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MUSHROOM DRYING

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1.0 Introduction

The production of mushrooms for the fresh market is subject to the problems of fitting variable production to the market demands. In periods of high production mushrooms are often wasted for lack of market. Some of the excess material is sold at lower prices to canners. Drying has been suggested as one route which would be suitable for the use of excess production. Dried mushrooms are popular in Europe and the Orient and are presently available in specialty shops in Canada.

The study undertaken investigated briefly the feasibility of drying and the influence of various blanching, sulfiting and drying conditions on the mushroom quality.

2.0 Review of Literature

Readily available literature revealed relatively few studies on mushroom quality during drying.

Brunell et al. (1943) determined that dehydration of steam blanched mushrooms at 63° to 66°C to a moisture content of less than 5% yielded a product which compared favorably (upon reconstitution and cooking) with the fresh product. They determined that blanched mushrooms had better flavour than did unblanched, and obtained mixed results using various chemical dips as pretreatments.

Komanowsky et al. (1970) studied the effects of various chemical pretreatments and drying temperatures on flavour, colour, storage stability, and bacterial population. They determined that a two-stage drying procedure at 43°C and 77°C yielded the best product. The various chemical pretreatments yielded mixed results, with mild sulfiting improving the colour, and most others not affecting colour too much one way or another. Chlorine soaks were used to reduce bacterial populations.

Several other authors have investigated various factors affecting fresh and frozen mushroom quality.

MacCanna and Gormley (1968) discuss quality in fresh mushrooms as affected by moisture loss, colour change, and toughness. Gormley (1972) also discusses quality in frozen mushrooms as compared to steam blanched and unblanched samples.

Sveine et al. (1967) discussed the effects of various controlled atmospheres on the shelf life of fresh mushrooms. Staden (1967) experimented with irradiation as a method of prolonging fresh product shelf life.

Chen and Chen (1974) investigated the shrinkage of mushrooms during drying and found the rate of shrinkage to be related to drying rate. McArdle and Curwen (1962) investigated shrinkage in canned mushrooms, and found shrinkage related to spawn strain, pre-processing conditions, blanch time, canning medium and handling roughness.

Neumann (1972) investigated the use of a hot sorbitol dip prior to dehydration as a means of improving the rehydration characteristics of dehydrated vegetables.

3.0 Experimental

3.1 Material

The whole fresh mushrooms used in these tests were obtained from Continental Mushrooms Ltd., Metcalfe, Ontario. Some cream-coloured mushrooms were dried in the first two tests, with all other tests using the white variety exclusively.

Mushrooms were sliced, treated, and dried on day of receipt in all tests except #4. Mechanical problems delayed this run 24 hours.

Various slice thicknesses were tried, ranging from 0.0794 cm (1/32 in) to 0.635 cm ($\frac{1}{4}$ in). Most tests used a 0.3175 cm (1/8 in) slice, since this gave a satisfactory product within a reasonable drying time.

The sample of commercially dried mushroom studied in test #5 was an imported product from France, obtained locally through a retail delicatessen.

3.2 Drier

All tests were carried out in a commercial tray drier[a]. Sliced mushrooms were spread evenly on 46 x 71 cm trays; 2.2 kg per tray being a standard loading.

Drier temperature was controlled by a commercial controller[b] during all tests.

Airflow was adjusted to provide a cross and down pattern. Single pass circulation drew inlet air from the room and exhausted outside the building.

3.3 Pretreatments

Several pretreatments were tried in an effort to improve the quality of the dried and reconstituted product. These treatments are listed in table 1.

Combinations of treatments were used in many tests. For example, in later tests, a fairly standard method consisted of a water rinse, followed by slicing and then soaking in the desired concentration of sulfite.

The microwave oven used was a commercial unit[c] which produced 1700 watts (measured) while operating.

Sodium bisulfite concentrations from 50 to 400 ppm free SO_2 were used.

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[a] Proctor & Schwartz Inc., Philadelphia, Pa. - Machine No. K14741.

[b] The Foxboro Co., Foxboro, Mass. - Model 40 on-off temperature controller.

[c] Phillips Oven, Model HA2510 S/F.

The sorbitol[d] solution used in test #8 was diluted to 65% sorbitol concentration with water. The solution was held at approximately 75°C during the soak time.

3.4 Drying Conditions

The two-stage drying method, as recommended by Komanowski et al., was used on most tests. The mushrooms were dried for three hours at 43°C, then for one hour at 77°C. Final moistures ranged between five and seven percent (wet basis).

One test followed the recommendations of Brunell et al., and dried the mushrooms at a continuous temperature of 66°C for 2.5 hours.

When slice thickness exceeded 0.3175 cm (1/8 in), the drying time increased noticeably. Little effect was seen on drying time of thinner slices, presumably due to tray loading densities.

Once dried, the mushrooms were heat sealed in poly bags for storage and later evaluations of colour, SO_2 residuals and reconstitution.

No attempt was made to control the wet bulb temperature of the drier during tests. The relative humidity of the room did not appear to affect the drying time noticeably.

The samples were turned and mixed twice during each trial, once after the first 30 minutes, and again at the two hour mark.

3.5 Microbiology

Two sets of microbial tests were carried out by the microbiology group of the Food Research Institute on each sample. Total plate counts[e] and presumptive coliform counts[f] were performed on the samples of raw, pre-treated and fully dried mushrooms.

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[d] Bate Chemicals Ltd., Don Mills, Ontario.

[e & f] Standard Methods for Examination of Dairy Products, APHA, Edition 13

The effects of washing, blanching and drying on the bacterial counts have been tabulated in table 3.

3.6 Colour Measurement

Blanching, sulfite dips, drying time and temperature all affect the colour of the dried product.

The colour changes from raw to dried to rehydrated mushroom were determined on an Agtron M400A relative spectral reflectance meter[g].

To obtain standardized colour readings on rehydrated mushrooms, a 30 minute soak in cold tap water followed by a 5 minute draining period was used.

The same sample was used to measure dried and rehydrated colour.

4.0 Results and Discussion

A wide range of product appearance was produced by the series of experiments. In general, there was a sharp differentiation between blanched and unblanched material. The water blanched mushrooms were translucent in appearance as well as being much darker than the unblanched samples. The blanched mushrooms were very brittle in the dry state in contrast to the unblanched which were quite friable. The unblanched control samples (no sulfite) were a light brown with white highlights. The sulfite dips produced a yellowing of the samples with the intensity increasing with level. This colour trend was obscured in the 150°F dried sample (Test 4) because of the very dark appearance of this sample. The microwave blanched sample was very dark (Table 5) although the sulfite dipped microwave blanched was not as severely darkened. The sulfite dip appeared to wash some of the dark oxidized liquid exudate from the sufface of the sliced mushrooms.

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[g]Magnuson Engineering Inc., San Jose, California.

In the unblanched samples, the influence of sulfite dip concentration was evident. Samples dipped in 50 ppm sulfite were of very good light colour. These samples were lighter coloured than the control. The 200 and 400 ppm SO_2 dipped showed considerable yellowing and were not as attractive as the 50 ppm dipped samples. The unblanched samples were opaque and quite friable. The sulfited samples were slightly more friable than the controls.

The sorbitol soaked samples were in marked contrast to the other unblanched samples, although they were somewhat translucent as were the blanched. The sorbitol soaked samples were sticky and were at least double the density of the regular samples. The non-sulfite, sorbitol soaked sample was a gray-yellow colour while the sulfited sample had a pronounced yellow colour. The texture of the sorbitol soaked samples was unusual, in that it was quite flexible in the dry state and somewhat similar to dried fruit in texture.

The dry commercial sample from France had a very good light, white, opaque appearance quite comparable to the 50 ppm sulfite dipped non-blanched experimental samples.

For the rehydrated samples there was the sharp difference between the blanched and unblanched samples as there had been in the dry state. The texture of the blanched samples was very rubbery, whereas the texture of the non-blanched samples was tender. The blanched samples were generally dull in appearance with a gray colour. The yellowing showed with the 200 and 400 ppm SO_2 dipped samples. For the non-blanched samples the 50 ppm SO_2 had a light bright colour, but with the 200 and 400 ppm SO_2 dip the yellowing was pronounced and was considered objectionable. The no sulfite samples showed considerable browning on rehydration with the rehydration water becoming a reddish-amber colour.

The commercial sample also showed a high degree of browning on rehydration and was very similar to the non-blanched, no sulfite control samples.

The influence of treatment on colour is seen in table 5 with the most significant difference being the lighter colour of the non-blanched samples (the higher the reading the lighter the colour). Low readings for the sorbitol soaked material are also seen, although the difference is not as marked with the rehydrated samples.

Microbial counts for the different samples are seen in table 3. The raw product had total plate counts from 1×10^5 to 4×10^7 and coliform counts generally around 3 to 8×10^3.

The blanching treatments reduced the coliforms to a very low level (or undetectable level) as did the hot sorbitol soak. Blanching reduced the total plate counts by 1 to 2 log cycles. The SO_2 dip did not reduce the microbial counts to any significant degree. On the dehydrated blanched samples the counts ranged from 7×10^3 to 1×10^5 viable cells per gram of dry sample. If the total plate counts after pre-treatment and after drying are compared on a dry basis (i.e. the counts on the "after pre-treatment" material and fresh samples would be about 10 to 15 times as high if given per gram of dry material), the reduction in viable micro-organism numbers is reduced anywhere from $\frac{1}{2}$ to $1\frac{1}{2}$ log cycles. Counts on the commercial sample were in the same range as the non-blanched samples for both coliform counts and total plate counts.

Residual sulfite levels (Table 4) for the samples dipped in the various SO_2 concentrations varied from undetectable (50 ppm SO_2 dip) to 640 ppm (400 ppm dip). The higher residual levels (above 60 ppm) had a noticeable

yellowing effect on the samples in proportion to the residual levels and the 480 ppm SO_2 residual also had a deleterious effect on flavour.

The flavour of the non-blanched control and non-blanched 50 ppm dipped samples was judged to be very good. Higher residual sulfite levels were undesirable for flavour characteristics. The sorbitol dipped samples had an undesirable combination of sweetness and mushroom flavour. The non-blanched control and low sulfite were judged to be at least equivalent to the commercial sample. Rehydration characteristics of the mushrooms were not improved by the sorbitol soak treatment.

5.0 Conclusions

Very satisfactory dehydrated mushrooms may be prepared using a treatment of a 5 min 50 ppm sulfite dip followed by drying in two steps at 43°C for 3 hrs and finish drying at 77°C for 1 hr. Slice thickness of 3.2 mm (1/8 in) worked well in our trials and is judged useable. Thinner slices result in too many fines being produced and the thicker slices increase the drying time. Flavour, colour and texture of the non-blanched 50 ppm dip were judged as the best for the conditions tested.

Dehydrated mushrooms produced with this system were judged comparable with commercially available imported material and had better colour on rehydration than the commercial samples.

6.0 Acknowledgements

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Table 1

MUSHROOM PREDRYING TREATMENTS

TREATMENT	FUNCTION
None	Control
Water Rinse	Bacteria Reduction
Boiling Water Blanch (2 min)	Enzyme Inactivation, Bacteria Reduction
Microwave Blanch (3.5 min)	Enzyme Inactivation, Bacteria Reduction
Sodium Bisulfite Soak (5 min)	Inhibit Oxidative Browning
Hot Sorbitol Soak (10 min)	Osmotic Dehydration; improved rehydration

Table 2

SUMMARY OF TESTS

TEST	SAMPLE	TYPE & SLICE	WASH	SULFITE DIP (PPM)	WATER BLANCH	DRYING CONDITION	OTHER
1	1	.8 mm White	Nil	0	1.5 min		
	2	.8 mm Cream	Nil	0	1.5 min	43°C - 3 hrs	
	3	1.6 mm White	Nil	0	2.0 min	77°C - 1 hr	
	4	1.6 mm Cream	Nil	0	2.0 min		
2	1	3.2 mm Cream	Nil	0	2.0 min	43°C - 3 hrs	
	2	3.2 mm White	Nil	50	2.0 min	77°C - 1 hr	
	3	3.2 mm Cream	Nil	100	2.0 min		
	4	3.2 mm White	Nil	150	2.0 min		
3	1	3.2 mm White	Nil	0	2.0 min	43°C - 3 hrs	
	2	3.2 mm White	Nil	200	2.0 min	77°C - 1 hr	
	3	3.2 mm White	Nil	300	2.0 min		
	4	3.2 mm White	Nil	400	2.0 min		
4	1	3.2 mm White	Nil	0	2.0 min		
	2	3.2 mm White	Nil	50	2.0 min	66°C - 2.5 hrs	
	3	3.2 mm White	Nil	200	2.0 min		
	4	3.2 mm White	Nil	400	2.0 min		
5	1	3.2 mm White	Nil	0	Nil	43°C - 3 hrs	
	2	3.2 mm White	Nil	0	Nil	77°C - 1 hr	3.5 min micro-wave blanch
	3	3.2 mm White	Nil	0	2.0 min		
	4	3.2 mm White	Nil	200	Nil		3.5 min micro-wave blanch
6	1	6.4 mm White	Tap Water Rinse	0	Nil	43°C - 3 hrs	
	2	6.4 mm White	Tap Water Rinse	50	Nil	77°C - 1 hr	
	3	6.4 mm White	Tap Water Rinse	200	Nil		
	4	6.4 mm White	Tap Water Rinse	400	Nil		
7	1	3.2 mm White	Tap Water Rinse	0	Nil	43°C - 3 hrs	
	2	3.2 mm White	Tap Water Rinse	50	Nil	77°C - 1 hr	
	3	3.2 mm White	Tap Water Rinse	200	Nil		
	4	3.2 mm White	Tap Water Rinse	400	Nil		
8	1	3.2 mm White	Tap Water Rinse	0	Nil	43°C - 3 hrs	
	2	3.2 mm White	Tap Water Rinse	200	Nil	77°C - 1 hr	
	3	3.2 mm White	Tap Water Rinse	0	Nil		10 min 75°C Sorbitol Soak
	4	3.2 mm White	Tap Water Rinse	200	Nil		10 min 75°C Sorbitol Soak

Table 3

MICROBIAL COUNTS (PER GRAM OF MATERIAL) BEFORE AND AFTER PROCESSING

TEST	SAMPLE	RAW		AFTER PRETREATMENTS (A)		AFTER DRYING	
		COLIFORM	T.P.C.	COLIFORM	T.D.C.	COLIFORM	T.P.C.
1	-	25×10^5	40×10^6	-	-	<200	12×10^4
2	-	87×10^2	37×10^4	Nil	45×10^3 (B)	Nil	14×10^3
3	-	82×10^2	19×10^5	Nil	50×10^2 (B)	Nil	630 (C)
4	-	-	-	-	-	-	-
5	1	45×10^2	11×10^6	-	-	Nil	92×10^4
	2	-		10	33×10^4	Nil	80×10^3
	3	-		20	58×10^3	Nil	64×10^2
	4	-		30	82×10^3	Nil	70×10^2
6	1	-	-	-	-	Nil	12×10^5
	2	-	-	-	-	48×10^2	10×10^5
	3	-	-	-	-	96×10	18×10^4
	4	-	-	-	-	Nil	14×10^4
7	1	31×10^2	12×10^4	24×10^3	55×10^3	60×10^3	12×10^4
	2	-	-	23×10^3	30×10^4	16×10^3	18×10^5
	3	-	-	18×10^2	30×10^3	46×10^2	62×10^4
	4	-	-	22×10^2	38×10^3	36×10^2	14×10^4
8	1	-	-	800	83×10^3	20	47×10^3
	2	-	-	90	39×10^3	1×10^3	34×10^3
	3	-	-	Nil	35×10^2	Nil	27×10^3
	4	-	-	Nil	29×10^2	Nil	21×10^3
Commercial		-	-	-	-	21×10^2	80×10^4

A) See Table 2 for details of pretreatments

B) Water blanched only

C) Estimate due to mould contamination

Table 4

RESIDUAL SULFITE AFTER DRYING - MEASURED AS PARTS PER MILLION SO_2

TEST	SAMPLE	SULFITE DIP CONCENTRATION	DRYING TEMP.	% FINAL MOIST.	SO_2 RESIDUAL
2	2	150 ppm	43/77°	6	192 ppm
	3	0	43/77°	6	0
3	1	0	43/77°	7	0
	2	200	43/77°	7	152
	3	300	43/77°	7	192
	4	400	43/77°	7	400
4	1	0	66°	5.4	0
	2	50	66°	5.4	16
	3	200	66°	5.4	160
	4	400	66°	5.4	640
5	4	200	43/77°	6.4	72
6	1	0	43/77°	6	0
	2	50	43/77°	6	0
	3	200	43/77°	6	64
	4	400	43/77°	6	160
7	1	0	43/77°	6	0
	2	50	43/77°	6	0
	3	200	43/77°	6	64
	4	400	43/77°	6	480
8	2	200	43/77°	4.9	72
	4	200	43/77°	3.3	8
Commercial		N/A	N/A	10	17

Table 5

AGTRON COLOUR READINGS, FRESH, DRIED AND RECONSTITUTED MUSHROOMS

TEST	SAMPLE	FRESH			DRIED			RECONSTITUTED		
		RED	GRN	BLUE	RED 640	GRN 546	BLUE 436 mμ	RED	GRN	BLUE
1	4	-	-	-	16	10	4.5	22	16	6
2	1	-	-	-	16.5	9	3	22	15	5
	2	-	-	-	17	10.5	3	24	18	5.5
	3	-	-	-	9	5	2	13	8	3
	4	-	-	-	12	7	2.5	16	11	5
3	1	-	-	-	17	10	3	20.5	13.5	5
	2	-	-	-	18.5	11	3.5	23.5	17	6
	3	-	-	-	19.5	11	3.5	25	17	6.5
	4	-	-	-	18	11	3	24.5	17	6
4	1	-	-	-	12	7.5	3	13.5	9	3.5
	2	-	-	-	11.5	7	3	13	9	3.5
	3	-	-	-	12	7	3	14.5	10	3.5
	4	-	-	-	10	6	2.5	13.5	9	3.5
5	1	-	-	-	25.5	17	10	21	9	2
	2	-	-	-	10	5	2.5	10	4	0
	3	-	-	-	14	10	4.5	16	12	6
	4	-	-	-	17	10.5	5	15	8.5	3
6	1	54	36	23	31	20.5	11	30	17	4
	2	-	-	-	32	21	10.5	28.5	16	5
	3	-	-	-	35	22.5	9	31.5	19	4
	4	-	-	-	36	26	12	35	25	9.5
7	1	64.5	44	32	30.5	19.5	10	26	13.5	4
	2	-	-	-	39.5	27	13.5	33.5	20	6
	3	-	-	-	38	26	12	35.5	23	8
	4	-	-	-	48	34	15	49	37	12.5
8	1	-	-	-	32.5	22.5	12	32	20	6.5
	2	-	-	-	42	30.5	16	37.5	24	7
	3	-	-	-	22	14	4	30.5	21.5	7
	4	-	-	-	24.5	13.5	2.5	30.5	20	3
Commercial		-	-	-	47	35	22	29	15.5	8

NOTE: Black = 0

White = 90