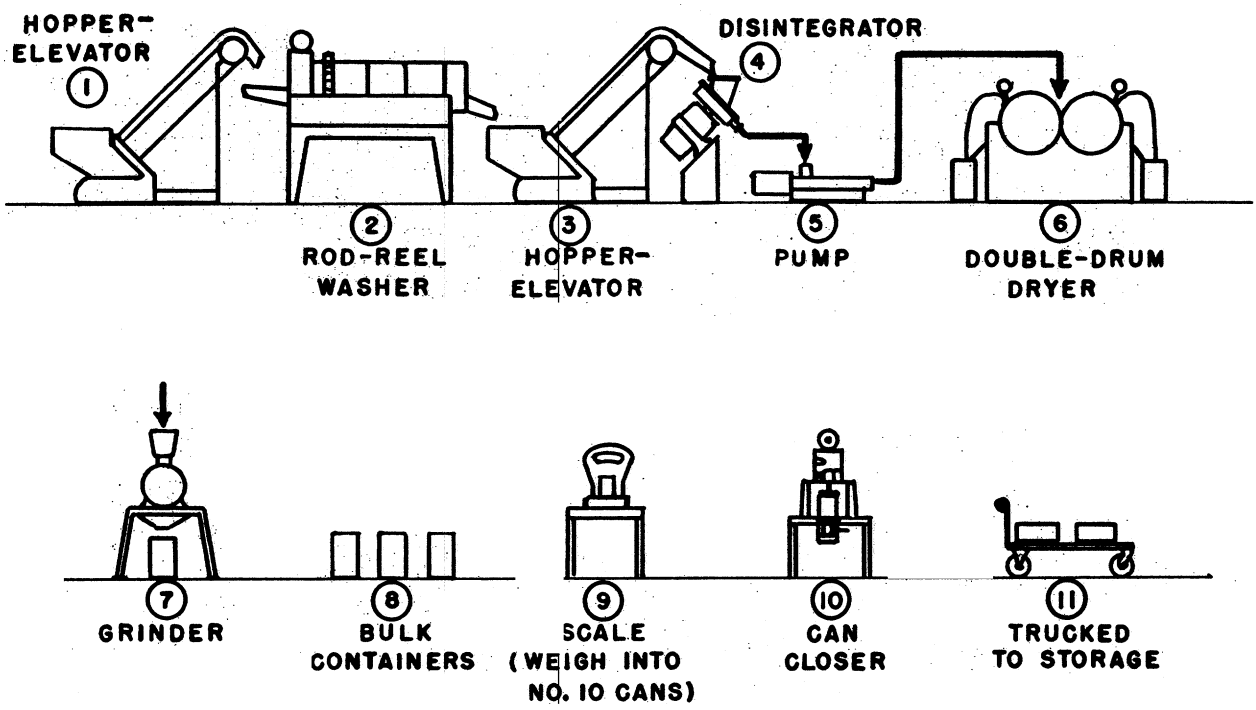

Figure 1.--Flow sheet for commercial production of drum-dried mushroom powder.

Certain precautions are taken to minimize enzymatic browning of the mushrooms. Washing is done with cold water to keep the temperature of the mushrooms low. Exposure of the pulped mushrooms to air is held to a minimum by: (1) operating the disintegrator continuously at only the feed rate required for the dryer, (2) transporting the pulp from disintegrator to dryer inside a closed system, and (3) making the volume of pulp in process as small as practical to minimize the time between pulping and drying.

Plant Capacity

Because plant capacity affects the cost of production, its choice requires some care. The capacity chosen is based on estimated annual sales volume. Because the powder is a new product, any estimate of its sales volume must be somewhat uncertain. The total United States consumption of dried mushroom products of all types and varieties is about 1 million pounds a year* (7, 8). About 85 to 90 percent consists of imports, chiefly from South America and Europe. They consist mostly of varieties other than the common domestic cultivated Agaricus campestris. The remaining 10 to 15 percent comprises chiefly United States production of freeze-dried Agaricus campestris pieces. There is a limited sale of powdered mushroom obtained by grinding dried pieces or from

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* Fineberg, B. Western Utilization Research and Development Division, U.S. Department of Agriculture, Albany, Calif. Private communication. 1965.

submerged culture of morel mycelium; however, the new drum-dried powder differs significantly from either of these products.

An arbitrary figure of 3 percent of the total United States consumption of dried mushroom products was taken as the output for this plant. Assuming that the nearest sized standard drum dryer is used and that the operating season is 130 days, then the annual production of powder is about 33,000 pounds. This operating season covers the two "flush" periods of mushroom production, namely from about October 10 to December 20, and from about March 1 to May 15. However, fresh mushrooms for processing are also available--although in lesser quantities--over the remaining time between October 1 and June 1, so that the plant could operate for 180 days a year. The advantage of the longer operating season, assuming the increased production can be sold, is the reduction in per-pound charges for items such as maintenance and repair, insurance, depreciation, taxes, and return on investment. Accordingly, cost calculations are presented for both a 130-day and a 180-day operating season, on the basis of single-shift operation for 6 days a week.

The several sections of the cost estimate are given below. The Equipment Summary lists the processing equipment required, together with a brief description of each item and its estimated cost. The Capital Costs section lists the items entering into the fixed capital investment, and also the working capital. Next are shown the daily Operating Costs, for both 130-day and 180-day operating seasons. The "cost to make" per pound computed in this section comes to $3.94 and $3.88 for the 130-day and 180-day seasons, respectively. With an assumed selling expense of 6 percent of sales price, and a net profit after taxes of 12 percent a year on fixed capital, factory selling prices of $4.68 and $4.50 per pound, respectively, are obtained as shown. The final section gives a financial analysis for the plant on an annual basis, for both the 130-day and 180-day operating seasons.

Equipment Summary

Item No.	Description	Estimated Cost Dollars
1	Hopper-elevator--to receive mushrooms from baskets and deliver them at controlled constant rate to washer, Item No. 2. Stainless steel construction, neoprene belt, variable speed drive, ½ hp. motor, about 4 feet discharge height. Hopper to hold 125 pounds raw mushrooms.	1,000
2	Rod-reel washer--to wash raw mushrooms by tumbling under pressure sprays of cold water. Drum of stainless steel rods, 20 inch diameter by 4 feet long, rotating at 18 r.p.m. Water spray of 60 gallons per minute, with 10 gallons per minute fresh water and 50 gallons per minute recirculated water. Cylinder mounted over water-tight underpan; 1/3 hp. variable speed drum-drive, and 2 hp. recirculating pump.	1,250

3	Hopper-elevator--to receive washed mushrooms and deliver them continuously at controlled rate to Item No. 4. Specifications similar to Item No. 1.	1,600
4	Disintegrator--to continuously convert washed whole mushrooms to pulp. All-stainless steel construction. Rotor blades direct-mounted on motor shaft extension; screen size approximately 0.060 inch. Capacity 500 lb. per hour. Motor 5 hp., 3,600 r.p.m.	1,300
5	Pump--to take mushroom pulp from Item No. 4 and deliver it to drum dryer at required rate. Slow-speed, positive delivery, helical-screw type with variable speed drive. Metal parts contacting product of stainless steel. ¼ hp. motor.	720
6	Drum dryer--double-drum type, with chromeplated cast iron drums 24-inch diameter X 36 inches long, rated for 100 p.s.i.g. internal steam pressure. Variable speed drive with range of about 2 to 6 r.p.m. Stainless-steel screw-type conveyor troughs; exhaust hood and fan; provision to blow current of ambient air across product at doctor knives for cooling. Approximately 6 hp. motor load.	16,000
7	Grinder--to pulverize dried product from Item No. 6. Operated batchwise. Stainless steel, hammermill type with approximately 0.020 inch perforated screen. 3 hp. motor.	1,800
8	Bulk containers--for temporary storage of dried product and powder. Plastic or aluminum.	150
9	Scale--for weighing powder into No. 10 cans; dial type.	175
10	Can closer--for No. 10 cans. Motor driven, hand-fed. 1/3 hp. motor.	300
11	Hand trucks--for transporting raw mushrooms, product, etc. Wooden platform, rubber-tired wheels, approximately 27 by 54 inch. Three at $75 each	225
	TOTAL PROCESSING EQUIPMENT.....	25,120

Capital Costs

1.	Land and site preparation		$500
2.	Roads and parking areas		700
3.	Building--750 sq. ft.; includes heating and lighting		9,000
4.	Equipment--processing, from Equipment Summary		25,120
5.	Erection of equipment--processing. 16 percent of line 4		4,000
6.	Instrumentation		300
7.	Piping and ductwork--5 percent of line 4		1,250
8.	Erection of piping and ductwork--5 percent of line 4		1,250
9.	Power--installed--16 kw		2,000
10.	Insulation of steam lines		300
11.	Freight on equipment--3 percent of line 4		750
12.	Fire and safety equipment		250
13.	Contingencies--10 percent of total		5,700
14.	Engineering fees--8 percent of total		4,500
15.	Start-up expense--2 percent of total		1,150
16.	Total fixed capital		$56,770
17.	Working capital:		
	For 130-day season	$20,000	
	For 180-day season	25,000	

Operating Costs

Production: 31.67 pounds of powder per hour for 8 hours per day; 253.33 pounds per day. For 130-day season, annual production is 32,933 pounds; for 180-day season, 45,600 pounds.

	130-Day Season		180-Day Season	
	Cost per day Dollar	Cost per lb. of powder Cent	Cost per day Dollar	Cost per lb. of powder Cent
I. Factory Manufacturing Costs:				
(A) Direct Production Costs:				
1. Raw materials: Mushrooms--350 lb. per hour for 8 hours = 2,800 lb. per day, at 30¢ per lb	840.00	331.58	840.00	331.58
2. Packaging materials:				
No. 10 cans at 13¢, containing 3.5 lb. net each, 72.4 cans per day	9.41	3.72	9.41	3.72
Cartons holding 6 cans, 12¢ each, 12.06 per day	1.45	0.57	1.45	0.57
Can labels--$5.00 per 1,000	0.36	0.14	0.36	0.14
Total packaging materials	11.22	4.43	11.22	4.43

3. Operating Labor: 2 men, 9 hours per day, 6 days per week.....	34.13	13.47	34.13	13.47
4. Indirect labor:				
Supervision--1 man, ¼ time	5.00	1.98	5.00	1.98
Office help.....	9.00	3.55	9.00	3.55
Total indirect labor.....	14.00	5.53	14.00	5.53
5. Maintenance and repair: For 130-day season, 4 percent of Fixed Capital per year; for 180-day season, 5 percent per year.....	17.47	6.90	15.77	6.23
6. Operating Supplies: 15 percent of (5).....	2.62	1.03	2.37	0.94
7. Utilities:				
Steam--4,050 lb. per day at 1.20 per 1,000 lb.....	4.86	1.92	4.86	1.92
Electricity--106 kw.-hr. per day at 1.2¢ per kw.-hr...	1.27	0.50	1.27	0.50
Water--6,000 gal. per day at 20¢ per 1,000 gal.....	1.20	0.47	1.20	0.47
Total Utilities.....	7.33	2.89	7.33	2.89
Total direct production costs (A)--Sum of (1) to (7).....	926.77	365.84	924.82	365.06
(B) Fixed Charges:				
8. Insurance--1 percent of Fixed Capital per year....	4.37	1.73	3.15	1.24
9. Taxes (real estate) 2 percent of Fixed Capital per year.....	8.73	3.45	6.31	2.49
10. Depreciation--40 yr. life on building, 12-1/2 years on equipment.....	29.95	11.55	21.12	8.34
Total fixed charges (B)--Sum of (8) to (10).....	42.35	16.72	30.58	12.07
(C) Plant Overhead Costs:				
11. Non-wage payments: Social Security, 4.2 percent of total payroll.....	2.02	0.80	2.02	0.80

Workmen's compensation, 1¼ percent of labor payroll, ½ percent of office.	0.47	0.19	0.47	0.19
Unemployment insurance, 3½ percent of total payroll..	1.68	0.66	1.68	0.66
Holiday pay (2 days for 130-day season, 3 days for 180-day season).....	0.74	0.29	0.80	0.32
Total non-wage payments....	4.91	1.94	4.97	1.96
12. Laboratories.....	4.00	1.58	4.00	1.58
13. Miscellaneous factory expense.....	2.00	0.79	2.00	0.79
Total fixed charges (C)--sum of (11) to (13).....	10.91	4.31	10.97	4.33
TOTAL FACTORY MANUFACTURING COSTS (I) Sum of (A), (B), and (C).....	980.03	386.86	966.37	381.47
II. General Expense:				
(D) Interest on working capital--6 percent.....	9.23	3.64	8.33	3.29
(E) Administration and General: 15 percent of operating labor, supervision, maintenance and repair, and supplies.....	8.88	3.51	8.59	3.39
TOTAL GENERAL EXPENSE (II)--Sum of (D) and (E).....	18.11	7.15	16.92	6.68
III. Cost to Make--Sum of (I) and (II)	998.14	394.01	983.29	388.15
IV. Selling Cost--6 percent of gross sales.....	71.16	28.09	68.32	26.97
V. Returns, Allowances, Discounts: 1 percent of gross sales.....	11.86	4.68	11.39	4.50
VI. Net Profit After Income Taxes: 12 percent per year on fixed capital.....	52.40	20.68	37.85	14.94
VII. Taxes on Income (State and Federal)--50 percent of net profit before income taxes.....	52.40	20.68	37.85	14.94
VIII. Selling Price--Sum of (III) to (VII).....	1,185.96	468.15	1,138.70	449.49

Financial Analysis
(Annual Basis)

		130-day Season	180-day Season
1.	Gross sales	$154,175	$204,966
2.	Returns, allowances, discounts--1 percent of line 1	1,542	2,050
3.	Net sales	152,633	202,916
4.	Production cost (factory mfg. cost X days of operation)	127,404	173,947
5.	Gross profit	25,229	28,969
6.	Other costs of operation:		
	Administrative and general	1,155	1,546
	Selling expense	9,250	12,298
	Interest on working capital	1,200	1,500
	Total, other costs	11,605	15,344
7.	Profit before taxes on income	13,624	13,625
8.	Taxes on income--50 percent of line 7	6,812	6,813
9.	Net earnings	6,812	6,812
10.	Earned on fixed capital (F.C.=$56,770)..pct..	12.0	12.0
11.	Selling price per pound	$4.68	$4.50
12.	Net earnings as percent of gross sales (100 X line 9 ÷ line 1).....pct..	4.42	3.32
13.	Depreciation	$3,802	$3,802
14.	Cash flow--line 9 plus line 13	10,614	10,614

Use of "Spots and Opens"

Raw mushrooms constitute the largest item of cost. Mushrooms of good quality and in good condition that cost 30¢ per pound are the standard processing grade. However, lower priced, lower quality grade mushrooms, called "spots and opens" because the material contains open veils, dark spots, or both, are available during most of the growing season. These are obtained toward the end of the productive period of a mushroom bed. Because of their less attractive appearance, they sell at a low price and their quality is more variable than the standard grade. However, "spots and opens" have been used at this Laboratory to make mushroom powder which is equal to that made from the standard grade mushrooms except for a slightly darker color. Use of "spots and opens" could lower the cost of the powder appreciably. Powder made entirely from "spots and opens," which cost about 18¢ per pound, could be sold for about $1.35 per pound less than powder made entirely from standard grade mushrooms. Use of part "spots and opens" and part standard grade would lower the cost proportionately. However, it should be emphasized that "spots and opens" vary widely in quality, and that only the better ones should be accepted for processing to powder.

STORAGE PROPERTIES

Organoleptic tests conducted at the Eastern Utilization Research and Development Division and by a private food company revealed that the initial flavor of drum-dried mushroom powder is equal or superior to that of powder from freshly prepared freeze-dried mushrooms. In order to determine the storage properties

of the drum-dried material, a test was conducted at this Laboratory with a trained taste panel of 17 to 23 judges.

Storage Conditions

The product used in the storage test was produced with 35 p.s.i.g. drum steam pressure, 4.6 r.p.m. drum speed, and a distance of 0.004 inch between drums. Its moisture content, determined by dehydrating 10-g. samples under vacuum for 6 to 7 hours at 84° F., was 6.5 percent. The product was in the form of flakes and was packed in 6 oz. cans, 25 g. per can. The cans were divided into three batches: the first, packed in nitrogen and stored in dry ice (treatment No. 1); the second, packed in nitrogen and stored at 70° F. (treatment No. 2); and the third, packed in air and stored at 70° F. (treatment No. 3). All cans were hermetically sealed. The oxygen content in the headspace of all nitrogen-packed cans was measured with a Beckman Model E-2 oxygen analyzer and found to be in the range from 0 percent to 1.1 percent.

Preparation of Samples and Tasting

Samples from each of the three treatments were periodically tasted after they were prepared by the following procedure:

Use 21 g. mushroom powder
3/8 teaspoon salt
3 tablespoons starch
3 cups of whole milk
270 cc. water

1. Add mushroom powder and salt to water and bring to a boil.
2. Make a slurry of the starch and some of the milk and add to the mushroom mixture.
3. Again, bring to a boil and cool until thickened.
4. Add the rest of the milk and heat to serving temperature.
5. Serve in paper cups, approximately 2 fl. oz. per cup.

Each member of the panel was presented with a standard sample (from treatment No. 1), which was not labeled, and with three coded samples (one from each of the three treatments). The taster was asked to compare each of the coded samples with the standard and to record the degree of difference on the following descriptive scale (3):

(a) Better than standard in flavor.
(b) Equal to standard in flavor.
(c) Below standard in flavor, no detectable off-flavor.
(d) Slightly off-flavor.
(e) Definitely off-flavor, not acceptable.

For statistical analysis, numbers from 5 to 1 were then assigned to the descriptive categories, e.g.: the sample considered "better than standard in flavor" was given a score of 5, while the sample that was "definitely off-flavor, not acceptable" received a score of 1.

Results and Discussion

Table 2 summarizes the mean flavor scores of each of the three treatments after 5, 7, and 9 months of storage. For each storage period, the highest numerical score indicates the treatment that gives a product closest in flavor to the standard. The numerical results were analyzed by analysis of variance. F-tests showed the difference between the sample means of each storage period to be significant at the 0.05 level; therefore, a mean comparison was made by the multiple range test described by Duncan (1).

The last column of the table shows that there was no significant difference at the 0.05 level between the three treatments after 5 and 7 months of storage. After 9 months, the panel reported the air-packed sample as significantly inferior to the hidden standard but equal to the nitrogen-packed sample. When the 9-month test was repeated, both the air-packed and the nitrogen-packed samples were reported significantly inferior to the hidden standard.

Table 2.--The effect of packaging and storage conditions on flavor stability of drum-dried mushrooms

Storage time (months)	Number of tasters	Mean flavor scores of-- Treatment 1 N_2 packed dry-ice storage	Treatment 2 N_2 packed 70°F. storage	Treatment 3 Air-packed 70°F. storage	Comparison of mean scores by Duncan's test 0.05 level
5	19	3.95	3.63	3.42	N.S.*
7	19	3.79	3.53	3.68	N.S.*
9	23	4.04	3.65	3.09	1 better than 3 1 and 2 N.S.* 2 and 3 N.S.*
9	20	3.90	3.15	3.20	1 better than 2 and 3 2 and 3 N.S.*

*N.S. = No significant difference at 0.05 level between mean scores.

However, as time of storage progressed a slight color difference among the samples was observed on reconstitution. To check whether this color difference affected the panel's reaction, a triangle test was carried out after 9-1/2 months of storage with the hidden standard as the odd stimulus and the air-packed sample as the two identical stimuli. Each of the samples was artificially colored with a different certified food color. Out of 21 tasters, only 7 were able to identify the odd sample. This showed that the results obtained in the storage test after 9 months had been influenced by the difference in color. It was, therefore, concluded that mushroom powder when packed in air can be stored at room temperature for at least 9 months without a significant change in flavor.

SUMMARY AND CONCLUSIONS

Drum-dried mushroom (Agaricus campestris) powder is a result of work directed toward the development of new mushroom products that could compete with imports in price and quality and, at the same time, would help expand the domestic market.

The process utilizes one of the most economical methods of dehydration. All the equipment is readily available commercially, and the processing steps are few and simple. To yield a 12 percent annual net profit on original fixed capital investment, the selling price of the product is estimated at $4.50 to $4.68 per pound when good quality fresh mushrooms costing 30¢ per pound are used. The selling price for the same net profit would be $3.10 to $3.30 per pound if the plant used lower quality mushrooms called "spots and opens" costing 18¢ per pound.

The flavor of the drum-dried powder is characteristic of the Agaricus campestris from which it is made. The powder is equal to or superior in flavor to freeze-dried Agaricus campestris. The freeze-dried product sells for about $9.50 per pound. Since the powder is produced from cultivated mushrooms, it is generally cleaner than the dehydrated imports, which are often infested with flies and maggots. The powder can be stored for about 9 months without significant change in flavor. All these properties of drum-dried Agaricus campestris make it ideally suited for use in many prepared foods, such as sauces, soups and gravies, and as a seasoning in the home kitchen.

PARTIAL LIST OF MANUFACTURERS OF EQUIPMENT

The companies listed below supply equipment which can be used for some of the steps in making drum-dried mushroom powder. The figure before the item is comparable to the item numbers in Figure 1 and in section on Equipment Summary.

1. Hopper-elevator

Blaw-Knox Co., Food and Chemical Equipment Div., 1543 Fillmore Ave., Buffalo, N.Y. 14211
The Jeffrey Manufacturing Co., 856 N. Fourth St., Columbus, Ohio 43216
A. K. Robins and Co., Inc., 713 East Lombard St., Baltimore, Md. 21202

2. Rod-reel Washer

Dixie Canner Equipment Co., P.O. Box 1348, Athens, Ga. 30601
A. K. Robins and Co., Inc. (SEE Item 1 for address)

3. Hopper-elevator

Same suppliers as for Item 1.

4. Disintegrator

The Fitzpatrick Co., 1001 W. Washington Blvd., Chicago, Ill. 60607
Rietz Manufacturing Co., 148 Todd Road, Santa Rosa, Calif. 95404

5. Pump

Jabsco Pump Co., 1485 Dale Way, Costa Mesa, Calif. 92626
Robbins and Myers, Inc., 1345 Lagonda Ave., Springfield, Ohio 45501

6. Drum Drier

Blaw-Knox Co., Food and Chemical Equipment Div. (SEE Item 1 for address)
Overton Machine Co., 407 South Front St., Dowagiac, Mich. 49047

7. Grinder

Same suppliers as for Item 4.

8. Containers

Goodyear Aerospace Corp., Akron, Ohio 44315
Union Steel Products Co., 900 Division St., Albion, Mich. 49224
United States Plastic Corp., 1550 Elida Road, Lima, Ohio 45805

9. Scale

Detecto Scales, Inc., 540 Park Ave., Brooklyn, N.Y. 11205
The Exact Weight Scale Co., Division of National Industrial Products Corp., 556 E. Town St., Columbus, Ohio 43215
Toledo Scale, Division of Toledo Scale Corp., 5225 Telegraph Road, Toledo, Ohio 43612

10. Can Closer

Dixie Canner Equipment Co. (SEE Item 2 for address)
FMC Corp., Canning Machinery Division, 333 W. Julian St., Box 1120, San Jose, Calif. 95108

11. Hand Trucks

The American Pulley Co., 4200 Wissahickon Ave., Philadelphia, Pa. 19129
Morris Truck & Wheel Co., Inc., 762 S. Forty Second St., Philadelphia, Pa. 19104
Orangeville Manufacturing Co., 2-20 North Main St., Orangeville, Pa. 17859

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