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NEW ENERGY SAVING TECHNIQUES FOR THE PRODUCTION OF DENSE FOODS, (U)
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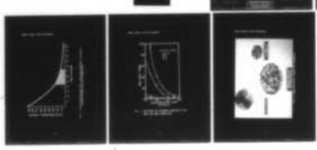

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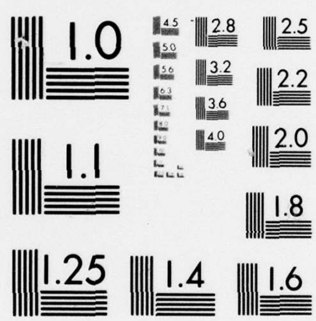

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NEW ENERGY SAVING TECHNIQUES FOR THE PRODUCTION OF DENSE FOODS,

JUN 1978

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INTRODUCTION

Dehydration has long been recognized as a successful method of preserving and reducing the weight of foods. Among the many drying methods, freeze-drying has shown to yield a very high quality finished product although with no significant reduction in volume. Therefore, research has been concentrated during the past few years on volume reduction of such dehydrated foods by compression. The use of dehydrated compressed foods compared to non-dried, non-compressed counterparts, results in savings in packaging, transportation and storage costs, since volume and weight are reduced by several fold. Benefits to combat operations are not only realized in military feeding systems but in logistics for the combat soldier, for underwater and surface naval vessels, and for aircraft and space vehicles. Ecological benefits due to reduction of packaging wastes are an added dividend.

THE PROBLEM

The current process for the production of many high quality dense foods requires complete freeze drying, rehumidifying, equilibrating, compressing and re-drying to a low moisture level to provide storage stability. It is time and energy consuming, inefficient and expensive.

THE OBJECTIVE

The objective of current studies reported here is to

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develop new techniques for the production of dense (compressed) foods with major emphasis on:

1. Energy savings
2. Increased throughput
3. Optimum use of equipment

REVIEW OF LITERATURE

Freeze drying, also known as sublimation drying or lyophilization, is the removal of water as vapor from a frozen product under vacuum (1). Even though the result is products of high quality, it remains an expensive process. There is little volume reduction from the original food form. However, volume reduction ranging from 4 to 16-fold can be achieved by compressing the freeze dried products without adverse effects on their overall quality (2,3,4). Hamdy, Ishler and Brockman (5,6,7) described the current conventional technique for the production of reversible foods. The product is prepared by blanching, chemical or physical pre-treatment as applicable, freezing, freeze drying, humidifying, equilibrating, compressing, re-drying and packaging. Thermal plasticization of high sugar content freeze dried products has been reported by Rahman, et al (8). The current industrial practices for moisturizing freeze dried foods prior to compression include steaming and water misting to 5 to 20 percent moisture, equilibrating and then compressing (9). MacPhearson (10) indicated that carrot bars of good quality can be produced by spraying with water to about 14% moisture level. Most of the research in the area of dehydration and compression has been with vegetables. Gooding and Rolfe (11) reported that during World War II, the United Kingdom produced dehydrated cabbage and carrots in compressed blocks. Other dehydration techniques which require less energy than freeze drying such as vacuum drying and air drying have also been used in the production of compressed foods (12). A compact shelf stable cabbage product especially suitable for use in cole slaw, was prepared, using air drying at a temperature of 55°C. Addition of a surfactant facilitated rehydration of the compressed cabbage (13, 14). Compressed peas, carrots, green beans and spinach have been successfully produced by: 1 - partial freeze drying (10-30% moisture), 2 - applying microwave energy (1-3 minutes), 3 - compressing, 4 - further drying, and 5 - packaging (15).

EXPERIMENTAL PROCEDURE

1. Partial Freeze-drying and Compression (Fig. 1).

Carrots: Fresh carrots of the variety Emperator, were peeled, cut into 1 cm dice and blast-frozen at -30°C. The frozen diced carrots were placed in trays at about 1 gm/cm^2 and freeze dried for about 5 hours, 3 hours at 120°C and then 2 hours at 80°C to a moisture level ranging from 15-20 percent (Fig. 2). This compares with 12-15 hours for conventional (industrial) freeze drying time, a saving of at least 50%. The partially freeze dried carrots were then placed in polyethylene bags (about 100 gm/bag) and treated with microwave energy either in a stationary unit rated at 0.625 KW and exposure time ranging from 10-60 seconds, or in a conveyorized microwave oven at 1.25 KW and exposure time ranging from 1-3 minutes. The treated carrots which were sufficiently plasticized, were compressed at pressures ranging from 70,000 to 210,000 Pa to form either bars (2.5 x 7.5 x 1 cm) or discs (9 cm in diameter and 1 cm thick). The compressed products were then further dried to about 3 percent moisture by vacuum drying.

Peas: Commercially frozen peas were mechanically slitted and then sulfited by soaking in a solution containing 5 gms of sodium meta bisulfite per liter. The drained peas were then frozen, freeze dried, microwave treated, compressed and further dried as above.

2. Air Drying and Compression

Cabbage: Fresh cabbage was cleaned, cored and sliced into 0.5 cm shreds. The shredded cabbage was sulfited by soaking in a solution containing 5 gms of sodium meta bisulfite per liter. The treated cabbage was then air dried at a starting temperature of 93°C which was lowered within 15 minutes to 55°C. The dehydration was continued until the moisture content reached about 5 percent within about 4 hours. The dehydrated cabbage was re-moistened by spraying with a water solution containing either Tween 60 or 80 as a surfactant, to increase the weight by about 12 percent. The moistened cabbage was then compressed at pressures between 70,000 - 140,000 Pa into discs (9 cm diameter and 1 cm thick). The discs were then re-dried to about 5 percent moisture for stability. For comparison, freeze dried and compressed cabbage treated with calcium as a firming agent was also prepared.

3. Test Procedures

a. Technological panel evaluations were conducted by ten trained judges using a 9-point scale ranging from 1 - Extremely poor to 9 - Excellent.

b. Compression Ratio: A No. 2½ can was filled with compressed discs leaving about 0.5 cm headspace and then weighed. Uncompressed dried product of equivalent weight to the compressed was packed loosely in No. 2½ cans leaving the same headspace. The number of cans utilized to pack the loose product gave the compression or packaging ratio.

c. Rehydration Ratio: A weighed dehydrated and compressed product was placed in boiling water for 10 minutes, drained for 5 minutes and weighed. Rehydration ratio was determined by dividing the rehydrated weight by the dry weight.

d. Fines: The amount of fines was determined by weighing the total sediment after rehydration.

e. Peroxidase: Testing for peroxidase enzyme was performed in accordance with A.O.A.C.

RESULTS AND DISCUSSION

Table 1 indicates that total inactivation of the enzyme peroxidase was achieved by applying microwave energy for one minute to the partially freeze dried carrots at 17 percent moisture. Blanching time is reduced as the microwave power and energy input is increased. This provides a significant advantage since it eliminates the need for water or steam blanching in the production of dehydrated vegetables. Accordingly, a better quality product at a reduced cost is realized. Tables 2 and 3 and Fig. 3 show that time exposure to microwave energy at a given power level determines the amount of fines caused by crushing of the unplasticized portion of the treated product. The optimum time of exposure to microwave energy depends upon the product and its moisture content. The amount of fines in the rehydrated untreated product was so excessive (50-90%) that the product was considered unacceptable. The results of technological panel evaluations of rehydrated compressed peas produced by the conventional technique and by the new partially freeze dried and microwave treated technique, as shown in Table 4, indicate no significant differences in the overall quality of both products. However, a significantly higher rating for texture was received by the product produced by the new technique over that produced by the conventional method.

Air dried cabbage, with a moisture content of 5%, exhibited many of the qualities of fresh cabbage when rehydrated (Table 5). It rehydrated to about 70 percent of its original fresh weight within 35 minutes. Texture of the freeze dried product was mushy, even after the addition of firming agents, such as calcium. Significant savings in volume can be achieved when fresh cabbage is compared with its dehydrated compressed counterpart (Fig. 4).

CONCLUSION:

It is concluded that acceptable compressed products can be produced by partial freeze drying and microwave plasticizing, thereby saving about 50 percent of the freeze-drying time and energy. This new technique enables the producer to make more efficient use of his equipment; namely, several batches of freeze dried compressed product can be produced per day instead of one batch using the current commercial process. There is also the distinct possibility that a semi-continuous process can be developed in which the freeze dried product can be placed on a conveyorized microwave unit and plasticized. The plasticized product can then be fed automatically into a hydraulic press for compression (Fig. 1). These studies have also shown that lower cost air drying can be successfully used for some products such as cabbage that have less sensitive cellular structures.

The microwave process has been covered by a patent which will be issued in the near future, and a patent application has been filed for the dehydrated compressed cabbage process.

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PRODUCT TYPE	BLANCHING TREATMENT	PEROXIDASE ACTIVITY
FRESH 1/2" CUBE	BOILED IN WATER - 30 SEC	POSITIVE
FRESH 1/2" CUBE	BOILED IN WATER - 1 MIN	NEGATIVE
FRESH 1/2" CUBE	MICROWAVE, 1000w, (IN OPEN DISH) - 1 MIN	NEGATIVE
FRESH 1/2" CUBE	MICROWAVE, 500w, (PLASTIC DISH) - 1 MIN	NEGATIVE
FRESH 1/2" CUBE	MICROWAVE, 500w, (PLASTIC DISH) - 30 SEC	POSITIVE
FRESH 1/2" CUBE, FREEZE DRIED TO ABOUT 17% MOISTURE	MICROWAVE, 500w - 30 SEC	NEGATIVE
FRESH 1" SLICE	BOILED IN WATER - 1 MIN	SLIGHT COLOR DEVELOPED AFTER 15 MIN
FRESH 1" SLICE	MICROWAVE, 500w - 1 MIN	NEGATIVE
FRESH 1" SLICE	MICROWAVE, 1000w - 30 SEC	NEGATIVE
FRESH 1" SLICE	MICROWAVE, 1500w - 15 SEC	NEGATIVE

TABLE 1 BLANCHING TREATMENTS TO INACTIVATE PEROXIDASE IN CARROTS

PERCENT MOISTURE	FREEZE DRYING TEMPERATURES	MICROWAVE ENERGY TREATMENT	CONDITION OF REHYDRATED PRODUCT	REHYDRATION RATIO
10	1 HR AT 250°F	0	90% FINES	--
	1 HR AT 200°F	30 SEC	5% "	9.6
	5 1/4 HR AT 150°F	40 SEC	0	9.3
	TOTAL 7 1/4 HRS	60 SEC	5% "	9.2
15	1 HR AT 250°F	0	80% FINES	--
	1 HR AT 200°F	30 SEC	5% "	8.3
		40 SEC	10% "	8.1
	4 HRS AT 150°F	50 SEC	15% "	8.7
	TOTAL 6 HRS	60 SEC	10% "	8.4
17	1 HR AT 250°F	0	50% FINES	--
	1 HR AT 200°F	30 SEC	0	8.6
		40 SEC	20% "	6.7
	4 HRS AT 150°F	50 SEC	10% "	7.2
	TOTAL 6 HRS	60 SEC	20% "	7.3

TABLE 2 . CARROTS FREEZE DRIED TO DIFFERENT LEVELS OF MOISTURE, TREATED WITH MICROWAVE ENERGY AND COMPRESSED

PERCENT MOISTURE	FREEZE DRYING TEMPERATURES	MICROWAVE ENERGY TREATMENT	CONDITION OF REHYDRATED PRODUCT	REHYDRATION RATIO
12.5	1 HR AT 250°F 2 HRS AT 200°F 3 1/2 HRS AT 150°F TOTAL 6 1/2 HRS	0 30 SEC 40 SEC 50 SEC	100% BROKEN & FINES 50% BROKEN 20% BROKEN 20% BROKEN	-- 4.9 4.7 4.7
14.4	2 1/2 HRS AT 260°F 1 1/2 HRS AT 200°F 1/2 HR AT 160°F TOTAL 4 1/2 HRS	0 20 SEC 30 SEC	90% BROKEN & FINES 40% " " 10% " "	-- 4.5 4.5
15.3	1 HR AT 250°F 2 HRS AT 200°F 2 1/2 HRS AT 150°F TOTAL 5 1/2 HRS	0 10 FT/SEC 12 FT/SEC	100% BROKEN & FINES 10% BROKEN 5% BROKEN	-- 4.4 4.0
19.5	2 HRS AT 250°F 1 1/2 HR AT 200°F 1 HR AT 160°F TOTAL 4 1/2 HRS	0 30 SEC 40 SEC	90% BROKEN & FINES 10% " " 5% " "	-- 4.3 4.0

TABLE 3 . PEAS FREEZE DRIED TO DIFFERENT LEVELS OF MOISTURE, TREATED WITH MICROWAVE ENERGY AND COMPRESSED

MICROWAVE TREATMENT	REHYDRATED PRODUCT				
	COLOR	ODOR	FLAVOR	TEXTURE	APPEARANCE
CONTROL (CONVENTIONAL)	6.9	6.9	6.7	5.7*	6.6
20 SEC	7.0	6.5	6.7	6.1	6.6
30 SEC	6.9	6.6	7.0	6.3	6.7
LSD	0.89	0.41	0.42	0.54	0.17

TABLE 4 TECHNOLOGICAL PANEL AVERAGE RATINGS OF PEAS, FREEZE DRIED TO 17% MOISTURE, TREATED WITH MICROWAVE ENERGY AND COMPRESSED

TREATMENT	COLOR	ODOR	FLAVOR	TEXTURE	APPEARANCE
CONTROL (FRESH CABBAGE)	6.7	6.8	7.3	7.2	6.7
FREEZE-DRIED & COMPRESSED	6.5	6.6	6.5	5.8	6.4
FREEZE-DRIED & COMPRESSED CA TREATED	6.7	6.7	6.5	5.8	6.5
AIR-DRIED TWEEN 60	6.8	6.9	6.9	6.8	6.8
AIR-DRIED TWEEN 80	6.8	6.9	6.7	6.8	6.8

TABLE 5. TECHNOLOGICAL EVALUATION OF DEHYDRATED AND COMPRESSED CABBAGE

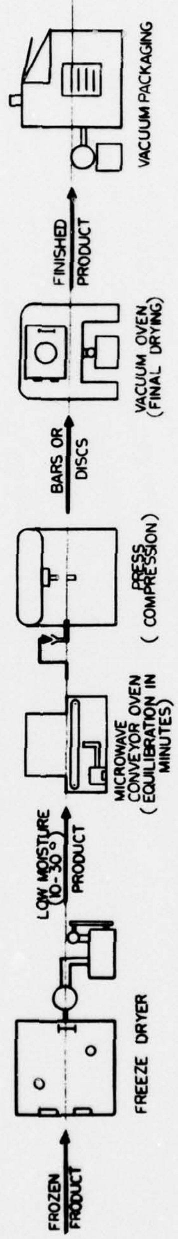

FIG. I. NEW ENERGY SAVING TECHNIQUE FOR THE PRODUCTION OF DENSE FOOD

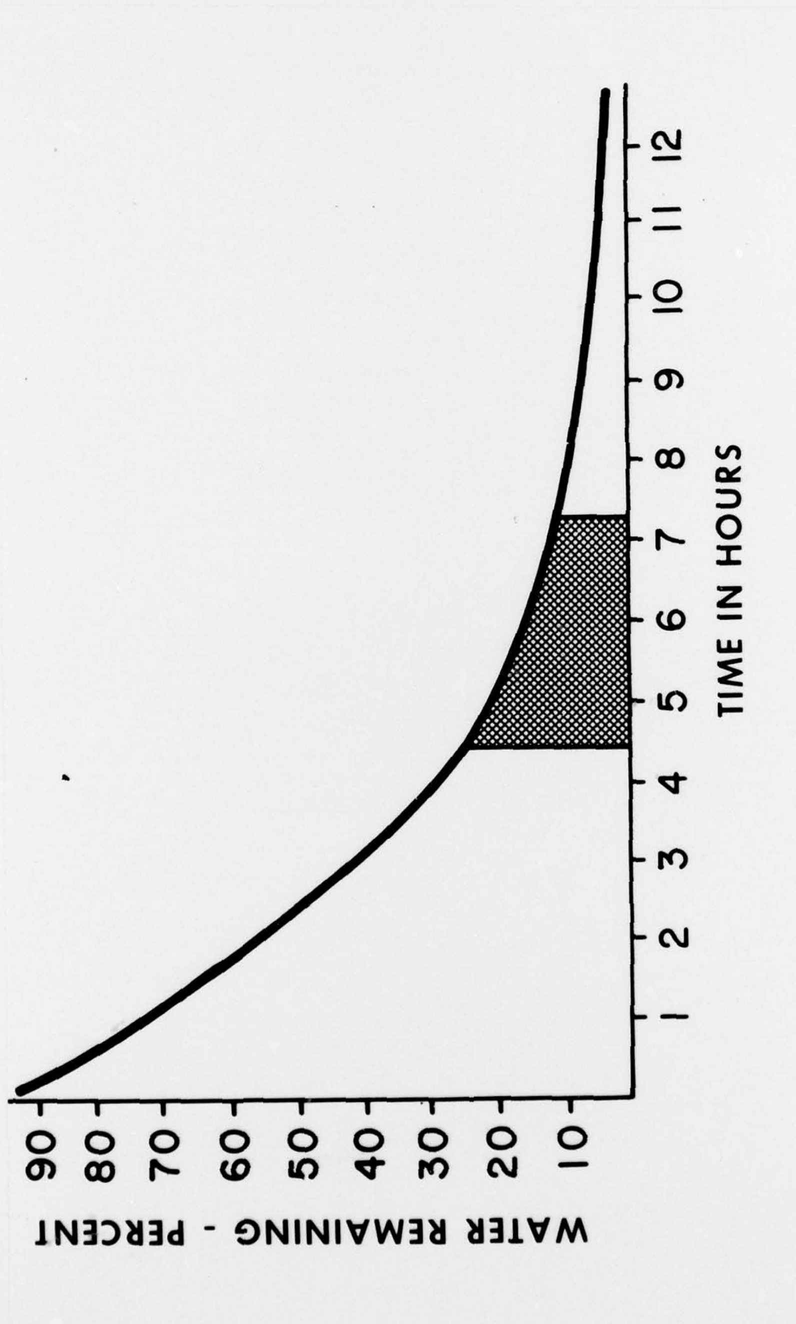

FIG. 2 - TYPICAL FREEZE-DRYING CURVE - SHADED AREA REPRESENTS' THE RANGE OF RESIDUAL MOISTURE IN PARTIAL FREEZE-DRYING

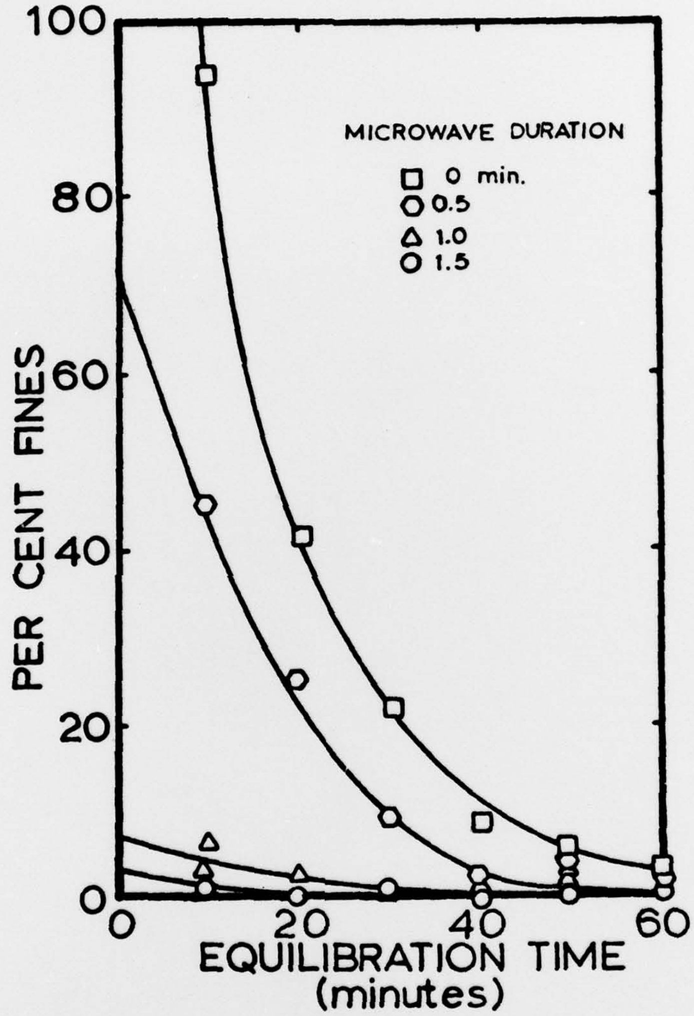

FIG. 3 THE EFFECT OF MICROWAVE DURATION AT 441 WATTS ON FINES PRODUCTION.

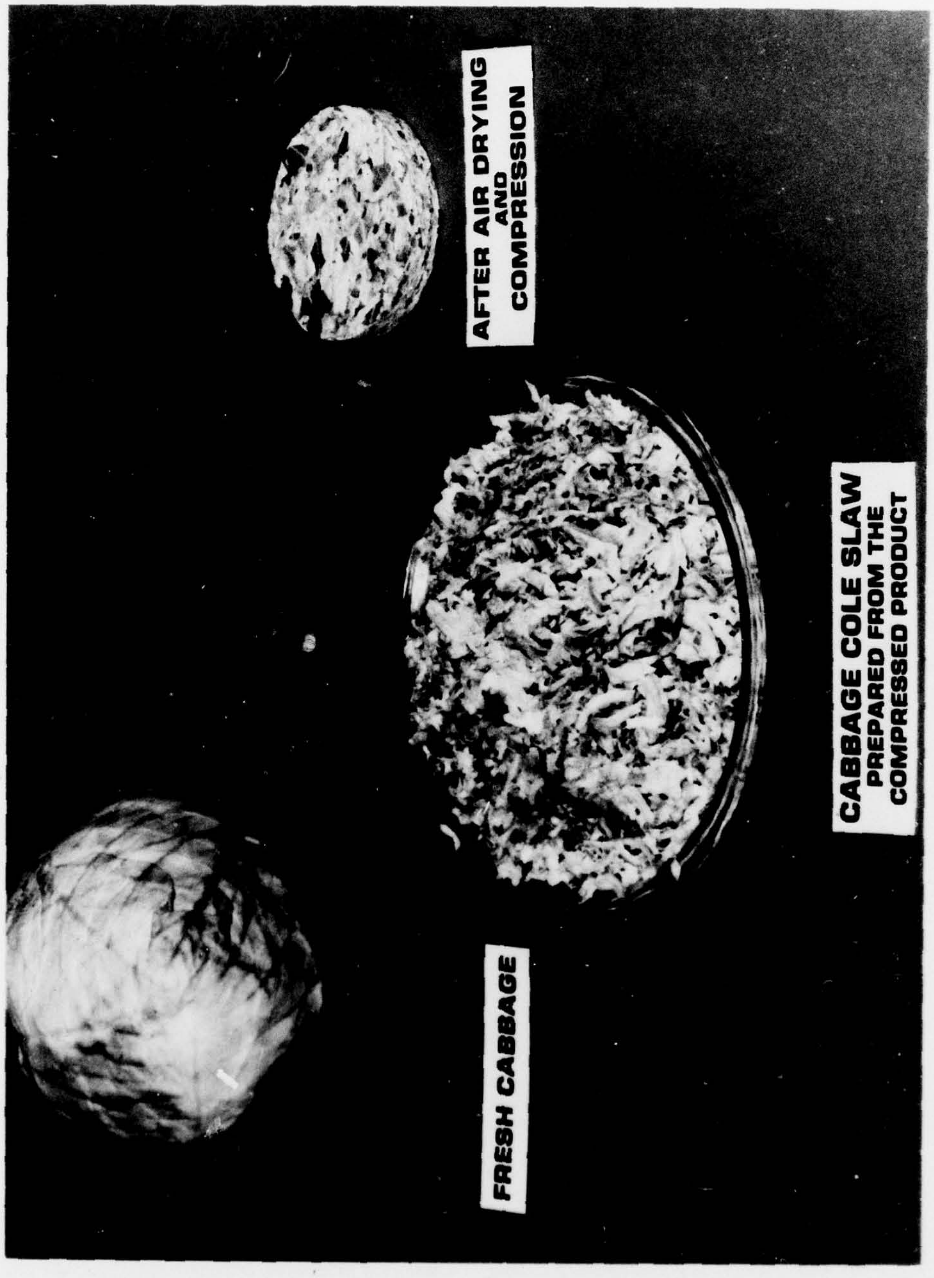

FIG. 4 - VOLUME REDUCTION IN CABBAGE UPON COMPRESSION