

A Research Note
Explosion Puffing of Fruits and Vegetables

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ABSTRACT

Explosion puffing is a processing system which facilitates hot air drying of fruits and vegetables. Explosion puffed foods are easily rehydrated and have excellent sensory properties. The process costs are similar to the cost of conventional hot air drying. Previous publications have reported the results relevant to carrots, potatoes, apples, and blueberries. Sufficient research has been done on other fruits and vegetables to establish that they, too, can be satisfactorily explosion puffed and dried to yield a good product. The processing conditions for explosion puffing of mushrooms, celery, onions, peppers, rutabagas, beets, yams, pears, pineapples, strawberries, and cranberries are presented.

INTRODUCTION

DRYING is an ancient, yet still excellent method for preserving fruits and vegetables. Conventional hot air drying is very practical during the early stages of drying; but, when drying passes from the first falling rate period to the second falling rate period, drying becomes difficult (Van Arsdel et al., 1973). The product to be dried shrivels and case hardens (Van Arsdel, 1963). The drying slows dramatically in the second falling rate period, and much more energy is consumed than in the first period. Conventionally hot air dried products are difficult to rehydrate, frequently requiring more than 20 min in boiling water to fully rehydrate (Luh and Woodroof, 1988).

Freeze drying yields an excellent product (Luh and Woodroof, 1988). Freeze-dried products rehydrate rapidly and retain high quality; but, its expense, resulting from high energy and capital costs, prohibit its use for most commodities.

Explosion puffing of fruits and vegetables is a relatively new process, investigated for some years at the Eastern Regional

Research Center (Sullivan and Craig, 1984). Early batch work used a modified cereal puffing gun. After years of research and modification of a series of puffing guns, the continuous explosion-puffing system (CEPS) evolved.

Sullivan and Craig, (1984) have summarized explosion puffing research, both batch and continuous, and Heiland et al. (1977) have described the CEPS. Logically, most of the research centered on commodities that would command a large portion of the dried food market—potatoes and carrots for vegetables (Sullivan et al., 1977, 1980, 1983) and apples for fruit (Sullivan et al., 1981). In 1984 the Georgia Blueberry Association built a plant to explosion puff blueberries (Anon, 1984 and Sullivan et al., 1982).

During the research on both batch and continuous puffing, various other commodities have been studied on a limited basis. Usually the work was done as the result of a request for a particular product. The objectives of this research were to determine whether the commodities studied could be explosion-puffed and to establish acceptable processing conditions for those which could be puffed.

MATERIAL & METHODS

THE EQUIPMENT and process have been fully described in the earlier publications (Sullivan et al., 1977, 1984; Heiland et al., 1977).

The raw material was peeled, trimmed, washed, cut, and sized as appropriate. Celery, rutabagas, sweet potatoes, beets, peppers, and onions were cooked or blanched before drying to the proper puffing moisture; whereas, mushrooms, cranberries, strawberries, pineapples, pears, apples, and blueberries were dried without cooking. The preferred processing conditions for all products successfully puffed are listed on Table 1.

Because the puffed commodity was porous and easy to dry, finish drying to a safe moisture level (generally from 2–10% depending on the commodity) was done at 54–66°C to avoid scorching the product. Products were rehydrated by placing in boiling water for the required time—typically about 5 min.

Table 1—Processing conditions in preparation for explosion puffing

Commodity	Steam blanch, min	NaHSO ₃		Dry bulb temp	Moisture %	Size mm	Varieties
		%	min				
Celery	6	1/2	1/2	66	25	12.7	Calif. Paschal
Mushrooms	--	1	5	79	20	8.0	<i>Agaricus Lampestris</i>
Onions ^a	--	--	--	--	15	(slices)	Calif. White Globe/Creole
Peppers	2	1/2	2	77	19	12.7 × 12.7 × 19.1	Calif. Wonder
Beets	50	--	--	77	20-26	9.5	Detroit Dark Red
Rutabaga	6	1/2	6	82	25	9.5	--
Yams	8	1/2	1	77	25	12.7 × 12.7 × 19.1	Centennial
Pears	--	1	2	77	18	9.5	Anjou; Bartlett
Pineapple ^a	--	--	--	66	18	(chunks)	--
Strawberries	--	--	--	66	25	whole	Cardinal
Cranberries	--	--	--	77	17-26	whole	Champion/Early Black
Cranberries	--	--	--	77	24	sliced	Champion/Early Black
Potatoes ^b	15	1/2	1/2	93	25	9.5	Any variety
Blueberries	--	--	--	88	18	whole	Any variety
Apples ^c	--	1	5	82	15	wedges	Any variety
Carrots	14	--	--	95	25	9.5	Imperator

^a Preprocessing done by supplier.

^b Precooked @ 71°C for 15 min.

^c Add 0.75% (dry basis) granulated monoglyceride to prevent sticking.

RESULTS & DISCUSSION

ONIONS, peppers, rutabagas, beets, yams, and pears were successfully explosion puffed in the batch process. Pineapples, strawberries, and cranberries were successfully explosion-puffed in the CEPS. With only minor adjustments in the conditions used in the successful batch processing, celery puffed satisfactorily in the CEPS. The explosion puffing processing conditions for these commodities as well as those previously reported (potatoes, apples, carrots, blueberries, and mushrooms) are listed in Table 2.

In previous studies, Rome Beauty and Winesap apples as well as Rabbiteye blueberries were puffed. In this study, Granny Smith apples and New Jersey Bluecrop blueberries were used. There was virtually no difference in the processing conditions used. In fact, no fruit or vegetable successfully puffed in the batch system has subsequently failed in the CEPS.

Not all foods were successfully explosion-puffed. Legumes, such as beans, with a tough outer skin failed. The skin separated from the bean without puffing. Raisins scorched without puffing. Raspberries blew apart. Attempts at puffing peanuts

and coconut also failed. Grains, such as wheat, rye, amaranth, and rice, require pressure (>700kPa) beyond the system capacity. Meat could not be explosion-puffed.

Most of the products rehydrate in boiling water in 5 min. The three notable exceptions are yams, peppers, and pineapples. Yams take up to 10 min whereas peppers take 2 min and pineapple only 1 min. In fact, pineapple rehydrates in about 15 min in cold water. The rehydration times are included in Table 2.

CONCLUSION

CELERY, onions, peppers, rutabagas, beets, yams, pears, pineapples, strawberries, and cranberries can be successfully explosion-puffed in addition to potatoes, carrots, apples, mushrooms, and blueberries. Processing conditions to achieve a good product are listed. Only minor process adjustments are needed to account for natural raw produce variability.

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Table 2—Explosion puffing conditions for fruits and vegetables

Commodity	Type	Steam pressure kPa	Temp °C	Dwell time sec	Rehydration min
Onions	Batch	414	154	30	5
Peppers	Batch	207	149	45	2
Beets	Batch	276	163	120	5
Rutabagas	Batch	241	160	60	6
Yams	Batch	241	160	75	10
Pears	Batch	228	154	60	5
Pineapple	CEPS ^a	83	166	60	1
Strawberries	CEPS	90	177	—	3
Celery	CEPS	275	149	39	5
Carrots	CEPS	275	149	49	5
Apples	CEPS	117	121	35	5
Blueberries	CEPS	138	204	39	4
Mushrooms	CEPS	193	121	39	5
Potatoes	CEPS	414	176	60	5
Cranberries	CEPS	138	163	64	3

^a CEPS = continuous explosion puffing system

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