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CENTRALIZED FOODS--A MARKET PERSPECTIVE

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MARKETING ECONOMICS DIVISION
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DEHYDRATED FOODS--A MARKET PERSPECTIVE 1/

Output of dehydrated foods doubled from 1955 to 1965, attaining a level of 3.26 billion pounds. 2/ Milk products, mainly nonfat dry milk, constituted 80 per cent of the output. Potato products ranked second (table 11). Since 1965, output of dehydrated milk and potatoes has slackened. Growth in volume of other dehydrated foods has not been enough to offset this slack, resulting in a slight decline in estimated total output.

The current market status of food dehydration was part of a recent study to identify: (1) Levels of production, (2) competitive relationships between dehydrated foods and other forms, (3) market outlets, and (4) raw materials and processing costs for dehydrated foods. This article summarizes these findings and presents a perspective of dehydration as a part of the food processing and marketing industry.

Industry Development

Drying with manmade energy sources, often called dehydration, became important when natural-drying and other food preservation methods failed to meet war needs. Long-supply lines--and lack of refrigeration, storage, and transportation for bulky, highly perishable foods during World War II--created big outlets for dried milk, fruits, eggs, and vegetables. As a result of the new technology developed during the war emergency, more foods became preserved by drying, and the dehydrator segment of the food processing industry became more important.

Artificial drying has attained its greatest impact among commodities wherein alternative processing-preservation methods were not already widely applied. Thus, dehydrated milk, potatoes, onions, and

Table 11.--Production of dehydrated foods, firms surveyed and industry estimates, 1965-67

Product	: Dehydration	: 1965 volume	: Industry volume			
	: firms reporting in survey	: Report- ing firms	: Proportion of the total industry	: 1965	: 1966	: 1967
	: Number	Mil. lb.	Pct.	Mil. lb.	Mil. lb.	Mil. lb.
Dairy products	156	1,662.5	65	2,574.0	2,225	2,338
Meat and poultry	6	1.7	28	6.0	--	--
Egg products	14	46.3	92	50.1	51.1	70.7
Potatoes, onion and garlic :	18	245.5	61	402.9	<u>2/351.3</u>	<u>2/338.4</u>
Other vegetables	18	26.7	89	30.0	--	--
Fruits, berries, and melons:	8	16.8	76	22.0	--	--
Miscellaneous	8	72.7	97	75.0	--	--
Total	<u>1/213</u>	2,072.2	64	3,260.0	--	--

1/ Includes duplications because of firms that dehydrate two or more products.

2/ Potatoes only.

Source: Tabulated from mail questionnaires, interviews and selected statistics published by U.S. Department of Agriculture.

1/ Prepared by the Market Development and Performance Branch, Marketing Economics Division based on information supplied by Battelle Memorial Institute, under contract with ERS, USDA.

2/ Excludes the following commodity groups often marketed in dehydrated forms: Imported products (mainly coffee and tea), cereals, nuts, seeds, sundried fruits, cured meats, and various food additives, essences, spices, and extracts.

garlic have attained the largest market share recognitions in comparison with other product forms (table 12).

Dehydrators process more than 70 commodities in 9 perishable-commodity groupings. Moisture content is a critical standard of quality of dehydrated foods. Industry and government buying tolerances for moisture contents range from 1.1 percent for freeze-dried applesauce up to 9.0 percent for instant rice. Low moisture levels, attainable with artificial drying, achieve long shelf life as well as compatibility as ingredients in dry foods.

Dehydration results in lowered transportation and storage costs. These savings often make the dehydrated product the economic choice, particularly when the location of production is a great distance from the market. For example, apples produced and dehydrated in the Northwest and marketed in the East ranged in price from 80 to 94 cents per pound (with 2 or 3 percent moisture). Alternative fresh or canned apples would need to be priced at less than 13 cents per pound to be equal in cost per unit of solids. 3/

Table 12.--Dehydrated products: Raw material equivalents and relationship to total domestic use, 1965

Product	: :Dehydrated :production	: :Conversion :factor <u>1/</u>	: :Raw material :equivalent	: :Total domestic :food use	: :Dehydrated pro- :duction as a :proportion of :total food use
	: : <u>Mil. lb.</u>		: : <u>Mil. lb.</u>	: : <u>Mil. lb.</u>	: : <u>Pct.</u>
Dairy products.....	2,574.0	11.0	28,314	<u>2/</u> 8,260	<u>2/</u> 31.2
Meat and poultry.....	6.0	3.0	18	<u>3/</u> 42,025	<u>4/</u>
Eggs.....	50.1	3.8	190	<u>5/</u> 7,871	2.4
Potatoes.....	355.5	7.2	2,560	<u>6/</u> 21,950	16.2
Onions and garlic...	47.4	6.5	308	<u>7/</u> 2,480	12.4
Other vegetables.....	30.0	13.0	390	<u>8/</u> 31,359	1.2
Fruits, berries and melons.....	22.0	9.7	213	<u>9/</u> 29,186	0.7
Miscellaneous.....	75.0	10.0	750	--	--

1/ Multiple to convert dehydrated weight to raw material equivalent weight. The products chosen to represent the 8 commodity groups were, (1) skim milk, (2) cooked beef, (3) whole fresh eggs, (4) fresh Idaho potatoes, (5) fresh onions and garlic (average), (6) fresh peas, green peppers, and carrots, (7) fresh strawberries, apples and peaches and (8) "miscellaneous" is the average of conversion factors for fruits and vegetables and potatoes. (From Conversion Factors and Weights and Measures for Agricultural Commodities and Their Products, Stat. Bul. No. 362, ERS-USDA)

2/ Milk solids-not-fat in all dairy products. (Total civilian use plus military and domestic donations). Dehydrated production is 31.2 percent of this total not-fat-solids consumption.

3/ Carcass weights of red meats, and poultry.

4/ Less than one-tenth of one percent.

5/ 5,014 million dozen eggs at 1.57 pounds per dozen.

6/ Fresh equivalent.

7/ Commercial production, less shrinkage and loss.

8/ Market weights of fresh and processed products, excluding potatoes.

9/ Market weights of fresh and processed products, including juices.

3/ Average wholesale prices for apples in New York in 1966 were: Fresh Northwest apples, 14.9 cents a pound; canned applesauce, 14.1 to 16.0 cents a pound. In contrast, Washington State air-dried apple slices were 38.2 cents a pound.

However, factors other than solids content are relevant. Taste, flavor, odor, appearance, structure and yield (rehydration ratio) also are important in ingredient selection. Until dehydrated products satisfy more of these criteria, they will be most frequently used when low moisture content is an essential property of the final product.

Most research by dehydrators and equipment suppliers is devoted to refinements in processing and product quality improvement. The unique processing methods and equipment requirements for dehydrating most commodities prevent easy transfer of benefits from successful development for one dehydrated product to another. So far, it has not been economically or technically feasible to produce dissimilar dehydrated products from one facility, as often can be done with canning or freezing. In addition, market acceptance of one dehydrated product has not increased demand for other commodities in dehydrated form, although success for one sparks product development efforts for others. Because of each commodity's uniqueness in processing and marketing, future expansion will depend more on discovery and exploitation of individual dehydrated commodities, rather than on a gradual growth in use of the technology among other products to the same levels attained by the current leaders.

Dehydration Technology

The study of dehydrated food processing and marketing indicated that the basic technology of dehydration is not expected to change radically. The three basic methods for removal of water by thermomechanical systems are: (a) Conduction or radiation (contact or exposure of food material to a heated surface or radiant source), (b) convection (exposure of food to a heated, moisture absorbing, air draft), and (c) vacuum-plus-heat (lower pressures increase vaporization rates of water).

Freeze-drying is the most exotic and expensive vacuum-plus-heat method. It

produces low temperature and pressure conditions sufficient to sublimate water vapor from ice in the food product and to condense and freeze it on another surface within the vacuum chamber. The principal advantages of this method are the minimum losses of volatile flavor components, and rapid rehydration of the dehydrated product.

There are many equipment design and operation variables applicable to all three methods that affect drying costs, and quality of products obtained. Loesecke ^{4/} identified (1) design of equipment, (2) air flow rate, (3) temperature, (4) ratio of recirculated air, (5) rate of product throughput, (6) structure of product, and (7) percentage and characteristics of bound water in the product as critical cost-affecting variables. Consumption of energy due to these variables can range from 1,500 to 5,000 Btu's per pound of water removed.

Costs of drying are lowest when the product (1) does not have a cellular structure, (2) is heat stable, (3) its water is not strongly bound up with the solids, and (4) becomes "dry" at a relatively high moisture level. Instant nonfat dry milk with 4 percent moisture and potato flakes or granules with 7 percent moisture are examples that are near the optimum in these characteristics.

As dehydration activity shifts toward more expensive and difficult-to-dry products, costs per unit of dried product increase (table 3). Evaluation of the technological progress attained so far for dehydrated foods indicates that unit costs have not attained an equilibrium level, but will be higher per unit of dehydrated product as expansion of activity is sought among more meat, poultry, fruit, and vegetable products.

Dehydration also is used on already-processed forms of foods. Frozen, or air-dried fruits and vegetables, cooked meats, cheeses, or canned foods are

^{4/} Loesecke, H.W. Drying and Dehydration of Foods, Reinhold Pub. Co., New York, 1955. 300 pp.

Table 13--Cost of dehydrating selected foods by type of equipment and size of plant 1/

Product	Dehydration equipment	Plant size			
		Small		Large	
		Output per day	Drying cost per pound	Output per day	Drying cost per pound
		Pounds	Cents	Pounds	Cents
Nonfat milk.....	Spray dryer	48,000	1.00	96,000	0.81
Potato flakes.....	Drum dryer	18,000	2.61	72,000	2.09
Sweet potato flakes....	Double drum dryer	15,600	2.53	46,800	2.06
Potato dices.....	2-stage continuous belt dryer	17,330	2.10	69,310	1.82
Onions.....	5-stage continuous belt dryer	24,000	3.04	144,000	2.54
Bell peppers.....	5-stage continuous belt dryer	16,840	4.27	50,520	3.94
Tomato flakes.....	Foam-mat dryer	7,400	7.99	14,000	7.10
Fruit powder.....	Foam-mat dryer	9,250	6.39	17,500	5.68
Fruit crystals.....	Vacuum belt dryer	6,600	14.66	11,000	12.59
Cooked chicken.....	Freeze-dryer	6,800	9.4	27,200	6.3
Cooked beef.....	Freeze-dryer	5,800	10.8	23,200	7.2
Cooked shrimp.....	Freeze-dryer	3,700	17.1	14,800	10.3
Mushrooms.....	Freeze-dryer	1,100	48.4	4,400	31.3

1/ Based on a 3-shift day and 250 days of operation per year. Costs are estimated for drying operations only. Costs of raw materials and their preparation prior to drying, as well as costs of packaging, storage and other marketing operations for the dried products were not included in the model plant cost estimates.

Source: Kermit Bird, Freeze-Drying of Foods: Cost Projections, MRR-639, ERS, USDA, 1964.

frequently dehydrated for use in dry soups, entrees, desserts, or other food products.

Dehydrated Food Markets

Dehydrators sell their products into three major markets. In order of volume, they are (1) remanufacturers, (2) the government, and (3) consumers directly. Since about half the total movement to market goes through remanufacturers, acceptability of dehydrated foods in remanufacturing is the dominant marketing factor. When the remanufactured food is in a dry form, dry ingredients are essential. If the dry ingredient must be rehydrated before use, its desirability decreases.

Appraisal of market potentials for profitable application of dehydration technology to different commodities reveals

greatly different factors of determination. For example, fruit dehydration opportunities cannot be equated to milk and potato experiences. Dehydration filled a well-recognized need for an alternative market form of milk and potatoes. Burden-some surpluses and distressed farm prices caused industrywide interest and support for development of dehydrated products from milk and potatoes. In contrast, fruit processing and marketing alternatives already available include drying, canning, preserving, freezing, and cold storage. These provide producers with alternative markets and consumers with diverse and highly acceptable forms of fruit for year-round use. The one exception may be dry foods or mixes that include fruit.

Red meats, poultry, potatoes, and other vegetables have to be made into slices, dices, or purees and partly or fully cooked before dehydration. This pre-drying treatment limits their menu applications to items such as soups, purees, casseroles, and stews. Thus, market potentials for the dehydrated products are clearly associated with the frequency of use and preferences of consumers for these dishes.

Dairy Products: Dairy products are a major volume dehydrated commodity group with nonfat dry milk as the most important item. Dehydration reduces weight and transportation costs, and greatly extends shelf life of nonfat milk solids. Surpluses of skimmed milk convert to stable, low-mass products acceptable in domestic and foreign outlets. Rehydration is simple and afterwards the product can be used interchangeably with fresh skim milk products. The production of major dehydrated dairy products is shown in table 14.

The market survey of dehydrated milk products revealed (1) the dehydrated form must be available to the user at prices below alternative fresh forms, (2) that convenience-in-use includes lower weight, easier storage, and other cost- or effort-saving advantages to the user, but that these conveniences do not outweigh the importance of lower prices, and (3) non-fat dry milk is most often chosen by food manufacturers for its binding, flavor carrier, bodying, and lowest nutrient cost characteristics when used as a dry product ingredient. In beverages, bakery, and other semiliquid ingredient or product uses, fresh skimmed, evaporated, or condensed milk are often preferred substitutes for the dry form. Dried whey and lactose often are used as ingredients of foods instead of nonfat dry milk.

Meat and Poultry: Meat and poultry products are marketed with a wide range of moisture contents. Pork products have moisture levels ranging from 69.3 percent

Table 14.--Production of dehydrated dairy products, 1955-67

Year	: Nonfat milk	: Whole milk	: Buttermilk	: Whey	: Cream	: Total
: - - - - - <u>Million pounds</u> - - - - -						
1955.....	1,410	108	58	196	0.8	1,773
1956.....	1,490	110	64	212	.8	1,877
1957.....	1,624	103	70	232	.5	2,030
1958.....	1,710	88	77	233	.6	2,109
1959.....	1,723	90	81	247	--	2,141
1960.....	1,818	98	86	277	--	2,279
1961.....	2,020	82	89	271	.2	2,462
1962.....	2,285	86	86	285	.7	2,743
1963.....	2,097	91	88	317	1.0	2,594
1964.....	2,177	88	92	362	.6	2,720
1965.....	1,993	89	87	404	1.0	2,574
1966.....	1,579	94	81	471	--	2,225
1967 <u>1/</u>	1,675	74	72	497	--	2,318

1/ Preliminary.

Source: Agricultural Statistics, USDA, 1960 and 1966; 1966 Census of Dry Milk Distribution Trends, The American Dry Milk Institute, 1967; and Dairy Situation, ERS, USDA.

for fresh to 8 percent for dry salt-cured products. ^{5/} Freeze-drying, which starts with already cooked pork, reduces moisture from as high as 56 percent to below 3 percent.

Retail markets for dehydrated meats include camper supplies and as minor ingredients in dried convenience foods (dry soup mixes, casseroles, and other traditional meat-flavored dishes). Manufacturers of dried foods say they can obtain the flavor and aroma of meat by using spices and synthetic flavorings, but actual pieces of meat enhance appearance and are essential to "put meat on the label." An estimated 64 percent of the 5 to 6 million pounds of dehydrated meats made in 1965 went into retail sales. Exports took 16 percent, institutional users 14 1/2 percent, while government, remanufacturers, and military purchases combined took the remaining 5 1/2 percent.

Because various low-cost processing methods yield a wide variety of red meat and poultry products with low moisture content and long shelf-life at competitive prices to fresh meats, freeze-dried meats at high prices are unlikely to attract other than highly specialized uses.

Eggs: Almost all dehydrated eggs are spray-dried. About 75 percent of dried eggs are used in food manufacturing. Government purchases, including military, took 7.5 percent of 1965 production, exports 5.4 percent, and retail about 4.4 percent. The remaining 8 percent went to miscellaneous or unknown uses.

Dried eggs compete in many uses with frozen liquid egg or shell eggs. Table shows U.S. production and market volume relationships between dried eggs and fresh and frozen liquid egg.

Higher cost for dried eggs, in comparison with frozen liquid egg, is the principal reason found for slow growth in dried egg use (table 15). Remanufacturers generally contrast the performance of dried eggs with

frozen liquid egg. However, because dried egg solids cost food manufacturers substantially more than liquid frozen or shell eggs, dried egg solids are used most in products that specifically require dry ingredients (table 16). Dry mixes sold for baking, puddings, desserts, and other egg-containing convenience-foods are growth areas and the primary determinant of market growth for dried eggs.

Potatoes: Dehydrated potatoes have attained a substantial share of total potato sales. Dehydrators have bought around 2 billion pounds of fresh potatoes annually since 1964. Fresh potatoes sold for dehydration have accounted for 15 to 20 percent of total potatoes used in processed products. Frozen, canned, and fried potato products and starch and flour compete with dehydration for the fresh potatoes utilized in processed potato products.

The dehydrator normally uses potatoes unsuited for fresh marketing, because of defects, misshapes, and undersizes. Peel and trim losses range from 5 to 48 percent, depending on quality of potatoes used. Average loss is about 25 percent. Shrinkage, which depends on the solids percentage in the fresh potato, differs by variety, storage, weather and cultural practices of producers. In 1966, surveyed potato flake makers were operating at only three-fourths of capacity, due mostly to supply conditions.

Dehydrated mashed potatoes, as flakes or granules, are about 90 percent of the dehydrated potato product consumption. Dice, slices, and pieces are the remaining 10 percent. Dehydrators estimated that about 70 percent of the granule and flake output goes to food service outlets and retail food stores. They compete with fresh potatoes served in mashed forms as well as in soups, gravies, or casseroles where a mashed potato ingredient is desired. Other important market outlets are as ingredients in prepared foods such as dry soup mixtures, bakery doughs, and frozen entrees. Government purchases for donation

^{5/} Composition of Foods. Agr. Handb. 8, (Rev.) ARS, USDA, 1963.

Table 15.--Liquid egg production and disposition, and market shares of dried eggs, 1958-67

Year	Liquid egg production	Disposition				Market shares	
		Fresh	Frozen	Frozen eggs later dried ^{1/}	Dried	Dried share of total production	Dried share of frozen and dried
		-1,000 pounds-				Percent	Percent
1958.....	480,798	31,334	350,886	15,815	98,578	20.50	21.93
1959.....	701,320	51,163	435,722	10,357	214,435	30.57	32.98
1960.....	582,466	44,025	362,366	8,123	176,075	30.22	32.70
1961.....	637,270	50,276	370,918	2,989	216,076	33.90	36.81
1962.....	634,764	55,473	381,683	4,885	197,608	31.13	34.11
1963.....	587,018	57,849	362,791	6,710	166,378	28.34	31.44
1964.....	658,961	68,105	381,606	2,924	209,250	31.75	35.41
1965.....	628,792	44,384	368,309	--	216,099	34.36	36.97
1966.....	621,392	40,310	356,440	--	224,642	36.15	28.65
1967.....	801,691	59,493	434,864	--	307,334	38.33	41.40

^{1/} Included in preceding column showing frozen in terms of liquid, beginning 1965, not available. Source: Statistical Reporting Service, USDA.

Table 16.--Cost comparison of dehydrated eggs versus other forms in major uses

Dehydrated eggs	Use or end product	Substitutes for dried eggs	Purchase cost index of substitutes ^{1/}	
<u>Powdered (Whole and Blend)</u>	Cookies, dough	Fresh eggs	45	
		Frozen eggs	62	
		Broken in plant	57	
	Eggnog, ice cream	Fresh eggs	45	
		Frozen egg	62	
		Broken in plant	57	
<u>Powdered Yolk</u>	Salad dressings	Frozen yolk	85	
		Liquid yolk	75	
	Eggnog, concentrates	Frozen yolk	76	
		Liquid yolk	66	
	<u>Dried Albumen</u>	Candy (whipping agents)	Frozen albumen	40
			Liquid	60
Bakery use		Frozen	72	

^{1/} Cost index = $\frac{\text{Purchase price of substitute}}{\text{Purchase price of equivalent amount of dried egg product}} \times 100$

A figure of 100 means equality in cost. Figures less than 100 mean that the substitute is lower in cost than the dried egg product.

and military uses, and exports have taken about another 15 percent of the output each year.

On the basis of the cost of potato solids, dehydrated potatoes are more expensive than fresh. Convenience and labor saving appear to account for the rapid growth and high rate of current usage of dehydrated potatoes.

Onions and Garlic: Most dried onions and garlic are marketed to food processors who use them as seasonings. Some go to away-from-home food service establishments and small quantities go to retail, export, and military purchases. The dehydrated products compete with fresh onions or garlic or their extracted juices or oils. They also have important utility in many uses due to their dry state. Advantages from convenience in storage, preparation, and use often favor the dried forms, even at higher prices than fresh forms.

A wide variety of prepared foods and mixes contain onion or garlic as flavoring. Cheese foods, cold cuts and sausages, potato chips, crackers and snack items, liquid and dry-mix salad dressings, catsup, and chili sauces were frequently reported uses. Because of the distinctive flavor of onion or garlic their presence is usually declared on the product label. Because of their compatibility with many processed food products and consumer awareness of them in foods, major outlets for the dried forms have developed, even though they are often only minor components in food products.

Other Vegetables: This group of dehydrated products includes 20 items of varying importance. About one-third of the "other vegetable" volume in 1965 was chili peppers. Carrots, bell peppers, and tomato powder combined amounted to another one-third. Asparagus, celery, cabbage, chives, corn, green beans, peas, pumpkin, green onions, shallots, parsley, lima beans, dill, mint, horseradish, and mushrooms as well as others comprise the remaining one-third. Amounts of each commodity dehydrated vary from year to year.

More than 20 firms operate "other vegetable" dehydration facilities and produce several different commodities. Most supplies come from contract production.

Market outlets for "other vegetables" are mostly other food processors (81 percent). Generally, dehydrated vegetables are rated inferior in quality to fresh or frozen forms and therefore food processors limit their use to products wherein dry ingredients are needed such as dry mixes for soups, sauces, casseroles, and gravies.

Many of the "other vegetables" are used to season, spice, or add variety to meat loaf, casseroles, meat pies, pizza garnishes, and other dishes. Like onions and garlic, they can create product diversity at a minimum added cost to the processor.

The market growth for "other vegetables" was shown to be closely related to growth of markets for dry food mixes and fully prepared or composite foods in which a change of a seasoning ingredient can produce a "new" product.

Fruits and Berries: Fruits and berries dried to less than 10 percent moisture are classed as dehydrated. Up to 1966, volume of all products was less than 20 million pounds a year. Berries were a minor part of this total, largely because of high costs for drying in freeze-dryer facilities. Dehydrated apples, prunes and dates were about 70 percent of dehydrated fruit and berry output.

Air-dried fruits with low moisture contents are marketed in much greater volumes and at much lower prices than dehydrated fruits. Specialty products with specific requirements for ingredients with less than 10 percent moisture are the major potential market for dehydrated fruits and berries. Such dry ingredients are required in breakfast cereals and packaged dry mixes (desserts, puddings, ice cream, and certain pancake, cookie, and cracker formulations). When a fruit ingredient is included in dry formulations, it must meet the low-moisture

criteria of the whole mixture. Uses of dehydrated fruits other than in these specific uses were not identified during the survey. Future market growth for dehydrated fruits and berries appears to be limited to uses as minor ingredients in some fruit-flavored dry food products.

Miscellaneous Foods: This group consists of many commodities and food products marketed in dried form. Beverage powders, for example, can be made from citrus or deciduous fruits, vegetables, or from extracted concentrates, such as coffee and tea. Product and market development of beverage powders from fruits and vegetables is centered on tomato powder and orange crystals for institutional, retail, and export outlets.

Instant rice is an important cereal grain product produced by dehydration. Users receive the conveniences of quicker rehydration and shorter home preparation time as a result of dehydration of pre-gelatinized rice kernels. Dehydration or

"instantizing" gives rice a convenience-food form to compete with other cereal grain and potato products.

Dehydrated mushrooms produced in the United States do not compete in quality or price with imported dried mushrooms. The freeze-dried domestic mushroom is priced 5 to 10 times higher than the air-dried imports (\$12 to \$15 per pound versus \$1.50 to \$2). The principal users of dried mushrooms are food processors and remanufacturers. At the time of the survey, remanufacturers reportedly preferred imported mushrooms on account of better appearance, less fragility, and lower prices. Since the domestic dehydrator must pay about 50 cents a pound for fresh mushrooms, and use 6 to 7 pounds to yield 1 pound of freeze-dried product, his markets are mostly specialty uses requiring under 3 percent moisture and strict sanitation control during processing.

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