AN ABSTRACT OF THE THESIS OF

Mohammed Saeed (Name) for the M. S. (Degree) in Food Science (Major)

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Title Suitability of Pollinizing Varieties of Pears for Dehydration.

Abstract approved _____ (Major Professor)

Commercial utilization of pollinizing varieties of pears is important both for pear growers and processors in Oregon. A study was made to determine the suitability of Comice, Packam's Triumph and Anjou, the three pollinizing varities of pears, for dehydration, as compared to the Bartlett variety which is commercially used for dehydration. These four varieties were dehydrated using conventional and dry-blanch-dry methods and were subsequently stored at 70° F. The storage period of Bartlett, Comice, Anjou, and Packam's Triumph was 275, 212, 186 and 175 days, respectively. Both fresh and dehydrated pears were analyzed for moisture, total acid, and total sugar. The over-all drying ratio and rehydration percentage of each dehydrated lot was determined. After storage, the dehydrated pears were evaluated for flavor, texture, color, over-all appearance, and over-all desirability by a panel of eight judges. The results

indicated the following conclusions.

(1) There was no significant difference in the over-all drying ratio of the unpeeled dried pears of all four varieties and treatments.

(2) Peeled dried Packam's Triumph had the highest over-all drying ratio followed by Anjou, Comice, and Bartlett, respectively.

(3) Bartlett had the highest rehydration percentage followed by Anjou, Comice, and Packam's Triumph, respectively.

(4) There was no significant difference in the rehydration percentage of conventionally dried unpeeled and dry-blanch-dry unpeeled pears. But dry-blanch-dry peeled pears had a significantly higher rehydration percentage than the conventionally dried peeled pears.

(5) The dehydrated Anjou pears had the lowest total sugar content of all four varieties. Packam's Triumph had a higher total sugar content than Anjou but lower than Comice and Bartlett. The total sugar content of the latter two varieties did not vary significantly.

(6) The dehydrated Anjou pears had the highest total acid content of all the four varieties. Packam's Triumph had lower total acid content than Comice and Bartlett. The total acid content of the latter two varieties did not vary significantly.

(7) The flavor, texture, and over-all appearance of all dehydrated lots did not vary significantly. The flavor and texture of all lots were liked by the panel, but the over-all appearance of these lots was disliked by the panel.

(8) The color of peeled dried pears was rated higher than unpeeled dried pears by the panel regardless of variety and method of dehydration. The panel liked the color of dry-blanch-dry unpeeled and peeled pears more than corresponding conventionally dried unpeeled and peeled pears. The color of Comice and Anjou was rated higher than Bartlett and Packam's Triumph by the panel. The color of the latter two varieties was disliked by the panel.

(9) The over-all desirability of all four varieties was rated higher than average by the panel.

SUITABILITY OF POLLINIZING VARIETIES OF PEARS FOR DEHYDRATION

by

MOHAMMAD SAEED

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In Charge of Major

Head of Department of Food Science and Technology

Dean of Graduate School

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES CONTINUED

LIST OF TABLES CONTINUED

SUITABILITY OF POLLINIZING VARIETIES OF PEARS FOR DEHYDRATION

INTRODUCTION

The processing of pears is an important industry in Oregon. Of the 240. 6 thousand tons of pears canned in the United States during 1963, 25. 9 thousand tons were processed in Oregon (28, p. 48). Most of the fruit is sold on the fresh market. The remainder is either canned or dried. Canning is the most desirable method of preservation. This is evident from the fact that only one percent of the total pears produced during 1962-63 in the United States was dried (28, p. 48).

Pears are cross pollinated, but pollination within a variety is not always successful. To ensure a good commercial crop, a pollinizing variety is grown with the regular commercial variety. The common practice is to plant every third row of the orchard with the pollinizing variety. Beside providing pollen the pollinizing variety bears fruit; the commercial utilization of this fruit is important both for pear growers and processors.

Dehydration is the oldest method of food preservation, but its application to pears is very limited. Most of the dried pears produced in the United States are sun dried; because of this they have the characteristic texture, color, taste, and appearance which have

been difficult to duplicate in the dehydrated fruit. Recently a new method for dehydrating pears and other cut fruits has been developed by Lazar et al. (17). The method is known as DBD after the sequence of operations: dry-blanch-dry. The method consists of steam blanching the fruit after partial dehydration and then completing the dehydration to the desired moisture level. These workers claim that blanching the fruit after partial drying permits better control of texture and appearance, and the dehydrated fruit resembles its sun-dried counterpart.

The production of fruit in Pakistan is always greater than the fresh consumption during the harvest season. The author of this thesis realizes the importance of introducing the food dehydration industry into Pakistan.

The purpose of this thesis is to ascertain whether the three pollinizing varieties most commonly grown in Oregon produce a commercially acceptable dehydrated product. Bartlett, which is the principal pear variety commercially used for dehydration, is included in the study for comparison. Two methods of dehydration, i. e. conventional and dry-blanch-dry, are compared to determine if there is a suitable method for the dehydration of these pollinizing varieties.

LITERATURE REVIEW

Reported investigations on the dehydration of pears are not numerous. Almost all the dried pears produced commercially in the United States are sun dried. Sun dried fruit has characteristics of taste, texture, color and appearance that have been difficult to duplicate by artificial means (26, p. 60). Dehydrated fruit, although nutritious and palatable, has not found popular acceptance because it does not have the familiar appearance of the sun dried fruit.

Ripening

The quality of the final product depends to a large extent on the condition of the fresh fruit at the time of dehydration. When dehydrating immature fruit the final product is chalky white in color and the amount of shrinkage is high (34, p. 10). Pears differ from other fruits in that they are harvested while still immature and are allowed to ripen while in storage. Optimum conditions regarding temperature and relative humidity should be maintained during ripening to get a better quality fruit. Cruess and Christie (7, p. 53) ripened Bartlett pears on trays and in wooden lug boxes in the shade. The losses due to "sort out" in lug boxes were reported to be more than on trays, but the fruit ripened more uniformly in boxes. Culpepper and Moon (8, p. 22) reported that Kieffer pears ripened at 60° F., for a

sufficient period of time to give a pressure test of 2. 5-3. 5 with a Magness pressure tester resulted in a dried product much superior to that made from unripened fruit.

Hukill and Smith (12, p. 13) pointed out that the optimum ripening temperature for most varieties of pears was between 65-70° F. They also added that Bartlett had much better quality when ripened in this range than at high temperature. A relative humidity of 85 percent was maintained during ripening.

Wiegand, Madsen and Price (45, p. 604) writing about commercial dehydration of fruits and vegetables, reported that pears should be ripened by storing at 65-68°F. and 80 percent relative humidity. Claypool et al. (4, p. 379) in a study on the effect of ripening temperature on the quality of canned Bartlett pears, concluded that ripening at 68° F. resulted in a slightly higher soluble solids and less volatile reducing substances than ripening at 77° or 85° F. They also showed that ripening at 68° F. to a firmness of two pounds per square inch as tested with a pressure tester having 5/16 inch plunger gave a canned product with a more natural flavor.

Dehydration

Cruess and Christie (7, p. 62, 65, 76) experimentally dehydrated Bartlett pears in a countercurrent dehydrater using a finishing temperature of 145-150° F. They pointed out that pears finished above

145° F. became yellowish brown when nearly dry, therefore, to produce a white product a finishing temperature of 145° F. was recommended. However, for producing a translucent product like sun dried pears a finishing temperature of 110-120° F. was mentioned.

With regard to case hardening, they added that case hardening could be greatly reduced by increasing the relative humidity of air at 150° F. to 30-35 percent. Dehydrated peeled and cored halves were reported to be superior in flavor to sun dried pears. The unpeeled dehydrated pears were, however, reported to be chalky white and not as translucent as when sun dried even if highly sulfured. With regard to drying time they added that drying time varied with variety, degree of maturity of fruit, preliminary treatments, temperature, humidity, volume of air, tray load and degree of dryness desired. A drying time of 36-48 hours for unpeeled halves and 16-18 hours for peeled and cored halves was stated.

Nichol et al. (30, p. 35) in a United States Department of Agriculture Bulletin in 1925 mentioned briefly that pears were dehydrated both as peeled and unpeeled halves. The fruit was sulfured before drying. A maximum drying temperature of 140-150° F. and a final moisture content of 10-15 percent in the dehydrated product was recommended.

Nichol and Christie (29, p. 42-43) in their investigations of drying cut fruits, reported that pears could be successfully

dehydrated in a tunnel dehydrater with countercurrent air flow. A maximum finishing temperature of 140-150° F., a relative humidity of 35-40 percent, and an air flow of 500-800 feet per minute were recommended. An approximate drying time of 30-48 hours for drying unpeeled halves under the above conditions was reported. Culpepper and Moon (8, p. 2, 22) experimentally dehydrated Kieffer pears in a small steam heated stack type dehydrater. The temperature of the air entering the dehydrater was 50-55° C., and the relative humidity was 9.2 percent. The temperature of the air at the discharge end was 35° C. and its relative humidity was 60 percent. The fruit was dehydrated to 10-15 percent moisture. The dehydrated peeled halves were reported to be superior to unpeeled halves in flavor and texture. The same two authors (9, p. 29) concluded that there was a great difference in the rate of drying of peeled and unpeeled halves. Peeling of the fruit prior to drying was recommended because of the increased rate of drying and the improvement of the quality of the product. They also pointed out (9, p. 29) that a temperature of 50-55° C. was the best at which to finish the drying process from the standpoint of quality. Using finishing temperatures above 60° C. was reported to have resulted in a dried product of poor quality. Pears dehydrated at 70° C. were reported to be definitely poor in color and flavor.

Chace, Noel and Pease (3, p. 33) mentioned briefly that pears were dried in both the peeled and unpeeled form. For preparing

peeled dried halves, the fruit was peeled, cored, sulfured and dried. A maximum drying temperature of 140-150° F. in a countercurrent dehydrater and a drying time of 15-24 hours for dehydrating such fruit to 10-15 percent moisture content was recommended.

Drown (42, p. 28) reported that Bartlett pears could be dehydrated successfully if exposed to the sun for two to three days or blanched for 15-20 minutes before drying. A maximum temperature of 140-150° F. at the beginning of dehydration in a countercurrent dehydrater and a much lower finishing temperature was recommended.

Wiegand, Madsen and Price (45, p. 604-605) listed the following steps in pear dehydration: ripening at 65-68° F. at 80 percent relative humidity, cutting, sulfuring, and drying. An entering temperature of 135° F. and a finishing temperature of 155° F. in a countercurrent dehydrater was recommended. They also added that the fruit should be dehydrated to 10 percent moisture content if shipped abroad.

Mrak et al. (36, p. 637) have reported that pears could be dehydrated successfully if blanched for 12-15 minutes and then sulfured for eight hours. A finishing temperature of 140° F. in a countercurrent dehydrater and a total drying time of 26-30 hours were stated for dehydrating unpeeled halves.

Perry et al. (34, p. 11-22, 45) reported that pears were dehydrated both as peeled and unpeeled halves. The steps in dehydration included cutting, peeling, and blanching in a steam blancher for 16

minutes and sulfuring by exposing to the fumes of burning sulfur for 10-15 hours. A finishing temperature of 150° F. was recommended in a countercurrent dehydrater.

Lazar, Smith and Chapin (18) showed that the preparation of dehydrated fruit having the characteristic of sun dried fruit included sulfuring the fresh fruit pieces, subjecting the fruit to hot air dehydration at a temperature of 150-180° F. until the weight of the fruit was reduced to about 40-60 percent of its initial fresh weight. This was followed by blanching the fruit in steam and then subjecting it to rapid dehydration in a current of hot air until the desired moisture content was obtained.

Lazar, Barta and Smith (17, p. 120-121) experimentally dehydrated pears using the dry-blanch-dry method. The method included sulfuring the fresh fruit halves, subjecting them to dehydration at a temperature of 180° F. for one hour and then dropping the temperature to 150° F. The dehydration was continued until the fruit lost 40-60 percent of its initial weight; the fruit was then taken out of the dehydrater, steam blanched and the dehydration completed. The dehydrated pears produced were reported to have excellent flavor and texture and to resemble their sun dried counterpart.

Treatments Preceding Dehydration

Blanching

Fruit sulfured and then dehydrated without other pre-treatments is ordinarily opaque, dull in appearance, less uniform in color and of tougher texture (26, p. 62). On the other hand, the sun dried fruit is translucent, somewhat glossy and of good color and texture. Because of these differences dehydrated cut fruits have been placed in lower quality grades. Mrak et al. (26, p. 60) and Phaff et al. (36, p. 637) found that cut fruit steam blanched prior to sulfuring yielded a dehydrated product which resembled the sun dried product in appearance. Nichol and Christie (29, p. 7) pointed out that steam blanching shortened the drying time. Mrak et al. (26, p. 61-62) substantiated this and showed that blanched fruit had a higher sulfur dioxide retention than unblanched fruit.

Crafts (5, p. 185; 6, p. 452) stated that the air pockets in the tissue of unblanched fruit dispersed light and gave the product a dull, opaque appearance. Blanching, he added, voided the tissues of air and improved the appearance of the fruit. He explained the blanching process by stating that the air was expanded by heat and most of it escaped from the cut surface through intercellular spaces. The cells are then killed by the heat and rendered permeable, allowing the sap to escape and, lastly, the cell walls are softened, so that

they bend and give under the compressional forces of surface tension.

Perry et al. (34, p. 20) have listed the following advantages of blanching: improves cleanliness of the product, reduces drying time and higher sulfur dioxide retention, superior retention of the fresh fruit flavor, and reduction in time required for rehydration and cooking. Melnick, Hochberg and Oser (24, p. 153) showed that steam blanching was preferred over water blanching because of the loss of soluble solids due to leaching in water blanching. Mrak et al. (26, p. 61) have observed that the retention of carotene and ascorbic acid was greater in blanched dehydrated fruit than in sun dried.

Blanching is best accomplished by exposing the fruit spread on trays to steam at atmospheric pressure in a continuous or discontinuous cabinet blancher. The time of blanching a fruit varies with the size, variety, and maturity of fruit, the efficiency of the blancher, the characteristics of the trays and the extent of continued heat penetration into the fruit after stacking of the trays. Phaff, Perry and Mrak (35, p. 151) have pointed out that the temperature obtained and maintained in different parts of fruit pieces at different intervals of time should be known to avoid under- or over-blanching. Phaff et al. (36, p. 637) have reported that peeled pears bleeded badly, especially if blanched and heavily sulfured. On the other hand, if under-blanched pears were dehydrated, the dried product was opaque

and chalky white in appearance instead of being translucent like the sun dried fruit. Mrak et al. (26, p. 62) have recommended 15-30 minutes blanching in steam for Bartlett pears whereas 15-25 minutes blanching has been recommended for Hardy and Du Comice pears. Phaff et al. (36, p. 637) have mentioned a blanching time of 12-16 minutes for pears. Lazar, Barta and Smith (17, p. 121) used eight minutes blanching time for unpeeled halves and five minutes blanching time for peeled and cored halves of Bartlett pears in the preparation of dry-blanch-dry pears.

Sulfuring

Sulfuring of pears as a treatment prior to dehydration is very widely recommended. Cruess and Christie (7, p. 57) pointed out that unsulfured Bartlett pears, when dehydrated, were an unattractive brown color. Culpepper and Moon (8, p. 22) showed that Kieffer pears dried without sulfuring were brown and less attractive in appearance than properly sulfured ones. Nichol et al. (30, p. 10), Nichol and Christie (29, p. 9-10), Chace, Noel and Pease (3, p. 7) and Drown (42, p. 19) pointed out that light fruits were sulfured to prevent discoloration and to retain the natural color during and after drying. Nichol and Christie (29, p. 9-10), Chace, Noel and Pease (3, p. 7), and Nichol et al. (30, p. 10) added that sulfuring facilitated drying by killing or plasmolyzing the cells in the tissue, making

permeable the semi-permeable cell membranes and thus facilitating the diffusion of water from the interior to the surface. Sulfur dioxide prohibited darkening by inhibiting enzymes and, by its reducing action, protected the fruit from the action of oxygen (29, p. 9-10). Drown reported (42, p. 19) that sulfuring preserved ascorbic acid, although it destroyed thiamine to a large extent. Perry et al. (34, p. 22), and Nichol and Christie (29, p. 7-10) pointed out that fruits were sulfured before dehydration to retain their natural color and flavor, prolong storage, retard the loss of provitamin A and ascorbic acid and to prevent microbial deterioration.

The most widely employed procedure of sulfuring fruit is by exposing the cut fruits to the fumes of burning sulfur in a closed and tightly sealed cabinet (29, p. 10; 27, p. 153). Mrak and Phaff (27, p. 154) have pointed out that the use of sulfite solution for sulfuring fruits was impractical because of poor penetration and leaching of sugars. They also added that the use of liquid sulfur dioxide in cylinders required the presence of fans in the sulfur house, because sulfur dioxide is a heavy gas and tended to collect at the bottom of the house.

Absorption and retention of sulfur dioxide by the fruit is conditioned by a number of factors. Long, Mrak and Fisher (20, p. 54) found that size, variety, maturity, as well as the locality in which the fruit was produced and dried were important factors in

determining the absorption of sulfur dioxide during sulfuring and its retention afterward. Whole and cut fruit absorbed less sulfur dioxide but retained it during drying when they were sulfured at a relatively high temperature such as 100-120°F. (11, p. 238). Perry et al. (34, p. 22) pointed out that immature fruits absorbed more sulfur dioxide than did mature fruits but lost it much more rapidly during the process of drying. Culpepper and Moon found (8, p. 22) that peeled Kieffer pears required much less sulfur dioxide to retain their natural color than unpeeled halves. Long, Mrak and Fisher (20, p. 54) showed that fruit sulfured at high temperature tended to decrease the absorption of sulfur dioxide and increased its retention. Phaff (34, p. 22) found that among the various factors conditioning the absorption and retention of sulfur dioxide by the fruit, the time of exposure, temperature and concentration of sulfur dioxide in the sulfur house were of primary importance. McBean, Johnson and Pitt (23, p. 257) on the other hand showed that sulfur dioxide concentration in the sulfur house and exposure time were the most important processing variables affecting absorption whereas air speed and temperature had little influence. They also showed that sulfur dioxide uptake through the skin was slow. Disorganization of the tissue through processing or over-maturity retarded absorption. Blanching extended absorption appreciably. Mrak et al. (26, p. 61) showed that blanched fruit retained more

sulfur dioxide than unblanched fruit. Cruess and Christie (7, p. 57), in their investigation on dehydration of fruits, found that to properly sulfur thinly sliced Bartlett pears required 20-30 minutes. Peeled and cored halves required one-three hours whereas unpeeled halves required 24-36 hours. Nichol and Christie (29, p. 40) pointed out that a minimum of six hours sulfuring in a natural draft sulfur house was required to obtain dried pears of satisfactory quality. Culpepper and Moon (8, p. 22) showed that to properly sulfur halved Kieffer pears required about four hours exposure to sulfur dioxide whereas two-three hours exposure was required for fruit sliced into eighths. Mrak et al. (26, p. 62) stated that, owing to high sulfur dioxide retention, blanched fruit should be sulfured for a shorter period than unblanched fruit. They also added that too much sulfuring at too high a temperature caused bleeding. A two and one-half to three hours exposure to sulfur dioxide in a sulfur house having three-five percent sulfur dioxide concentration has been recommended for Bartlett, Du Comice and Hardy varieties of pears. Lazar, Barta, and Smith (17, p. 121) used a sulfuring period of two hours for peeled and cored halves of Bartlett pears and a sulfuring period of four hours for unpeeled halves in the production of dry-blanch-dry pears.

Over-all Drying Ratio

The ratio of the weight of the ingoing raw material to the weight of the finished product is called the over-all drying ratio. The higher the over-all drying ratio, the greater will be the cost of the dried product. A fruit or a variety of fruit having a low over-all drying ratio is naturally desirable.

Cruess and Christie (7, p. 58) found that the yield of dried pears varied with the locality in which the fruit was grown, the season, the maturity of the fruit and the variety. Maturity, area of production, variety, pre-treatment waste, season and drying conditions have been shown to be important factors influencing the over-all drying ratio (13, p. 343; 14, p. 18-21). Perry et al. (34, p. 5) have mentioned that the over-all drying ratio varied with variety and locality as well as from year to year. Phaff et al. (36, p. 636) pointed out that for clingstone peaches the over-all drying ratio depended on the total solids content, the preparation losses and to a great extent on the percentage of "sort out" in the fresh and finished product. Van Arsdel and Copley (44, p. 133) have listed the following factors in determining the over-all drying ratios: (1) moisture content of the raw material, (2) peel, core, rot, bruises or other material that must be removed and discarded; size and shape of the raw material (small or irregular shapes have greater peeling, trimming, sizing,

and inspecting losses), (3) reject for poor color, odor and composition, and (4) reject of dried material smaller than acceptable minimum screen size.

Cruess and Christie reported (7, p. 59) an over-all drying ratio of 7.8:1 for peeled and cored Bartlett pears and an over-all drying ratio of 5.1:1 for unpeeled pears. Nichol et al. (30, p. 32) pointed out that an approximate yield of 12-17 percent of dried pears containing 10-15 percent moisture can be obtained from fresh unprepared pears, whereas a yield of 17-20 percent could be obtained from peeled and cored fruit. Perry et al. (34, p. 5-6) stated that large variations in the over-all drying ratio due to variety, locality as well as from year to year made it difficult to give a reliable over-all drying ratio. They showed that the over-all drying ratio of Bartlett pears varied from 4.0:1 to 7.1:1.

Rehydration of Pears

Rehydration, also referred to as reconstitution, signifies the restoration of water to the dehydrated product. Standardized rehydration procedures have not been developed for dehydrated pears.

Culpepper and Moon (8, p. 23) reported that dried Kieffer pears were readily refreshed by soaking in water. They also pointed out that the absorption of water, by the dried material, increased with the temperature of soaking water. Slicing the material also increased

the rate of water absorption. The reconstitution of the dried material to 75-80 percent moisture content was reported to make the product suitable for table use. Drown (43, p. 29) stated that pears could be reconstituted by soaking for one hour or longer if the fruit was very dry or hard and then simmered for 10-30 minutes or until tender. He also added that the amount of water required for soaking and the boiling time could be increased over that recommended, but that boiling too long resulted in deterioration of taste, flavor, color and excessive vitamin loss.

Nury, Bolin and Brekke (33, p. 98) devised a method for rapid rehydration of fruit to a moisture content making the fruit suitable for table use. The method involved subjecting the dehydrated fruit to steam or boiling water for 3-25 minutes followed by immersion in cold water for 3-5 minutes. The rate and extent of hydration was reported to be greater and the heat damage was less as compared with several other methods of rehydration.

Storage

Nichol and Reed (31, p. 30) studied the influence of temperature on the rate of darkening in dried sulfured pears. They concluded that the rate of darkening at 75° F. was approximately double the rate at 32° F., while the rate at 100° F. was three or four times as severe as at 32° F. The method of color measurement was highly

subjective. It was noted that only two-four months were required for dried fruit at 100° F. to darken to a point described as "poorest acceptable commercially" whereas the same degree of discoloration was not reached even after 23 months at 32° F.. Nichol and Reed (31, p. 30) packed pears in vacuum sealed glass jars and in air and stored them at 32°, 70° and 100° F. The vacuum packed samples darkened slightly less rapidly than the sample packed in the air.

In another experiment (30, p. 11), they packed the fruit in tin cans under vacuum, in hydrogen, in air, and in cardboard cartons. Samples were sent to Manila and Singapore for storage. They were examined for changes in color and sulfur dioxide after various periods of time. These workers concluded that sulfur dioxide was lost during storage and the color deteriorated faster in the cartons than in tin cans. Vacuum cans gave the best protection and were better than cans filled with hydrogen and these in turn were better than air packed cans.

Culpepper and Moon (8, p. 8-9, 23) studied the effect of relative humidity on dried Kieffer pears during storage. The storage temperature was 20-23° C. They concluded that regardless of previous treatment the dried product deteriorated in moist air and the rate and amount of deterioration varied directly with the relative humidity. Ripened material that had been sulfured prior to drying and dried to 11.1 percent moisture content was reported to be in

fairly good condition after six months storage in an atmosphere of 48.84 percent relative humidity. They also added that the material deteriorated rapidly in an atmosphere above 70 percent relative humidity.

MATERIALS AND METHODS

Raw Materials

Comice, Anjou and Packam's Triumph, the three most commonly grown pollinizing varieties of pears in Oregon, were selected as raw materials for this research. Bartlett variety which is commercially used for dehydration was included in the study for comparison.

Comice, Packam's Triumph and Bartlett pears were obtained from a commercial cold storage in Medford, while Anjou pears were obtained from the Southern Oregon Agricultural Experiment Station near Medford. The fruit was shipped by motor freight to Oregon State University and was placed in the Horticulture Department's cold storage (30° F.) room.

Ripening

The pears which were in open wooden boxes were ripened by placing them at 70° F. and 85 percent relative humidity in a controlled room. The ripening period varied from seven days in the case of Bartlett to 12 days in the case of Packam's Triumph. The fruit was sorted daily during ripening. The firmness of the fruit was tested with a Magness pressure tester having a 5/16 inch plunger (21). Each lot was considered to have reached optimum ripeness

for dehydration when an average pressure test of 2-3. 5 pounds per square inch was obtained in a sample of eight pears from the lot. Each variety was ripened separately.

Pre-drying Treatments

The ripened fruit of each variety was divided into four lots. Each lot was washed and weighed separately. The pears of Lot 1 and Lot 3 were simply cut into halves while the pears of Lot 2 and Lot 4 were peeled and cored separately. The fruit halves of each lot were separately held in two percent salt solution to prevent discoloration. Each lot was rinsed with cold water, weighted and spread evenly on 23" x 23" stainless steel wire mesh trays. The fruit of Lot 1 was blanched for ten minutes in a steam blancher and the fruit of Lot 2 was blanched for eight minutes.

Sulfuring

The fruit was sulfured by exposing to sulfur dioxide gas in a small sulfur house, which consisted of a wooden cabinet having a capacity of seven 23" x 23" trays. It was connected with a gas tank for the supply of sulfur dioxide gas. The fruit of Lot 2 and Lot 4 was sulfured for two hours and the fruit of Lot 1 and Lot 3 was sulfured for four hours. Following sulfuring each lot was separately transferred to the dehydrater.

Dehydration

The pears spread on wire trays were dehydrated in a cabinet-type air recirculating dehydrater in the Food Technology pilot plant. This dehydrater consists of a self-enclosed cabinet approximately 17 feet long and six feet high. It is equipped with a steam-heating coil, a circulating air fan, an adjustable air vent, wet and dry bulb thermometers, and a steam jet humidifier. The dehydrater has the capacity of holding 15 trays 23" x 23".

Typical conditions used for preparing the four lots of each variety are shown in Table I.

Lot 1 and Lot 2 were dehydrated using the conventional method of dehydration. In this process, an initial temperature of 180° F. was maintained in the dehydrater for the first hour. The temperature was then dropped to 150° F. and maintained for the remainder of dehydration period. A relative humidity of 35 percent was maintained throughout dehydration time. A total dehydration time of 27 hours was used for Lot 1 for all four varieties, and a total dehydration time of 12 hours was used for Lot 2. The dehydration time in each case was established as the time required to dehydrate the Bartlett variety of the corresponding treatment lot to 18 percent moisture.

Lot 3 and Lot 4 were dehydrated using the dry-blanch-dry method. In this process an initial temperature of 180° F. was

Table I. Typical Conditions Used for Preparation of Four Lots of Each Variety.

Lot No.	Style	Pre-drying treatment Method & Concentration		Tray Load	Blanching Min./Temp. °F.	Dehydration Hours	Dehydration Temp. °F.
1	Unpeeled halves	SO_2 gas	4 hours	2.5 pounds/square foot	10/212	27	150
2	Peeled halves	SO_2 gas	2 hours	2.5 pounds/square foot	8/212	12	150

					1st stage drying Time(hrs.)	Blanching Min./temp. °F.	2nd stage drying Time(hrs.)	2nd stage drying Temp. °F.
3	Unpeeled halves	SO_2 gas	4 hours	2.5 pounds/square foot	7	10/212	13	150
4	Peeled halves	SO_2 gas	2 hours	2.5 pounds/square foot	3 1/2	8/212	9	150

maintained for the first hour. The temperature was then dropped and maintained at 150° F. until the fruit had lost 50 percent of its fresh weight. This partial dehydration was called the first stage dehydration. A time of seven hours and three and one-half hours for Lots 3 and 4, respectively, were required for the first stage dehydration. Following the first stage dehydration the fruit of Lot 3 was steam blanched for 10 minutes and Lot 4 was blanched for eight minutes. The fruit of Lot 3 and Lot 4 were allowed to drain for two minutes and then returned to the dehydrater. A dry bulb temperature of 150° F. and a relative humidity of 35 percent were maintained throughout the second stage of dehydration. A total dehydration time of 13 hours was used for Lot 3 and a total dehydration time of 9 hours was used for Lot 4 for the second stage dehydration. The dehydration time in each case was established as the time required to dehydrate the Bartlett variety of the corresponding treatment lot to 18 percent moisture. When the dehydration of one lot was completed, the tray loads of dry pears were removed, weighed, and put in one gallon glass jars provided with air-tight caps. These jars were stored at 34° F. until all four lots of one variety had been dehydrated.

Storage

When all four lots of a particular variety had been dehydrated, the jars containing the dehydrated pears were transferred to a temperature controlled room at 70° F. This gave a uniform starting date for storage tests of a variety. However, since the four varieties included in the study were dehydrated at different times, all had different starting dates of 70° F. storage.

ANALYTICAL PROCEDURES

Analysis of Fresh Pears

Preparation of Sample

Twenty fresh pears were selected at random from each variety after ripening. Each fruit was cut into halves and the seeds removed. To make a composite sample one-half was selected at random from each pear. The 20 halves so obtained were blended in a Waring blender for three minutes. Aliquots from this slurry were taken for analysis.

Moisture Determination

Duplicate ten gram samples were weighed in tared aluminum dishes and dried for 24 hours in a vacuum oven at 70° C. and 25 inches of vacuum. The dried samples were cooled in a desiccator and weighed. The moisture content was ascertained by the loss in weight. The results were expressed as percent of moisture on a fresh weight basis.

pH

A Beckman model H pH meter with a magnetic stirrer was used to determine the pH of the slurry.

Total Acid

Duplicate ten gram samples of the slurry were weighed into 250 ml beakers, diluted with 100 ml of distilled water and titrated with 0.2 N NaOH to a pH 8.1 using a Beckman model H pH meter. The results were reported as percent citric acid on a fresh weight basis.

$$\text{Percent acid} = \frac{0.2 \times 0.06404 \times 100}{10}$$

Total Sugar

The phenol method of M. Dubois et al. (10) was followed. Duplicate five gram samples of the slurry were weighed into tared 50 ml glass beakers. The content of each beaker was quantitatively transferred to a 50 ml round bottomed centrifuge tube with 40 ml distilled water. They were then centrifuged for 30 minutes at 2800 r.p.m. in an Internationel Model DU centrifuge. The clear supernatant was transferred to a 100 ml volumetric flask. The residue was mixed with 40 ml of distilled water and centrifuged again for 30 minutes. The supernatant obtained was mixed with one obtained in the first extraction and made to volume with distilled water and mixed. One ml of this solution was diluted to 100 ml with distilled water and two ml of the diluted solution was used for the total sugar determination.

One ml of five percent phenol solution was added to I" x 6" test tubes containing two ml of sample. Five ml of concentrated sulphuric acid was added with a free running pipette. The content of the tubes was well mixed and the tubes placed in a boiling water bath for exactly five minutes. The tubes were then cooled in running tap water. The tubes were read for percent transmission at 490 mμ wavelength in a Model B spectrophotometer. The blank was prepared by substituting distilled water for the sample.

A standard curve was prepared using anhydrous dextrose.

Analysis of Dehydrated Fruit

Preparation of Sample

At the beginning of the storage period a sample of ten dried pear halves was selected at random from each lot. The sample was thoroughly ground by passing it through a manually operated food chopper. The ground sample was well mixed with a spoon to obtain a homogenous mixture. An aliquot of 40 grams was weighed to which 200 ml of distilled water was added. The mixture was blended in a Waring blender for one minute at slow speed and for two minutes at full speed. Aliquots from this slurry were taken for the following analysis.

Moisture Determination

The same procedure as given for the fresh fruit was followed and the percent moisture calculated.

Total Acid

The procedure given for determining total acid in fresh fruit was followed. The percent total acid as citric acid was calculated using the following formula:

$$\text{Percent total acid in dehydrated pears} = \frac{0.2 \times 0.06404 \times 6 \times 100}{10}$$

Total Sugar

The same procedure as given for fresh fruit was followed and the percent total sugar as dextrose was calculated as follows:

$$\text{Percent total sugar in dehydrated pears} = \frac{\text{total sugar in five gram sample} \times 240 \times 100}{5 \times 40}$$

Rehydration

The method of Nury, Bolin and Brekke (33) for raising the moisture content of dried fruit was followed. The method involves three to 25 minutes heating in boiling water followed by immersion in cold water. A series of preliminary trials were run to find an optimum

procedure. These trials included the factors such as the holding time in boiling water and cold water, the amount of water with respect to the size of sample, open and closed vessel cooking. The following rehydration procedure was followed for all samples.

Two hundred grams of dehydrated pears were taken from each lot. One thousand ml of tap water was measured into an open Pyrex glass container. The container was placed on a gas burner and brought to boiling. The samples of dehydrated pears was added and boiled gently for exactly 15 minutes in case of peeled dried pears and 25 minutes in case of unpeeled dried pears. The fruit was then immediately transferred to a stainless steel pan containing 1200 ml of cold water. The fruit stayed in cold water for three minutes. It was then drained on a stainless steel wire tray for two minutes and weighed. The percent rehydration was calculated for each lot using the following formula:

$$\text{Percent rehydration} = \frac{\text{Rehydrated weight}}{\text{Dehydrated weight x drying ratio}} \times 100$$

Sensory Appraisal

A panel of eight judges experienced in sensory evaluation was selected among the graduate students and staff members of the Food Science and Technology Department. Flavor, color, texture, over-all appearance and over-all desirability of each lot of fruit were judged.

Samples for sensory appraisal were moisturized by the method given for determination of percent rehydration. For serving, each rehydrated half pear of the sample was cut into four pieces. Then each sample of cut pieces was mixed together and sub-divided into eight equal servings. The samples were served in coded cups on a serving tray to the judges, who were seated in individual booths equipped with a sink and overhead red light. The red light was chosen to obscure the differences in color between the pear samples. The judges were asked to score on a seven point scale for flavor and texture, in which a score of seven indicated typical pear flavor, normal eating firmness, and a score of one indicated extremely off-flavor and extremely soft or firm texture, respectively. The over-all desirability was also scored on a seven point hedonic scale in which seven indicated very desirable and one indicated very undesirable. For color and over-all appearance a single reconstituted half pear was taken at random from each lot and placed in coded white bowls on the counter in an adjacent laboratory. The same panel of eight judges, after scoring the flavor factors, scored the color and over-all appearance of the samples on a nine point hedonic scale in which nine indicated like extremely and one indicated dislike extremely.

RESULTS AND DISCUSSION

The four varieties were dehydrated both as peeled and unpeeled halves using two different methods of dehydration as described under Materials and Methods. This resulted in a total of 16 lots of dehydrated pears, each variety having four different lots. These 16 lots were organized into four treatment groups, each group consisting of four lots representing four varieties and one treatment. The four lots of each variety treatment group had the same pre-treatments and were dehydrated under similar conditions of temperature, time, relative humidity, velocity of air, tray load, etc. The drying time for each of the above groups was found experimentally. This was the time required for Bartlett pears to be dehydrated to 18 percent moisture content. This made the comparison between the four varieties possible.

The data obtained were analyzed statistically by the analysis of variance method (19, p. 207-208). Where the effects were found significant by the "F" tests, the least significant difference between individual means was calculated.

Percent Moisture in Dehydrated Pears

The dehydrated Bartlett pears of all four treatments are shown to exhibit a higher moisture content than the corresponding four

treatments of the other three varieties (Table II). The four treatments of Anjou contain more moisture than corresponding four treatments of Comice and Packam's Triumph but less moisture than the corresponding four treatments of Bartlett. The moisture content of the four treatments of Packam's Triumph and Comice are variable, although fresh Comice contained more moisture than the other three varieties (Table II).

This means that more moisture was evaporated from the four treatments of Comice than the other three varieties assuming that all the varieties were dehydrated under similar conditions. Packam's Triumph occupied the next position with regard to loss of moisture per unit time. Anjou lost more moisture than Bartlett under the same conditions but less than Packam's Triumph. The above four varieties under a particular treatment had the same pre-treatment and were dehydrated under similar conditions of temperature, relative humidity, time, tray load, velocity of air over fruit, etc. This difference in the moisture content of the dehydrated pears was due to size, composition, and varietal characteristics.

Table II. Percent Moisture in Fresh and Dehydrated Pears of Different Varieties and Treatments.

(Average of duplicate samples)

Treatment	Bartlett	Comice	Anjou	Packam's Triumph
Fresh	83.52	85.30	83.05	83.77
Conventionally dried, unpeeled	19.61	15.10	18.52	15.91
Conventionally dried, peeled	18.11	15.39	17.84	16.20
Dry-blanch-dried, unpeeled	19.39	15.67	18.64	15.64
Dry-blanch-dried, peeled	17.98	14.29	17.03	15.27

Over-all Drying Ratio

The over-all drying ratio was calculated as the ratio of the weight of the fresh fruit to the weight of the dried fruit containing 18 percent moisture in order to make the comparison between varieties and methods of dehydration possible. Because of the preparation losses due to peeling and coring in case of peeled dried pears there was an obvious difference in the over-all drying ratio of peeled and unpeeled dried pears regardless of variety and method of dehydration. It was therefore considered necessary to compare the over-all drying ratio of peeled and unpeeled dried pears separately. The results of the over-all drying ratio of the conventionally dried unpeeled and dry-blanch-dry unpeeled pears of all four varieties are tabulated in Table IIIa. The statistical analysis of variance showed that the effect of variety and method of dehydration on the drying ratio were not significant (Table IIIb). This showed that the yield of the unpeeled dehydrated pears from the same amount of fresh pears of each variety did not vary significantly. This also indicated that the two methods of dehydration were equally good insofar as the yield of unpeeled dehydrated pears of the same moisture content from the same amount of fresh pears of each variety was concerned.

Table IIIa. Over-all Drying Ratio of Unpeeled Pears of Different Varieties and Treatments.

Treatment	Variety			
	Bartlett	Comice	Anjou	Packam's Triumph
Conventionally dried, unpeeled	4.9	5.4	5.0	5.2
Dry-blanch-dry, unpeeled	5.2	4.8	5.5	5.4

Table IIIb. Analysis of Variance of Over-all Drying Ratio of Unpeeled Pears of Different Varieties and Treatments.

Source of Variation	Sum of square	Degree of Freedom	Mean square	F
Total	0.455	7		
Variety	0.085	3	0.028	0.23
Treatment	0.020	1	0.020	0.17
Error	0.350	3	0.116	

The result of over-all drying ratio of the conventionally dried peeled and dry-blanch-dry peeled pears of all four varieties is shown in Table IVa.

The analysis of data showed that the effect of method of dehydration on the over-all drying ratio was not significant (Table IVb). However, the effect of variety on the over-all drying ratio was found to be significant. The Packam's Triumph variety was indicated to have the highest over-all drying ratio of all the four varieties (Table IVc). Anjou had a higher over-all drying ratio than Comice and Bartlett. There was no significant difference in the over-all drying ratio of Comice and Bartlett (Table IVc). The over-all drying ratio varies with variety, maturity, pre-treatment waste, season and drying conditions (14, p. 18-21). The higher over-all drying ratio of Packam's Triumph and Anjou was due to more pre-treatment losses. Packam's Triumph fruit has an irregular shape and therefore the losses, due to peeling and coring, were more. The losses in preparation, in the case of Anjou, were more because of the breakdown of the tissue due to non-uniform ripening.

Table IVa. Over-all Drying Ratio of Peeled Pears of Different Varieties and Treatments.

Treatment	Variety			
	Bartlett	Comice	Anjou	Packam's Triumph
Conventionally dried, peeled	7.3	7.1	8.3	9.5
Dry-blanch-dry, peeled	7.2	7.4	8.1	9.7

Table IVb. Analysis of Variance of Over-all Drying Ratio of Peeled Pears of Different Varieties and Treatments.

Source of Variation	Sum of square	Degree of Freedom	Mean square	F
Total	7.5	7		
Variety	7.39	3	2.46	82 ***
Treatment	0.01	1	0.01	0.33
Error	0.1	3	0.03	

*** Significant at 1% level of significance

Table IVc. Mean Over-all Drying Ratio of Different Varieties

Variety				
Bartlett	Comice	Anjou	Packam's Triumph	
7.25	7.25	8.2	9.6	LSD 5% = 0.54

Percent Rehydration

Rehydration which is also referred to as reconstitution signifies the restoration of water to the dehydrated product. A dehydrated product which rehydrates quickly and returns somewhat closely to its original moisture content and physical properties is naturally more desirable than the one which does not. Thus, percent rehydration could be taken as an index of quality of a dehydrated product.

The dried pears were rehydrated by the methods described in the previous section and the percent rehydration calculated. The results of percent rehydration are shown in Table Va.

The statistical analysis of variance showed that the effect of both variety and treatment on percent rehydration was significant (Table Vb). Bartlett had the highest rehydration percentage of all the four varieties studied (Table Vc). The Anjou variety had a significantly lower rehydration percentage than Bartlett, but a higher rehydration percentage than Comice or Packam's Triumph. Rehydration values for the latter two varieties did not vary significantly (Table Vc).

Conventionally dried peeled pears had a significantly higher rehydration percentage than conventionally dried unpeeled pears in all four varieties (Table Vd). Similarly, the dry-blanch-dry peeled pear had a higher rehydration percentage than the dry-blanch-dry unpeeled

pears of all four varieties (Table Vd). This showed that the unpeeled dehydrated pears of all four varieties did not absorb the same amount of water during reconstitution as the peeled dehydrated pears and that the skin retarded the absorption of water. This agrees with the findings of Culpepper and Moon (8, p. 23), who showed that the unpeeled dried Kieffer pears did not absorb the same amount of moisture as did peeled dried pears upon reconstitution. The percent rehydration of conventionally dried unpeeled pears did not vary significantly from the percent rehydration of dry-blanch-dry unpeeled pears. On the other hand, the dry-blanch-dry peeled pears had a higher rehydration percentage than the conventionally dried peeled pears (Table Vd). This difference was due to the fact that in the production of conventionally dried peeled pears the fruit was blanched and then sulfured. This resulted in the collapse of tissue and thus the rehydration was poor. On the other hand, in the production of dry-blanch-dry peeled pears the fruit was sulfured, partially dried, blanched and then dehydration completed. Blanching the fruit after partial dehydration allowed a better control of the texture and consequently the percentage rehydration was higher.

Table Va. Mean Percent Rehydration of Different Varieties and Treatments.

Treatment	Variety			
	Bartlett	Anjou	Comice	Packam's Triumph
Conventionally dried, unpeeled	36.8	35.0	35.9	34.3
Conventionally dried, peeled	38.0	36.1	37.2	36.7
Dry-blanch-dried, unpeeled	37.7	34.6	36.9	35.3
Dry-blanch-dried, peeled	42.1	39.2	40.5	38.7

Table Vb. Analysis of Variance of Percent Rehydration of Dried Pears of Different Varieties and Treatments.

Source of Variation	Sum of square	Degree of freedom	Mean square	F
Total	69.06	15		
Treatment	50.56	3	16.85	80.23***
Variety	16.54	3	5.51	26.23***
Error	1.96	9	0.21	

*** Significant at 1% level of significance

Table Vc. Mean Percentage of Rehydration of Different Varieties.

Variety				
Bartlett	Comice	Anjou	Packam's Triumph	
38.65	36.22	37.62	36.25	LSD 5% = 0.723

Table Vd. Mean Percentages of Rehydration of Different Dehydration Treatments of Pears.

Treatments	Mean percentage of rehydration	
Conventionally dried, unpeeled	35.50	
Conventionally dried, peeled	37.00	LSD 5% = 0.723
Dry-blanch-dry, unpeeled	36.12	
Dry-blanch-dry, peeled	42.37	

Total Sugar

The total sugar content of the dehydrated product representing various treatments and varieties was calculated as dextrose on an 18 percent moisture basis for all 16 lots (Table VIa). The analysis of variance showed that the effect of variety and treatment on the total sugar content was significant (Table VIb). Anjou had the lowest total sugar content of the four varieties (Table VIc). Packam's Triumph had higher total sugar content than Anjou but lower total sugar content than Comice and Bartlett. The total sugar content of the latter two varieties did not vary significantly. The difference in the total sugar content of the dehydrated pears of the four varieties was due to the difference in the total sugar content of the fresh fruit (Table VIa).

Fresh Anjou had the lowest total sugar content of the four varieties. Packam's Triumph had higher total sugar content than Anjou but lower than Bartlett. Although fresh Comice had lower total sugar content than Bartlett on fresh weight basis, the total sugar content of the dehydrated pears of the two varieties did not vary significantly. This was because fresh Comice had a higher moisture content than fresh Bartlett and the total sugar content was calculated on fresh weight basis, while the sugar content of the dehydrated pears was calculated on 18 percent moisture basis.

The conventionally dried unpeeled and the dry-blanch-dry unpeeled pears had a lower total sugar content than the corresponding conventionally dried peeled and dry-blanch-dry peeled pears (Table VId). This was because in the preparation of the peeled dried pears the peel and core of the fresh pears were removed. These two parts contain less sugar and the removal of these left the pear half with more sugar. The dry-blanch-dry unpeeled pears had a significantly lower sugar content than the conventionally dried unpeeled pears. This showed that the losses in total sugar were less in the conventional method than in the dry-blanch-dry method. On the other hand, the conventionally dried peeled and dry-blanch-dry peeled pears did not vary significantly in total sugar content (Table VId).

Table VIa. Mean Percentages of Total Sugar on 18 Percent Moisture Basis for Different Varieties and Treatments.

Treatment	Variety			
	Bartlett	Comice	Anjou	Packam's Triumph
Fresh	9.15	8.75	8.20	8.90
Conventionally dried, unpeeled	41.13	41.57	38,71	40.01
Conventionally dried, peeled	43.21	41.56	40.75	41.94
Dry-blanch-dry, unpeeled	40.22	40.66	37.80	39.06
Dry-blanch-dry, peeled	42.16	42.52	39.72	40.99

Table VIb. Analysis of Variance of Percent Rehydration of Dried Pears of Different Varieties and Treatments.

Source of Variation	Sum of square	Degree of freedom	Mean square	F
Total	30.88	15		
Variety	15.51	3	5.17	32.31***
Treatments	13.94	3	4.64	29.00***
Error	1.43	9	0.16	

*** Significant at 1% level of significance

Table VIc. Mean Percentage of Total Sugar on 18 Percent Moisture Basis for Different Varieties.

Variety	Mean Percentage	
Bartlett	41.69	
Comice	41.57	
Anjou	39.24	LSD at 5% = 0.63
Packam's Triumph	40.50	

Table VId. Mean Percentage of Total Sugar on 18 Percent Moisture Basis for Different Treatments of Dehydrated Pears.

Treatments	Mean percentage	
Conventionally dried, unpeeled	40.35	
Conventionall dried, peeled	41.86	LSD at 5% = 0.63
Dry-blanch-dry, unpeeled	39.43	
Dry-blanch-dry, peeled	41.34	

Total Acid

The total acid was determined as percent citric acid on all lots of dehydrated pears on 18 percent moisture basis (Table VIIa). Results of the analysis of variance indicated that the effect of variety on total acid content of the dried product was significant (Table VIIb). Anjou had a significantly higher total acid content than the other three varieties (Table VIIc). Packam's Triumph had a lower total acid content than Comice and Bartlett. The total acid content of the latter two varieties did not vary significantly. The difference in the total acid content of the dehydrated pears of the four varieties was due to the difference in the total acid content of the fresh pears (Table VIIa).

Table VIIa. Mean Percentage of Total Acid on 18 Percent Moisture Basis for Different Varieties and Treatments.

	Variety			
	Bartlett	Comice	Anjou	Packam's Triumph
Fresh	0.235	0.210	0.280	0.188
Conventionally dried, unpeeled	1.13	1.15	1.30	0.88
Conventionally dried, peeled	1.10	1.12	1.25	0.83
Dry-blanch-dry, unpeeled	1.08	1.06	1.32	0.90
Dry-blanch-dry, peeled	1.14	1.10	1.27	0.85

Table VIIb. Analysis of Variance of Mean Percentage of Total Acid on 18 Percent Moisture Basis for Different Varieties and Treatments.

Source of Variation	Sum of square	Degree of freedom	Mean square	F
Total	0.3701	15	------	-----
Variety	0.3577	3	0.1192	99.33***
Treatments	0.0013	3	0.0004	0.33
Error	0.0111	9	0.0012	

*** Significant at 1% level of significance

Table VIIc. Mean Percentage of Total Acid on 18 Percent Moisture Basis for Varieties.

Variety	Mean percentage	
Bartlett	1.11	
Comice	1.10	
Anjou	1.28	LSD at 5% = 0.05
Packam's Triumph	0.86	

The total acid content of the four varieties did not vary significantly due to treatments (Table VIIb). This showed that the two methods of dehydration did not significantly affect the total acid content of the dehydrated product. This also indicated that dehydrating the pear with skin or without skin did not significantly change the total acid content of the dehydrated product.

Sensory Appraisal of the Reconstituted Pears

The dehydrated pears were stored at 70° F. prior to evaluation. The storage period of Bartlett, Comice, Anjou and Packam's Triumph was 275, 212, 186 and 175 days, respectively.

A panel of eight judges selected among the graduate students and staff members of the Food Science and Technology Department scored the dehydrated pears after storage for flavor, texture, color, over-all appearance and over-all desirability. Samples representing each lot were reconstituted and presented to the panel by the methods described in the chapter on Materials and Methods.

Flavor

The average flavor scores for eight judgements is shown in Table VIIIa. The statistical analysis of variance showed that regardless of treatments there was no significant difference between the four varieties in typical pear flavor (Table VIIIb). Statistical

analysis of the flavor data also indicated that the flavor of the dehydrated product was not affected significantly by the treatment, regardless of the variety. Since all the samples were scored on a seven point scale in which seven indicated typical natural pear flavor and one indicated extremely weak or off-flavor, a sample having a mean score above four was considered to have a natural pear flavor. All the samples representing various dehydrated lots were rated above four by the panel (Table VIIIa). This showed that all the lots had a natural pear flavor when reconstituted.

Table VIIIa. Mean Flavor Score of Eight Judges for Different Varieties and Different Treatments.

Treatment	Variety			
	Bartlett	Comice	Anjou	Packam's Triumph
Conventionally dried, unpeeled	3.93	4.28	3.43	4.31
Conventionally dried, peeled	4.37	4.56	4.25	4.56
Dry-blanch-dry, unpeeled	4.31	4.43	4.25	4.25
Dry-blanch-dry, peeled	4.68	4.68	4.50	4.06

Table VIIIb. Analysis of Variance of Mean Flavor Score of Eight Judges for Different Varieties and Different Treatments.

Source of Variation	Degree of freedom	Sum of squares	Mean square	F
Total	127	233.13	1.75	
Treatments	3	3.15	1.05	0.403
Judges	7	45.83	6.54	2.51**
Treatment x judges Error (a)	21	54.65	2.60	
Variety	3	2.38	0.79	0.699
Treatment x variety	9	6.00	0.66	0.559
Variety x judges	21	36.40	1.73	1.46
Variety x treatment x judges Error (b)	63	74.72	1.18	

** Significant at 5% level of significance.

Texture

Table IXa shows the average score for texture by eight judges. The analysis of variance indicated that the dehydrated pears of the four varieties and treatments did not vary significantly in having a normal eating firmness (Table IXb). All the samples were rated on a seven point scale in which seven indicated normal eating firmness and one indicated extremely soft or firm texture. All the samples representing various lots were rated favorable by the panel (Table IXb). This means that all the dehydrated lots when reconstituted were

considered to have the normal eating firmness.

Table IXa. Mean Score of Eight Judges for Fruit Texture of Different Varieties and Treatments.

Treatment	Variety			
	Bartlett	Comice	Anjou	Packam's Triumph
Conventionally dried, unpeeled	4.56	3.62	3.43	3.43
Conventionally dried, peeled	4.50	3.93	4.93	4.56
Dry-blanch-dry, unpeeled	4.12	4.50	3.68	3.50
Dry-blanch-dry, peeled	4.18	4.25	4.87	4.62

Table IXb. Analysis of Variance of Mean Score of Eight Judges for Fruit Texture of Different Varieties and Treatments.

Source of Variation	Degree of freedom	Sum of squares	Mean square	F
Total	127	244.72		
Treatments	3	9.86	3.28	2.37
Judges	7	76.93	10.99	7.96***
Treatment x judges Error (a)	21	29.05	1.38	
Variety	3	1.98	0.66	0.56
Treatment x variety	9	19.63	2.18	1.86
Variety x judges	21	33.43	1.59	1.35
Variety x treatment x judges Error (b)	63	73.84	1.17	

*** Significant at 1% level of significance

Color

The average color quality rating of eight judges is tabulated in Table Xa. The statistical analysis of variance showed that the effect of treatment and variety on color of reconstituted pears were both highly significant (Table Xb). The conventionally dried peeled pears were shown to have a better color than the conventionally dried unpeeled pears and the color of the dry-blanch-dry peeled pears was scored higher than the dry-blanch-dry unpeeled pears (Table Xc). Since all the samples were scored on a nine point scale in which nine indicated extremely liked color and one indicated extremely disliked color, a lot getting a mean score above five was considered to be liked by the panel. The conventionally dried unpeeled and the dry-blanch-dry unpeeled pears had a mean score below five (Table Xa). This indicated the color of the unpeeled pears of all four varieties was not liked by the panel. On the other hand, the color of the peeled pears of all the four varieties was rated above five. This showed that the color of the peeled pears was liked by the panel. The peeled pears of all four varieties had a light, attractive color.

Table Xa. Mean Score of Eight Judges for Color of Different Varieties and Treatments.

Treatment	Variety			
	Bartlett	Comice	Anjou	Packam's Triumph
Conventionally dried, unpeeled	4.00	3.25	3.25	3.75
Conventionally dried, peeled	6.00	4.87	7.00	5.50
Dry-blanch-dry, unpeeled	2.00	6.87	4.62	3.50
Dry-blanch-dry, peeled	7.00	7.82	7.00	6.62

Table Xb. Analysis of Variance of Mean Score of Eight Judges for Color of Different Varieties and Treatments.

Source of Variation	Degree of freedom	Sum of squares	Mean squares	F
Total	127	541.37		
Treatments	3	154.21	51..40	23.36***
Judges	7	72.18	10.31	4.68***
Treatment x judges Error (a)	21	46.23	2.20	
Variety	3	15.96	5..32	5.78***
Treatment x variety	9	167.07	18..56	20.17***
Variety x judges	21	27.48	1.30	1.41
Variety x treatment x judges Error (b)	63	58.24	0.92	

*** Significant at 1% level of significance

The dry-blanch-dry peeled and unpeeled pears were shown to have better color than corresponding conventionally dried peeled and unpeeled pears (Table Xc). This indicated that the dehydrated pears made with dry-blanch-dry method preserved its color upon storage better than the ones dehydrated by the conventional method of dehydration. The panel rated the color of Comice and Anjou much higher than Bartlett and Packam's Triumph (Table Xd). This was due to the fact that Bartlett had a longer storage period at 70° F. than Anjou and Comice and so the color deteriorated more in the case of Bartlett, due to longer storage. However, in the case of Packam's Triumph the storage period was less than Comice and Anjou, but the color deteriorated much faster than Comice and Anjou. The color of Comice and Anjou did not vary significantly (Table Xd), although Comice had 26 days longer storage period at 70° F. than Anjou. This indicated that the 26 days extra storage period at 70° F. did not affect the color of Comice enough to be detected by the panel. There was no significant difference in the color of Packam's Triumph and Bartlett, although Bartlett had a 100 days longer storage period at 70° F. than Packam's Triumph. This indicated that the color of the Packam's Triumph deteriorated much faster than any other variety upon storage. It took dried Bartlett pears 275 days storage at 70° F. and Packam's Triumph dried pears 175 days to deteriorate in color to the same degree as shown by panel results. Both Bartlett

Table Xc. Mean Scores for Treatments.

Treatment	Mean Scores	
Conventionally dried, unpeeled	3. 56	
Conventionally dried, peeled	5. 84	
Dry-blanch-dry, unpeeled	4. 24	LSD 5% = 0. 7488
Dry-blanch-dry, peeled	7. 11	

Table Xd. Mean Scores for Varieties.

Variety	Mean Scores	
Bartlett	4. 75	
Comice	5. 70	
Anjou	5. 46	LSD 5% = 0. 46
Packam's Triumph	4. 84	

and Packam's Triumph were rated below five by the panel which indicated that the color of these two varieties was not liked by the panel. Comice and Anjou had a mean score above five which indicated the fact that the color of these two varieties was liked by the panel.

Over-all Appearance

The average judgements of eight judges is tabulated in Table XIa. The statistical analysis of variance shows that there was no significant difference in the over-all appearance of four varieties and treatments (Table XIb). All the samples were scored on a nine point scale in which nine indicated liked extremely well and one indicated disliked extremely. All the samples had a mean score below five which indicated that the over-all appearance of all the samples was not liked by the panel. This was because the unpeeled dried pears of all lots had a brown, unattractive color. The peeled dried pears had a light, attractive color, but did not keep the typical cup shape upon reconstitution and were, therefore, rated poorer by the panel.

Table XIa. Mean Score of Eight Judges for Over-all Appearance of Different Varieties and Treatments.

Treatment	Variety			
	Bartlett	Comice	Anjou	Packam's Triumph
Conventionally dried, unpeeled	4.06	3.81	3.37	3.00
Conventionally dried, peeled	4.68	4.00	4.37	4.00
Dry-blanch-dry, unpeeled	3.87	4.00	3.81	3.56
Dry-blanch-dry, peeled	4.62	4.31	4.12	4.18

Table XIb. Analysis of Variance of Mean Score of Eight Judges for Over-all Appearance of Different Varieties and Treatments.

Source of variation	Degree of freedom	Sum of squares	Mean squares	F
Total	127	273.74		
Treatments	3	10.65	3.55	1.86
Judges	7	121.99	17.42	9.16**
Treatment x judges Error (a)	21	40.03	1.90	
Variety	3	2.44	0.81	0.73
Treatment x variety	9	9.49	1.05	0.95
Variety x judges	21	19.68	0.93	0.84
Variety x treatment x judges Error (b)	63	69.46	1.10	

** Significant at 1% level of significance

Over-all Desirability

The scores that were given by the judges are shown in Table XIIa. The statistical analysis of variance indicated that the effect of variety and treatment on the over-all desirability was significant (Table XIIb). The conventionally dried peeled pears were shown to be more desirable than conventionally dried unpeeled pears, and the dry-blanch-dry peeled pears were indicated to have better over-all desirability than dry-blanch-dry unpeeled. This was because all the peeled dried pears had a more attractive color than unpeeled dried pears. All the samples representing the various varieties and treatments were scored on a seven point scale in which seven indicated extremely desirable and one indicated extremely undesirable. The dehydrated pears of the four treatments were rated favorably by the panel indicating that the over-all desirability of all four treatments was liked by the panel.

The over-all desirability of conventionally dried unpeeled and dry-blanch-dry unpeeled pears did not vary significantly (Table XIIc). The same was true for conventionally dried peeled and dry-blanch-dry peeled pears. Packam's Triumph was indicated to be less desirable than the other three varieties (Table XIId). This was because Packam's Triumph had a brown, unattractive color. The over-all desirability of Bartlett, Comice and Anjou did not vary significantly.

All the four varieties were rated higher than four showing that the over-all desirability of these varieties was liked by the panel.

Table XIIa. Mean Scores of Eight Judges for Over-all Desirability of Different Varieties and Treatments.

Treatment	Variety			
	Bartlett	Comice	Anjou	Packam's Triumph
Conventionally dried, unpeeled	4.50	3.50	3.25	3.75
Conventionally dried, peeled	6.75	5.00	6.50	4.12
Dry-blanch-dry, unpeeled	3.62	6.25	4.62	3.62
Dry-blanch-dry, peeled	6.87	7.12	6.75	6.50

Table XIIb. Analysis of Variance of Mean Scores of Eight Judges for Over-all Desirability of Different Varieties and Treatments.

Source of variation	Degree of freedom	Sum of squares	Mean square	F
Total	127	500.22		
Treatments	3	105.53	35.17	10.16
Judges	7	85.97	12.28	3.54**
Treatment x judges Error (a)	21	72.72	3.46	
Variety	3	19.90	6.63	23.67
Treatment x variety	9	127.04	14.11	50.39
Variety x judges	21	71.35	3.39	12.10
Variety x treatment x judges Error (b)	63	17.71	0.28	

** Significant at 5% level of significance

Table XIIc. Mean Scores for Treatments.

Treatment	Mean score	
Conventionally dried, unpeeled	3.75	
Conventionally dried, peeled	5.59	
Dry-blanch-dry, unpeeled	4.52	LSD 5% = 0.956
Dry-blanch-dry, peeled	6.81	

Table XIId. Mean Scores for Varieties.

Variety	Mean Score	
Bartlett	5.43	
Comice	5.46	
Anjou	5.28	LSD 5% = 0.26
Packam's Triumph	4.49	

SUMMARY AND CONCLUSIONS

In this thesis a study was made of the suitability of Comice, Anjou, Packam's Triumph, the three pollinizing varieties of pears, for dehydration as compared to the Bartlett variety which is commercially used for dehydration. The pears were dehydrated using conventional and dry-blanch-dry methods and were subsequently stored at 70° F. The storage period of Bartlett, Comice, Anjou, and Packam's Triumph was 275, 212, 186, and 175 days, respectively. Following storage the dehydrated pears were subjectively evaluated for flavor, texture, color, over-all appearance, and over-all desirability. The results indicated the following conclusions.

(1) There was no significant difference in the over-all drying ratio of the unpeeled dried pears of all four varieties and treatments.

(2) Peeled dried Packam's Triumph had the highest over-all drying ratio followed by Anjou, Comice and Bartlett, respectively.

(3) Bartlett had the highest rehydration percentage followed by Anjou, Comice, and Packam's Triumph, respectively.

(4) The peeled dried pears of all four varieties and treatments had a higher rehydration percentage than the unpeeled dried pears.

(5) There was no significant difference in the rehydration percentage of conventionally dried unpeeled and dry-blanch-dry unpeeled pears. But dry-blanch-dry peeled pears had a significantly higher

rehydration percentage than conventionally dried peeled pears.

(6) The dehydrated Anjou pears had the lowest total sugar content of all four varieties. Packam's Triumph had a higher total sugar content than Anjou but lower than Comice and Bartlett. The total sugar content of the latter two varieties did not vary significantly.

(7) The dehydrated Anjou pears had the highest total acid content of all the four varieties. Packam's Triumph had a lower total acid content than Comice and Bartlett. The total acid content of the latter two varieties did not vary significantly.

(8) The flavor, texture, over-all appearance of all dehydrated lots did not vary significantly. The flavor and texture of all lots were liked by the panel, but the over-all appearance of these lots was disliked by the panel.

(9) The color of peeled dried pears was rated higher than unpeeled dried pears by the panel, regardless of variety and method of dehydration. The panel liked the color of dry-blanch-dry unpeeled and peeled pears more than corresponding conventionally dried unpeeled and peeled pears. The color of Comice and Anjou was rated higher than Bartlett and Packam's Triumph by the panel. The color of the latter two varieties was disliked by the panel.

(10) The over-all desirability of all four varieties was rated higher than average by the panel.

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