ASCORBIC ACID CONTENT AND SENSORY CHARACTERISTICS OF DEHYDRATED GREEN PEPPERS

by

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INTRODUCTION

Drying as a method of food preservation has been practiced for hundreds of years. Originally, the sun provided the source of energy, but today foods are dried more commonly by electric, hot air dehydrators or ovens. Recently dried foods have found increasing popularity, probably because they do not require energy for storage as frozen foods do and they take up less storage space than canned foods.

Major problems with any preservation method include the retention of nutrients and desirable sensory characteristics. Most researchers believe that frozen food retains more nutrients than canned or dried food. However, there is some controversy in the literature on whether dehydration or canning is more detrimental to the nutritional quality of the food (Lund, 1979; Drew and Rhee, 1980). In dehydrated foods, nutrient losses generally are dependent on the method of preparation before dehydration, the dehydration process, and the conditions of storage. Nutritional losses include the loss of protein biological value, fat and water soluble vitamins (Labuza, 1972), and minerals. The nutrients most susceptible to destruction in food dehydration, vitamins A and C, are sensitive to heat and oxidation (Bluestein and Labuza, 1975). The loss of desirable sensory characteristics include the loss of fresh flavor (Villota et al., 1980) and poor texture (White, 1973) resulting from the shrinkage of the food.

Most vegetables are dehydrated commercially using hot air drying techniques (Villota et al., 1980). Green peppers are one of the major dried vegetables (Labuza, 1976) sold by the food industry for use in dry soup mixes, salads, and canned foods.

REVIEW OF LITERATURE

Drying as a method of food preservation is dependent upon the removal of sufficient water to prevent microbial growth. Dehydrated or low moisture foods generally are below 20% moisture content and have a water activity of .70 or below (Salunke et al., 1973). The reduction of the water activity to safe levels in hot air dehydrators requires subjecting the food to moderate temperatures, 75°C to 90°C, for extended periods of time, 8 to 16 hr (Labuza, 1972).

Heat Treatment Prior to Dehydration

Blanching foods prior to dehydration usually is done for one or more of the following effects: to reduce the drying time; soften the texture; inactivate the enzymes and therefore, retard the development of objectionable odors or flavors, and retain ascorbic acid and carotene during storage; and retard non-enzymatic browning. Moyer and coworkers (1959) found that steam blanching increased the drying rate of peas. Blanching breaks the surface skins and allows moisture to be removed from the vegetables with skins more rapidly. Although a softening of the texture of dehydrated foods has been attributed to blanching, Gee et al. (1977) found that fruits and vegetables dehydrated without blanching were tender enough to be eaten without rehydration. They reported that direct low temperature dehydration without blanching minimized the formation of a tough leathery skin. Most researchers agree that blanching of vegetables prior to dehydration is required to inactivate enzymes (Tressler, 1956; Schwimmer, 1980). Since enzymes are relatively insensitive to dry heat they are not inactivated in drying (Derosier and Derosier, 1977; Escher and Blanc, 1977). In addition, enzyme action can continue below A_w 0.70, and some are even active at A_w as low as 0.01, so it is not economically advantageous to lower the A_w to levels where all enzyme action ceases (Schwimmer, 1980).

Sensory characteristics. Among the quality defects attributed to enzyme action in vegetables during drying and storage are the development of off-odors and off-flavors, especially the hay-like aroma of unblanched vegetables. Although blanching is recommended to prevent the formation of those odors, Mallette et al. (1946) and Foda et al. (1967) reported finding those odors in blanched vegetables. Mallette et al. (1946) also observed that vegetables (Irish potatoes and sweet potatoes) with no significant amount of oxidative enzyme activity after blanching developed hay-like aromas in storage. The enzyme responsible still has not been identified (Schwimmer, 1980). Feinberg (1973) maintains that blanching before dehydration may alter the flavor of vegetables because the heating process drives off some of the volatile flavor compounds.

The browning or discoloration of ruptured plant tissues is believed to be caused by oxidative enzyme systems and controlled by heat inactivation of these enzymes (Derosier and Derosier, 1977). Although the browning of vegetables generally is detected during storage, Mallette et al. (1946) observed a slight darkening, prior to storage, in cabbage that had been blanched (steam, 3 min) and dehydrated. A significant amount of peroxidase activity was found in the cabbage after the blanching treatment. One of the negative aspects of blanching vegetables containing chlorophyll prior to dehydration is the increase in the conversion of chlorophyll to pheophytin (Dutton et al., 1943; Feinberg, 1973). Without blanching, Gee and coworkers (1977) observed that the bright, natural color of their dehydrated vegetables was stable for many months in the absence of light at room temperature and with A_w of 0.45-0.50.

Nutrient retention. Water soluble nutrients lost in the preparation (sorting, washing, cutting, and blanching) for dehydration include minerals, vitamin C, and the B vitamins to a small extent (Labuza, 1972). Nutrient loss during blanching is caused by leaching of water soluble compounds into the blanching medium and some oxidation of vitamin C. Negligible losses of nutrients occur because of thermal destruction (Feaster, 1971). Relatively small amounts (up to 10%) of riboflavin, niacin, and pantothenic acid (Hendel, 1971) and pyridoxine (Holmes et al., 1979) are lost in blanching. A 20% loss of free folacin was found in the blanching of green beans (Holmes et al., 1979).

Preparation for dehydration accounts for a 10-50% loss in ascorbic acid (Labuza, 1972). Morgan et al. (1945) reported approximately 50% losses of ascorbic acid in spinach blanched using steam for 4 min or boiling water for 2 min. Losses were slightly higher for the boiling water bath. Holmes et al. (1979) found a 33% loss of ascorbic acid in green beans blanched for 3 min in boiling water.

Although blanching results in a loss of water soluble vitamins, especially vitamin C, some researchers have found that it aids in the retention of ascorbic acid during dehydration and storage, possibly because of enzyme inactivation. Morgan et al. (1945) found that during dehydration, blanched broccoli lost 10-20% of its ascorbic acid while unblanched broccoli lost 64% of its ascorbic acid; blanched spinach lost 30% of its ascorbic acid during dehydration while the unblanched lost 70% of its ascorbic acid. However, if one includes blanching losses for spinach (50%), the unblanched spinach still retained more ascorbic acid after dehyration. Morgan et al. (1945) also reported similar findings for snap beans. After dehydration only 20-30% of the ascorbic acid was retained in the beans whether they were unblanched or blanched by steam, water or pressure cooking methods. This is in agreement with Holmes et al. (1979) who found that in green beans, blanching had no effect on ascorbic acid retention during dehydration. Both blanched (which lost 33% in blanching) and unblanched retained only 2% of their original ascorbic acid after dehydration.

Apparently the protection against ascorbic acid loss that blanching provides is more critical in the storage of the dried vegetables than in dehydration. As Morgan et al. (1945) reported, the unblanched spinach retained 30% of its ascorbic acid after dehydration and the blanched spinach retained only 9-16% of its ascorbic acid; however the blanched spinach lost little ascorbic acid in storage while the unblanched spinach continued to lose ascorbic acid over the 4 month time period until it reached the same level as the blanched.

Dehydration

A limited variety of dried vegetables is available on the market. Poor quality characteristics such as discoloration, loss of physical form, poor rehydration, loss of volatile flavors, off-flavor development, and nutrient loss limit their acceptability.

Sensory characteristics. Drying can promote the formation of pheophytin from chlorophyll in grassy-green vegetables changing them to an olive green color. Foda et al. (1967) observed that only 35-40% of the chlorophyll of four varieties of fresh green beans was retained after blanching and dehydration. The variety with the lowest original moisture content retained the most chlorophyll. This finding was attributed to the shorter drying time required to reach the desired moisture content.

Vegetables dehydrated by hot air drying techniques typically have dense shrunken structures which do not rehydrate well. The greater the degree of drying the more extensive the cell structure damage (Villota et al., 1980). Foda et al. (1967) observed this phenomena in dehydrated green beans. The variety of beans subjected to the shortest drying time suffered least from shrinkage.

Acceptance of most dehydrated products is limited because of the loss of desirable flavor compounds. This is particularly true for vegetables in which the major flavor compounds are volatile oils, as in onions. However, when volatile and non-volatile flavor compounds exist, as in root vegetables, the loss of volatile oils in dehydration is not as detrimental to the flavor of the dried vegetables. Equally important as the loss of fresh flavor, is the development of off-flavors in the dried vegetables caused by non-enzymatic browning and oxidation. As noted previously, flavor defects such as the hay-like aroma in dehydrated vegetables which develop during drying and storage have been attributed to, as yet, unidentified enzymes (Schwimmer, 1980).

Nutrient retention. The loss of nutrients in dehydrated foods is affected more by the pretreatment of the raw material and storage of the dry product than by the actual drying procedure (Escher and Blanc, 1977). Nutrient losses reported in the literature vary considerably because they are dependent on pretreatment (blanching method, sulfuring), drying conditions (time, temperature, and method), and the specific food system. Generally, in dried vegetables losses of vitamins A and C occur to a greater extent than losses of the B vitamins or folacin during the dehydration procedure.

According to Hendel (1971) only moderate losses of thiamin, riboflavin, niacin, and pantothenic acid occur during dehydration. B vitamin losses generally do not exceed 10% of the amount in the blanched product (Bluestein and Labuza, 1975). Holmes et al. (1979) reported losses of total vitamin B_6 ranging from 4-41% in the blanched and dehydrated green beans, tomato puree, raspberry and boysenberry leathers, and zucchini squash. The greatest loss of vitamin B_6 was found in the green beans and tomato puree which were blanched and dehydrated (and exposed to light) 2 hours longer than the berry leathers or the zucchini squash. They also reported that the blanched green beans lost more vitamin B_6 (29%) during dehydration than the unblanched green beans (21%). In the same study the range of retention of total folacin was 46-92% in the blanched and dehydrated fruits and vegetables.

Vitamin A or its precursor, carotene, is sensitive to heat and oxidation (Bluestein and Labuza, 1975) and is, therefore, susceptible to destruction by hot air drying conditions. Because the major losses of vitamin A are the result of the interaction of the vitamin with peroxides of free radicals formed in the oxidation of lipids, increasing moisture contents which lower the rate of lipid oxidation also decrease the destruction rate of vitamin A. However, increasing moisture contents are destructive to other vitamins, especially vitamin C (Labuza, 1972).

Many researchers have found that carotene retention ranges between 70-96% in blanched and dehydrated vegetables (Tressler, 1956; Foda et al., 1967; Drew and Rhee, 1980). However, Holmes et al. (1979) reported retentions of carotene of only 5% in tomato puree and green beans (blanched and unblanched) dried for 6-6.5 hours at 60°C. They postulated that the light bulbs used to heat their dryer may have accelerated the oxidation of carotene.

Ascorbic acid is the most labile of all the vitamins. It is destroyed rapidly by heat at neutral or alkaline pH and by oxidation (Labuza, 1972; Lund, 1979). The oxidation of reduced ascorbic acid to dehydroascorbic acid is accelerated in the presence of light, oxygen, and metal catalysts (Labuza, 1972). The reaction is reversible and dehydroascorbic acid retains about 75-80% of the biological activity of reduced ascorbic acid (Freed, 1966). However, dehydroascorbic acid is relatively labile and in the presence of heat is easily converted in an irreversible reaction to diketugulonic acid which is not nutritionally active (Labuza, 1972).

Ascorbic acid is the most difficult of the vitamins to preserve during the blanching and dehydration of vegetables. Oxidation is the primary cause of the loss of vitamin C during drying (Hendel, 1971) because of oxidative enzymes such as phenol oxidase (Foley and Buckley, 1977). Since drying does not inactivate enzymes completely (Derosier and Derosier, 1977; Escher and Blanc, 1977) some form of pretreatment such as blanching to inactivate enzymes or sulfite to protect ascorbic acid from oxidation is recommended.

Reports of the retention of ascorbic acid vary widely but suggest that approximately half of the original amount present in the raw material is lost during blanching and dehydration (Hendel, 1971). It is very difficult to compare losses reported in the literature because retention of the vitamin is dependent upon the food system, pretreatment (blanching method, sulfuring), and drying conditions (time, temperature, and method).

The food system and its composition may have a significant effect on the retention of ascorbic acid. Raspberry leathers dried for the same length of time and at the same temperature (4.5 hr at 60°C) as boysenberry leathers retained 54% more ascorbic acid than the boysenberry leathers (Holmes et al., 1979). In addition, shorter drying times at higher temperatures generally resulted in higher retentions of ascorbic acid. Farrell and Fellers (1942) dried green snap beans for 36 hr at 130-140°F (54.4-62.8°C) in a hot air dryer to a 2.9% moisture content and reported 95% losses of ascorbic acid during blanching and dehydration. Foda et al. (1967) dehydrated four varieties of green snap beans for 2 hours at 75°C and for 11 hours at 65°C in a hot air dehydrator to a 6% moisture content and found an 80-90% loss of the original ascorbic acid during blanching and dehydration. Foda et al. (1967) also reported that varieties of green snap beans with lower moisture contents dried for shorter lengths of time retained the most ascorbic acid. Holmes et al. (1979) reported higher losses in green beans (blanched and unblanched) and tomato puree than in fruit leathers or zucchini squash. The higher losses were attributed to longer drying times (2 hr) and subsequent exposure to light, variations in the total moisture contents, and the possible effects of water activity and food composition.

Storage

Nutrient losses and deterioration in the color, odor, and taste of dehydrated vegetables occur during storage. Several factors influence those changes, including oxygen concentration, moisture content, water activity, exposure to light, and temperature and length of storage.

Sensory characteristics. Changes in the color of dehydrated vegetables include enzymatic and non-enzymatic browning and the degradation of chlorophyll in green vegetables. Non-enzymatic browning is sensitive to moisture content and generally can be controlled by regulating A_w and by using additives such as sulfite (Villota et al., 1980). Mallette et al. (1946) observed that the rate of non-enzymatic browning increased with increasing moisture content. White potatoes, containing no significant amount of oxidative enzymes, dried to a moisture content of 13% darkened at a much faster rate than those dried to a 7% moisture content. Also, at a moisture content of 13%, higher temperatures accelerated the rate of darkening much faster than in potatoes with moisture contents of only 7%.

Chlorophyll degradation is affected by light, moisture content, and temperature and length of storage. Chlorophyll fades rapidly in the presence of light and green plant food products retain their color better when protected from the light. Chlorophyll is also sensitive to increases in moisture. Dehydrated green beans stored for 6 months in paper cartons increased in moisture more than those stored in metal containers and also lost more chlorophyll than those stored in metal containers (Foda et al., 1967).

The flavor of dried vegetables during storage also is affected by moisture content and temperature and length of storage. The development of off-aromas, such as hay-like, during storage has been attributed to enzyme action, although the specific enzyme has not yet been identified (Schwimmer, 1980).

Generally, lower moisture contents retard the development of off-aromas. Nelson et al. (1956) found that lima beans dried to a moisture content of 7% had only slightly more acceptable scores for flavor and off-flavor than those beans dried to a 7% moisture content and lowered to a 4% moisture content by an inpackage dessicant. Mallette et al. (1946) found that Irish potatoes dried to a moisture content of 13% developed off-odors (hay-like and toasted) at lower temperatures (70-80°F) and at a faster rate at higher temperatures (95-105°F) than potatoes dried to a 7% moisture content.

Several researchers (Mallette et al., 1946; Nelson et al., 1956; Coleman et al., 1979) have observed that the flavor of dehydrated vegetables changed with increasing temperature and length of storage. The flavor of sulfited green peppers was retained better when peppers were stored at 35°F than at 70° or 85°F (Coleman et al., 1979). Mallette et al. (1946) found that Irish potatoes with moisture contents of 7 or 13% stored at 40-50°F did not develop any of the off-flavors studied (hay-like, sweetish, toasted, and burned) during 30 wk of storage. However, in the potatoes dried to a 13% moisture content and stored at 70-80°F, hay-like aroma was apparent by 30 wk of storage and at 95-105°F, a slightly toasted aroma was apparent by 6 wk of storage and by 30 wk of storage the potatoes had a toasted aroma.

Nutrient retention. Packaging dehydrated foods under vacuum, nitrogen or carbon dioxide helps preserve the nutrient content of dehydrated foods (Tressler, 1956; Villota et al., 1980). The moisture content should be at the lowest possible level to retain ascorbic acid; however, extremely low levels promote the loss of fat soluble vitamins because of lipid oxidation (Villota et al., 1980). According to

Tressler (1956) more than 1% moisture will result in a gradual decrease in vitamin content during storage. Lower moisture contents will also slow the rate of loss of water soluble vitamins at any given temperature during storage.

Temperature also affects the rate of nutrient loss. At room temperature, the rate is relatively slow and the vitamin content of dehydrated vegetables can be retained for 6-9 months. But at temperatures in the 90-100°F range the loss of vitamins is rapid. Refrigeration temperatures aid in retaining ascorbic acid and carotene (Tressler, 1956). The exposure of vitamins such as thiamin, riboflavin, and ascorbic acid to light initiates or accelerates their destruction (Villota et al., 1980).

Of the B complex vitamins studied, thiamin is the least stable during the storage of dehydrated vegetables. Morgan et al. (1946) reported that levels of riboflavin and niacin did not decrease during 3-4 months storage at 86°F (30°C) when packaged in glass jars at a moisture content of 3-6%. The loss of thiamin was relatively small in the five vegetables studied, except in broccoli where a 40% loss in storage occurred. Pantothenic acid also was destroyed in storage but not to the extent of thiamin or ascorbic acid. Farrell and Fellers (1942) observed similar results in their study on snap beans stored at 2.9% moisture in the dark for one year at 38°F (3.3°C) in sealed but not vacuumized glass containers. There was no loss of riboflavin in dehydration or storage and only a 16% loss of thiamin after one year of storage. Mallette et al. (1945) found that higher temperatures (100°F) did not accelerate the loss of thiamin, niacin, and riboflavin more than room temperature (75°F) when cabbage was dehydrated to a 4-5% moisture content and sealed in metal containers with a carbon dioxide atmosphere during 9-15 wk of storage.

Carotene losses usually are greater than those of the B vitamins. Drew and Rhee (1980) observed a 50% loss of carotene in dehydrated carrots and zucchini stored for 6 months at room temperature in glass jars--even though little of the vitamin precursor was lost in the blanching or dehydration of the carrots. Foda et al. (1967) observed lower losses (10-20%) of carotene in dehydrated green beans stored at room temperature for 6 months in metal containers, polyethylene bags, and paper cartons. The beans were dried to a 6.5% moisture content. In both studies the losses do not include those that occurred during blanching or drying.

Wide variations in the loss of ascorbic acid during storage are reported in the literature. Drew and Rhee (1980) observed that almost all of the ascorbic acid in fresh zucchini and summer squash was lost after 6 months of storage. Moisture content is critical to the retention of ascorbic acid especially at higher temperatures. Mallette et al. (1946) reported that the ascorbic acid content of white potatoes dried to a 7% moisture content was relatively stable and constant at all temperatures evaluated (40°F, 70°F, 95°F). However, at a 13% moisture content, the rate of destruction of ascorbic acid was much faster at the higher temperatures. Foda et al. (1967) studied 3 different storage containers for dehydrated green beans: metal containers, paper cartons, and polyethylene bags. Dried beans packaged in metal containers had the least moisture uptake (0.2%) and the greatest retention of ascorbic acid (60.1%) after 6 months of storage. Those packaged in paper cartons had the greatest moisture uptake (1.2%) and retained the least ascorbic acid (53.1%).

The effect of temperature on the degradation of ascorbic acid was demonstrated by Berry et al. (1979) in sulfited green peppers (air dried) stored in sealed #2 cans. After 6 wk of storage at 2°C (35°F), 85% of the ascorbic acid was retained; and at 21°C (70°F) only 60% of the ascorbic acid was retained; and at 30°C (85°F) only 15% of the ascorbic acid was retained in the peppers. Coleman et al. (1979) reported that in green peppers, with high and low sulfite levels, stored at 21°C (70°F) the rate of loss of ascorbic acid tended to level off or decline between 6 wk and 12 wk of storage. However, at 30°C (85°F) the rate of loss continued at a high rate throughout the 12 wk of storage.

Although research has been conducted on dehydrated foods, much of it is related to commercial practices and not applicable to home drying. Because ascorbic acid is very sensitive to dehydration conditions it is used extensively as an indicator of nutrient retention. However, little scientific effort has been spent investigating conditions which would maximize the sensory qualities of foods dehydrated under home conditions. The purpose of this project was to investigate the effects of blanching, drying time and temperature, and storage on ascorbic acid, sensory characteristics, color, moisture content and water activity of green peppers processed under home conditions.

MATERIALS AND METHODS

Four treatments for processing dried green peppers were studied: unblanched peppers were dried for 1) 9 hr at 140°F (60°C) and for 2) 12 hr at 120°F (49°C); blanched peppers were dried for 3) 8 hr at 140°F (60°C) and for 4) 12 hr at 120°F (49°C). Peppers were evaluated after dehydration and after 8 wk of storage. Data from five replications were subjected to analysis of variance.

Pretreatment, Drying, and Storage Conditions

Locally grown green peppers (approximately 50 lb) were obtained weekly for each of five replications. Peppers were washed, pitted, and sliced into 5 to 6 mm wide strips. Peppers (2.25 kg) were blanched in boiling water for 2 min in quantities of 0.5 kg/4.7 l water. Timing for the blanching period began as soon as the peppers were immersed in boiling water. Another 2.25 kg were cleaned and sliced for drying but not blanched. An electric dehydrator (Excalibur Model ED 301) with nine shelves was used for drying the peppers. Sliced peppers (250 g) were spread evenly over each of the nine shelves. Halfway through the drying process, the trays were turned from the front to the back and their positions in the dryer were rotated.

Dried peppers were packaged in polyethylene bags (.95 mil), placed in half pint canning jars, and stored in sealed cardboard boxes at room temperature (approximately 24°C) for 8 wk.

Evaluation and Measurements

Sensory analysis. A five-member sensory panel evaluated the dried and rehydrated peppers after storage using a semi-structured intensity scale (Fig. 1 and 2, Appendix). Intensity scores for each characteristic were determined by measuring the distance of line from No (0 cm) to Extreme (20 cm). Characteristics evaluated for the dried peppers were hay-like aroma, chewiness, fracturability, green pepper flavor, bitterness, and sweetness. For the rehydrated peppers, hay-like aroma, green pepper aroma, firmness, green pepper flavor, and bitterness were evaluated. The peppers were evaluated in a room specifically designed for sensory analysis and under red lights to mask the color differences between the treatments. Dry samples at room temperature were presented to panelists in covered, 30 ml plastic cups. For rehydrated samples, 200 ml of boiling water was poured over 8.0 g peppers, simmered on medium heat for 8 min, placed in individual 30 ml covered cups and served immediately to the panel.

Water activity, moisture content, color, and ascorbic acid measurements. All measurements were made within 7 days after the peppers were dried and after 8 wk of storage. Water activity was measured on 0.5 g samples with a Beckman Hygroline Model SMT. Percentage moisture was determined for 1.0 g samples using the AOAC vacuum oven method (AOAC, 1980).

Color measurements (HunterLab L, a, b) were made using the HunterLab Spectrophotometer (Model D54P-5) on both dried and rehydrated peppers. Color of dried peppers was measured before and after storage and of rehydrated peppers after storage. The dried peppers (5.0 g) were placed in cold water (150 ml) for 30 min and then blended in a Waring Blendor for 1 min. The rehydrated peppers were heated (5.0 g peppers/150 ml boiling water) as those for sensory analysis and then blended for 1 min.

All slurries were allowed to stand for 30 min for the foam to dissipate; any remaining foam was manually removed before taking measurements.

Ascorbic acid was measured by both the 2,6 dichloroindophenol method and the microflourometric method. The 2,6 dichloroindophenol method is a titration method and measures reduced ascorbic acid (AOAC, 1980). Samples were prepared by rehydrating 2.5 g dried green peppers in 75 ml metaphosphoric acetic acid (3%/8%) extracting solution for 15 min (Freed, 1966), and then blending in a Waring Blendor for 1 min. The microflourometric method measures total ascorbic acid which includes reduced and dehydroascorbic acid (AOAC, 1980). Samples were prepared by blending 0.5 g peppers in 100 ml extracting acid (3% metaphosphoric/8% acetic acid) in a Brinkman Homogenizer. Flourescence was determined on a Coleman photoflourometer (Model 12C).

Analysis of Data

Panel scores were subjected to analysis of variance using the following design.

Source	Degrees of Freedom
Block (Rep)	4
Treatment (Trt)	3
Rep × Trt (Error a)	12
Judge (Jud)	4
Trt × Jud	12
Error	60
Total	95

Water activity, percentage moisture, color, and ascorbic acid were subjected to analysis of variance using the following design.

Source	Degrees of Freedom
Block (Rep)	4
Treatment (Trt)	3
Error (a)	12
Storage time (St)	1
Trt × St	3
Error (b)	16
Total	39

When F values were significant, least significant differences (LSD) at the 5% level were calculated.

RESULTS AND DISCUSSION

Moisture content, water activity, ascorbic acid content (reduced and total), and color of dried green peppers were determined before and after storage; sensory analysis of the peppers was conducted after 8 wk storage. Data for all replications are presented in Tables 6-15, Appendix.

Moisture Content and Water Activity

Moisture content and water activity of the dried green peppers are presented in Table 1. Drying treatment and storage had a significant effect on both the moisture content ($p < 0.01$) and water activity ($p < 0.05$). Blanched peppers dried for 12 hr at 120°F had less ($p < 0.01$) moisture than peppers processed by the other treatments. Others (Moyer et al., 1959) have found that blanching increases the rate of drying in vegetables with surface skins. Blanching had no effect on the water activity of the peppers, but those dried for 12 hr at 120°F had lower A_w than peppers dried for 8 or 9 hr at 140°F.

The green peppers decreased in moisture content ($p < 0.01$) and water activity ($p < 0.05$) during storage, contrary to results observed by

Table 1-Moisture content (%), water activity, and reduced and total ascorbic acid content (mg ascorbic acid/g dry wt) of dried peppers before and after storage[1]

	Drying Treatments									
	Blanched		Unblanched		Storage	Significance of F-value[2]				
	8hr/140°F	12hr/120°F	9hr/140°F	12hr/120°F	Means	Trt	LSD[3]	St	T×S	LSD[3]
Moisture										
0 wk	12.6	11.1	13.1	12.9	12.4[a]	**	1.0	**	ns	-
8 wk	11.5	10.1	11.3	11.6	11.1[b]					
Drying Trt, Means	12.1[a]	10.6[b]	12.2[a]	12.2[a]						
Water Activity										
0 wk	0.41	0.37	0.41	0.37	0.39[a]	*	0.04	*	ns	-
8 wk	0.39	0.31	0.39	0.35	0.36[b]					
Drying Trt, Means	0.40[a]	0.34[b]	0.40[a]	0.36[b]						
Reduced Ascorbic Acid										
0 wk	9.2[b]	8.5[b]	15.5[e]	14.8[e]		***	2.1	***	**	1.9
8 wk	6.4[a]	7.7[a,b,c]	8.7[c,d]	10.4[d]						
Total Ascorbic Acid										
0 wk	11.7[b]	10.5[b]	19.0[c]	21.2[c]		***	3.0	***	**	2.2
8 wk	6.7[a]	8.8[a,b]	10.3[b]	11.5[b]						

[1] Means of 5 replications

[2] * significant at the 5% level; ** significant at the 1% level; *** significant at the 0.1% level; ns not significant

[3] LSD, least significant difference at the 5% level

[a,b,c,d,e] Means with the same letter indicate no significant difference between those means

Foda et al. (1967) and Nelson et al. (1956) who found that dried green beans and lima beans, respectively, increased in moisture content during storage packaged in paper cartons, polyethylene bags, metal containers or tin cans. However, those beans were dried to lower moisture contents (6.5-7%) than our green peppers (11-13%).

Ascorbic Acid

Before storage, the unblanched peppers contained more ($p < 0.001$) reduced and total ascorbic acid than the blanched peppers (Table 1). This is in agreement with Morgan et al. (1945) who found that unblanched spinach retained more ascorbic acid than blanched spinach after dehydration, but contrary to Holmes et al. (1979) who reported that both blanched and unblanched green beans retained approximately the same amount of ascorbic acid after dehydration.

Drying time and temperature did not affect the ascorbic acid content of the peppers. After 8 wk of storage, blanched peppers dried for 8 hr at 140°F contained less ($p < 0.001$) reduced or total ascorbic acid than the unblanched peppers; while unblanched peppers dried for 12 hr at 120°F contained more ($p < 0.001$) ascorbic acid than the blanched. Morgan et al. (1945) also found that blanched spinach was more stable in storage than unblanched and unblanched spinach eventually (after 16 wk) reached the same level of ascorbic acid content as blanched. During storage, all of the peppers, except those blanched and dried for 12 hr at 120°F, lost ($p < 0.01$) reduced and total ascorbic acid. This treatment also had the lowest moisture content. Foda et al. (1967) also observed that green beans with the lowest moisture content lost the least ascorbic acid during storage.

Color

L, a, and b values of the dehydrated peppers determined with the HunterLab spectrophotometer are reported in Table 2. Unblanched, dehydrated peppers were darker ($p < 0.001$), more ($p < 0.001$) green, and less ($p < 0.001$) yellow in color than the blanched peppers. As reported by Dutton et al. (1943) and Feinberg (1973), blanching prior to dehydration increases the conversion of chlorophyll to pheophytin and relates to the increase in yellow color and decrease in green observed in the blanched peppers. Drying time and temperature had no effect on the darkness, greenness or yellowness of the dried peppers. After storage, all of the peppers were slighty, but significantly ($p < 0.05$), darker in color, less ($p < 0.001$) green, and less ($p < 0.05$) yellow in color.

L, a, and b values of the rehydrated and heated green peppers are reported in Table 3. Drying treatment had no effect on darkness or greenness of the peppers. However, blanched peppers were significantly ($p < 0.05$) more yellow than unblanched peppers.

Sensory Analysis

Hay-like aroma, chewiness, fracturability, green pepper flavor, sweetness, and bitterness scores for dried green peppers stored 8 wk are presented in Table 4.

Aroma. Unblanched peppers dried for 9 hr at 140°F had more ($p < 0.01$) hay-like aroma than peppers processed by the other treatments. There was no significant difference in the intensity of hay-like aroma among blanched peppers and unblanched peppers dried for 12 hr at 120°F.

Table 2-HunterLab L, a, and b values of dried green peppers before and after storage[1]

	Drying Treatments				Storage Mean	Significance of F-value[2]				
	Blanched		Unblanched							
	8hr/140°F	12hr/120°F	9hr/140°F	12hr/120°F		Trt	LSD[3]	St	T×S	LSD[3]
L										
0 wk	33.5	33.1	28.5	28.3	30.9[a]	***	0.7	*	ns	-
8 wk	32.2	32.0	28.0	27.9	30.0[b]					
Drying Trt, Means	32.9[a]	32.6[a]	28.3[b]	28.1[b]						
a										
0 wk	-4.1	-4.0	-5.2	-5.0	-4.6[a]	***	0.4	***	ns	-
8 wk	-3.0	-3.5	-4.0	-4.2	-3.7[b]					
Drying Trt, Means	-3.6[a]	-3.7[a]	-4.6[b]	-4.6[b]						
b										
0 wk	10.7	10.5	7.3	7.0	8.9[a]	***	0.6	*	ns	-
8 wk	9.6	9.3	6.7	6.5	8.0[b]					
Drying Trt, Means	10.1[a]	9.9[a]	7.0[b]	6.7[b]						

1 Means of 5 replications

2 * significant at the 5% level; *** significant at the 0.1% level; ns not significant

3 LSD, least significant difference at the 5% level

a,b Means with the same letter indicate no significant difference between those means

Table 3-HunterLab L, a, and b values of rehydrated and heated dried green peppers after 8 wk storage[1]

	Drying Treatments					
	Blanched		Unblanched			
	8hr/140°F	12hr/120°F	9hr/140°F	12hr/120°F	Significance of F-value[2]	LSD[3]
L	30.3	29.7	28.5	28.6	ns	-
a	-1.1	-1.3	-1.3	-1.4	ns	-
b	8.4[a]	8.0[a]	6.9[b]	6.8[b]	*	1.0

1 Means of 5 replications

2 * significant at the 5% level

3 LSD, least significant difference at the 5% level

a,b Means with the same letter indicate no significant difference between those means

Table 4-Sensory characteristics of dried green peppers after 8 wk storage[1]

	Drying Treatments					
	Blanched		Unblanched			
	8hr/140°F	12hr/120°F	9hr/140°F	12hr/120°F	Significance of F-value[2]	LSD[3]
Aroma						
Hay-like	8.2^{a}	8.1^{a}	11.9^{b}	8.6^{a}	**	1.8
Texture						
Chewy	$8.6^{a,b}$	4.6^{c}	10.4^{a}	7.9^{b}	***	1.9
Fracturable	6.0^{a}	12.1^{b}	3.9^{a}	6.1^{a}	***	3.2
Flavor						
Green Pepper	5.8^{a}	$6.3^{a,b}$	8.2^{c}	$7.2^{b,c}$	**	1.3
Bitter	3.8^{a}	4.1^{a}	7.6^{b}	8.1^{b}	**	2.1
Sweet	$7.1^{a,b}$	6.4^{a}	8.9^{c}	$8.2^{b,c}$	*	1.6

[1] Means of 5 replications; 0 (No) to 20 (Extreme)

[2] * significant at the 5% level; ** significant at the 1% level; *** significant at the 0.1% level

[3] LSD, least significant difference at the 5% level

[a,b,c] Means with the same letters indicate no significant difference between those means

One of the purposes of blanching is to inactivate enzymes that promote the development of hay-like aromas and bitterness. Hay-like aroma was lower in the blanched peppers, but still present. Mallette et al. (1946) and Foda et al. (1967) also found hay-like aromas in blanched, dehydrated vegetables.

Texture. Blanched peppers dried for 12 hr at 120°F were less ($p < 0.001$) chewy and more ($p < 0.001$) fracturable than peppers prepared by the other treatments. Those peppers also had the lowest moisture content.

Flavor. Unblanched peppers dried for 9 hr at 140°F retained more ($p < 0.01$) green pepper flavor than peppers that were blanched. A major component of the volatile oil of green peppers has been characterized and associated with the aroma of freshly chopped green bell peppers (Buttery et al., 1969). Since both blanching (Feinberg, 1973) and dehydration (Villota et al., 1980) drive off volatile oils, unblanched peppers dried for only 9 hr would be expected to retain more green pepper flavor than blanched peppers. Unblanched peppers were more ($p < 0.01$) bitter than blanched. Drying time and temperature had no effect on the bitterness of the peppers. The unblanched peppers dried for 9 hr at 140°F were sweeter ($p < 0.05$) than blanched peppers.

Taste panel evaluations of the rehydrated and heated green peppers after storage for hay-like aroma, green pepper aroma, firmness, green pepper flavor, and bitterness using a semi-structured intensity scale are presented in Table 5.

Aroma. After the peppers had been rehydrated and heated no difference was found in the intensity of hay-like aroma of the peppers. Unblanched peppers dried for 9 hr at 140°F retained more ($p < 0.05$) green

Table 5-Sensory characteristics of rehydrated and heated dried green peppers after 8 wk storage[1]

	Drying Treatments					
	Blanched		Unblanched			
	8hr/140°F	12hr/120°F	9hr/140°F	12hr/120°F	Significance of F-value[2]	LSD[3]
Aroma						
Hay-like	7.6	8.3	7.8	9.0	ns	-
Green Pepper	7.3^{a}	6.5^{a}	9.9^{b}	$8.2^{a,b}$	*	2.2
Texture						
Firmness	5.9^{a}	5.9^{a}	9.1^{b}	9.6^{b}	**	1.9
Flavor						
Green Pepper	6.7	6.7	8.0	8.0	ns	-
Bitter	4.0^{a}	$5.6^{a,b}$	$7.5^{b,c}$	8.9^{c}	***	1.9

[1] Means of 5 replications; 0 (No) to 20 (Extreme)

[2] * significant at the 5% level, ** significant at the 1% level; *** significant at the 0.1% level; ns, not significant

[3] LSD, least significant difference at the 5% level

[a,b,c] Means with the same letter indicate no significant difference between those means

pepper aroma than blanched peppers. Those unblanched peppers also had more green pepper flavor than the blanched peppers before rehydration.

Texture. The unblanched peppers were more ($p < 0.01$) firm than blanched peppers, but drying time and temperature had no effect on the firmness of the peppers. One of the purposes of blanching is to soften the texture of dehydrated vegetables (Salunke et al., 1973). This may be desirable if the vegetable is to be consumed in the dry state; however, additional heat treatment may soften the texture beyond acceptable limits.

Flavor. After rehydration and heating, no difference was found between the treatments in the intensity of green pepper flavor. However, the unblanched peppers dried for 12 hr at 120°F were more ($p < 0.001$) bitter than blanched peppers.

Generally, blanching of the green peppers resulted in reduced ascorbic acid retention, and the loss of fresh green pepper aroma, flavor, and color. However, blanching provided some protection against the development of hay-like aromas and bitterness. Extended drying time at a lower temperature lowered the water activity of the dried peppers. Under the conditions of this study, the dehydrated peppers lost ascorbic acid and fresh green color during storage.

SUMMARY

Moisture content, water activity, total and reduced ascorbic acid content, and color of blanched and unblanched green peppers, dried for 8 or 9 hr at 140°F or 12 hr at 120°F were determined before and after 8 wk storage at room temperature. Sensory characteristics of the dehydrated peppers were evaluated after 8 wk storage. Unblanched

peppers contained more ($p < 0.001$) reduced and total ascorbic acid before storage; were darker ($p < 0.001$), more ($p < 0.001$) green, and less ($p < 0.001$) yellow in color than blanched peppers. Dry, unblanched peppers were more ($p < 0.01$) bitter than blanched, but after rehydration and heating they were more ($p < 0.01$) firm and less ($p < 0.05$) yellow than the blanched peppers. Unblanched peppers dried for 9 hr at 140°F were sweeter ($p < 0.05$), had more ($p < 0.01$) green pepper flavor, and more ($p < 0.01$) hay-like aroma than blanched peppers. After rehydration and heating, they had more ($p < 0.05$) green pepper aroma than the blanched peppers.

Blanched peppers dried for 12 hr at 120°F had the lowest ($p < 0.01$) moisture content; were the least ($p < 0.001$) chewy and most ($p < 0.001$) fracturable. During storage, they were the only peppers that did not lose ($p < 0.01$) reduced or total ascorbic acid. After 8 wk of storage, only the blanched peppers dried for 8 hr at 140°F contained less ($p < 0.001$) reduced or total ascorbic acid than the unblanched peppers. Peppers dried for 12 hr at 120°F, with or without blanching, had lower ($p < 0.05$) water activities than peppers dried for 8 or 9 hr at 140°F. All of the peppers decreased in moisture content ($p < 0.01$) and water activity ($p < 0.05$) during storage, and were darker ($p < 0.05$), less ($p < 0.001$) green, and less ($p < 0.05$) yellow in color after storage. After rehydration and heating, there was no significant difference between the treatments in greenness, darkness, intensity of hay-like aroma or green pepper flavor in the peppers.

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APPENDIX

Fig. 1-Score card for evaluation of green peppers

Dried Green Peppers

Name ______________________ Date ______________

Place a line perpendicular to the scored line at the point which best describes your evaluation for the characteristics listed. Label each mark with the sample code number.

AROMA

Hay-like

No Moderately Extremely

TEXTURE

Chewy

No Moderately Extremely

Fracturable

No Moderately Extremely

FLAVOR

Green Pepper

No Moderately Extremely

Bitter

No Moderately Extremely

Sweet

No Moderately Extremely

Comments:

Fig.2-Score card for evaluation of green peppers

Rehydrated Green Peppers

Name ______________________ Date ______________________

Place a line perpendicular to the scored line at the point which best describes your evaluation for the characteristics listed. Label each mark with the sample code number.

AROMA

Hay-like

No ——— Moderately ——— Extremely

Green Pepper

No ——— Moderately ——— Extremely

TEXTURE

Firmness

No ——— Moderately ——— Extremely

FLAVOR

Green Pepper

No ——— Moderately ——— Extremely

Bitter

No ——— Moderately ——— Extremely

Comments:

Table 6-Moisture content and water activity of green peppers before and after storage

Factor	Block 1	2	3	4	5	Mean
Moisture, %						
Blanched						
8 hr/140°F						
0 wk	11.4	14.1	13.4	11.7	12.5	12.6
8 wk	9.5	13.1	14.5	9.6	10.8	11.5
12 hr/120°F						
0 wk	10.9	11.3	11.1	10.2	11.9	11.1
8 wk	10.6	10.4	12.0	8.2	9.2	10.1
Unblanched						
9 hr/140°F						
0 wk	13.9	12.1	13.0	12.8	13.9	13.1
8 wk	11.4	11.6	13.5	9.4	10.5	11.3
12 hr/120°F						
0 wk	12.8	12.6	12.2	13.2	13.7	12.9
8 wk	11.8	12.1	13.2	10.2	10.5	11.6
Water Activity						
Blanched						
8 hr/140°F						
0 wk	0.39	0.49	0.40	0.43	0.36	0.41
8 wk	0.39	0.45	0.41	0.36	0.34	0.39
12 hr/120°F						
0 wk	0.35	0.35	0.34	0.41	0.39	0.37
8 wk	0.37	0.30	0.32	0.28	0.30	0.31
Unblanched						
9 hr/140°F						
0 wk	0.41	0.46	0.40	0.38	0.41	0.41
8 wk	0.46	0.40	0.37	0.32	0.38	0.39
12 hr/120°F						
0 wk	0.37	0.38	0.35	0.42	0.33	0.37
8 wk	0.43	0.40	0.32	0.32	0.30	0.35

Table 7-Reduced and total ascorbic acid of the green peppers before and after storage (mg ascorbic acid/g dry wt)

Factor	Block 1	2	3	4	5	Mean
Reduced Ascorbic Acid						
Blanched						
8 hr/140°F						
0 wk	10.3	8.0	7.1	9.9	10.6	9.2
8 wk	7.8	3.8	4.1	7.5	8.9	6.4
12 hr/120°F						
0 wk	9.2	7.0	5.8	11.6	9.0	8.5
8 wk	9.3	5.4	5.7	9.7	8.2	7.7
Unblanched						
9 hr/140°F						
0 wk	17.5	11.0	12.3	17.6	19.2	15.5
8 wk	5.0	5.8	8.3	11.9	12.3	8.7
12 hr/120°F						
0 wk	14.4	13.5	13.2	16.3	16.7	14.8
8 wk	8.2	6.9	10.2	12.9	14.3	10.4
Total Ascorbic Acid						
Blanched						
8 hr/140°F						
0 wk	12.2	10.2	7.6	13.0	15.7	11.7
8 wk	7.5	3.8	5.1	7.1	10.2	6.7
12 hr/120°F						
0 wk	11.4	7.1	6.6	13.3	13.9	10.5
8 wk	7.6	5.7	5.4	10.9	14.6	8.8
Unblanched						
9 hr/140°F						
0 wk	13.2	14.9	18.8	21.0	27.1	19.0
8 wk	4.8	6.3	11.5	15.0	14.0	10.3
12 hr/120°F						
0 wk	21.2	17.7	17.0	23.4	26.5	21.2
8 wk	7.6	6.3	11.5	14.7	17.5	11.5

Table 8-Reduced and total ascorbic acid of the green peppers before and after storage (mg ascorbic acid/g wet wt)

	Block					
Factor	1	2	3	4	5	Mean
Reduced Ascorbic Acid						
Blanched						
8 hr/140°F						
0 wk	9.15	6.90	6.12	8.75	9.25	8.03
8 wk	7.07	3.33	3.46	6.81	7.91	5.72
12 hr/120°F						
0 wk	8.19	6.20	5.11	10.40	7.95	7.57
8 wk	8.32	4.85	4.98	8.93	7.45	6.91
Unblanched						
9 hr/140°F						
0 wk	15.05	9.65	10.74	15.30	16.50	13.45
8 wk	4.40	5.09	7.20	10.75	11.04	7.70
12 hr/120°F						
0 wk	12.59	11.80	11.62	14.10	14.40	12.90
8 wk	7.19	6.06	8.83	11.42	12.79	9.26
Total Ascorbic Acid						
Blanched						
8 hr/140°F						
0 wk	10.83	8.77	6.55	11.47	13.73	10.27
8 wk	6.79	3.34	4.33	6.41	9.08	5.99
12 hr/120°F						
0 wk	10.18	6.38	5.84	11.94	12.35	9.34
8 wk	6.82	5.14	4.73	9.96	13.27	7.98
Unblanched						
9 hr/140°F						
0 wk	11.33	13.04	16.23	18.23	23.61	16.49
8 wk	4.28	5.59	9.90	13.53	12.53	9.17
12 hr/120°F						
0 wk	18.57	14.28	14.89	20.33	22.85	18.18
8 wk	6.66	5.52	9.97	13.16	15.69	10.20

Table 9-HunterLab L and a values of the dried green peppers before and after storage

Factor	Block 1	2	3	4	5	Mean
L value						
Blanched						
8 hr/140°F						
0 wk	33.17	34.18	34.73	32.60	33.03	33.5
8 wk	34.94	30.37	32.35	31.68	31.66	32.2
12 hr/120°F						
0 wk	33.19	33.98	32.23	32.75	33.39	33.1
8 wk	32.63	31.47	32.08	31.36	32.46	32.0
Unblanched						
9 hr/140°F						
0 wk	29.45	29.54	27.37	28.26	27.98	28.5
8 wk	27.88	27.31	28.27	28.21	28.40	28.0
12 hr/120°F						
0 wk	29.15	29.78	27.74	27.12	27.58	28.3
8 wk	27.34	27.95	27.96	28.27	27.89	27.9
a value						
Blanched						
8 hr/140°F						
0 wk	-3.96	-3.40	-4.76	-4.05	-4.42	-4.1
8 wk	-4.14	-2.08	-3.05	-2.83	-2.90	-3.0
12 hr/120°F						
0 wk	-4.08	-3.75	-3.99	-3.78	-4.39	-4.0
8 wk	-4.02	-3.44	-3.52	-2.96	-3.29	-3.5
Unblanched						
9 hr/140°F						
0 wk	-5.40	-5.65	-4.61	-5.20	-4.92	-5.2
8 wk	-3.67	-3.36	-4.16	-4.89	-4.10	-4.0
12 hr/120°F						
0 wk	-5.41	-5.64	-4.73	-4.40	-4.81	-5.0
8 wk	-3.88	-3.52	-4.27	-4.80	-4.52	-4.2

Table 10-HunterLab b values of the dried green peppers before and after storage

Factor	Block 1	2	3	4	5	Mean
b value						
Blanched						
8 hr/140°F						
0 wk	10.24	11.28	11.45	10.09	10.29	10.7
8 wk	12.44	7.91	9.30	9.15	9.27	9.6
12 hr/120°F						
0 wk	10.38	11.70	9.72	10.23	10.60	10.5
8 wk	9.58	8.90	9.36	8.91	9.67	9.3
Unblanched						
9 hr/140°F						
0 wk	7.76	8.06	6.36	7.33	6.90	7.3
8 wk	6.58	5.84	6.67	7.30	6.96	6.7
12 hr/120°F						
0 wk	7.36	8.20	6.49	6.24	6.47	7.0
8 wk	6.18	6.14	6.28	7.18	6.54	6.5

Table 11-HunterLab L, a, and b values of the rehydrated and heated peppers after 8 wk storage

Factor	Block 1	2	3	4	5	Mean
L value						
Blanched						
8 hr/140°F	31.70	29.42	-	30.20	29.85	30.3
12 hr/120°F	31.89	29.81	-	29.81	27.53	29.7
Unblanched						
9 hr/140°F	28.77	28.16	28.14	29.93	27.59	28.5
12 hr/120°F	29.41	28.21	28.61	29.48	27.14	28.6
a value						
Blanched						
8 hr/140°F	-1.18	-0.67	-	-1.15	-1.16	-1.1
12 hr/120°F	-1.47	-1.38	-	-1.25	-0.99	-1.3
Unblanched						
9 hr/140°F	-1.21	-1.04	-1.20	-1.90	-0.96	-1.3
12 hr/120°F	-1.58	-0.87	-1.58	-1.50	-1.38	-1.4
b value						
Blanched						
8 hr/140°F	9.81	7.74	-	8.05	7.97	8.4
12 hr/120°F	9.93	8.08	-	8.01	6.04	8.0
Unblanched						
9 hr/140°F	7.13	6.62	6.45	8.23	6.22	6.9
12 hr/120°F	7.40	6.43	6.96	7.71	5.66	6.8

Table 12-Hay-like aroma, chewiness, and fracturability of the dried green peppers after 8 wk storage

	Block					
Factor	1	2	3	4	5	Mean
Hay-like Aroma						
Blanched						
8 hr/140°F	9.3	5.6	7.8	8.0	10.2	8.2
12 hr/120°F	9.9	8.8	5.7	7.8	8.5	8.1
Unblanched						
9 hr/140°F	14.9	11.8	10.8	11.2	10.9	11.9
12 hr/120°F	9.9	8.8	8.4	8.7	7.1	8.6
Chewiness						
Blanched						
8 hr/140°F	7.0	11.7	10.8	7.8	5.8	8.6
12 hr/120°F	7.4	6.1	4.3	2.7	2.6	4.6
Unblanched						
9 hr/140°F	12.6	11.7	10.9	8.3	8.8	10.4
12 hr/120°F	10.1	11.3	6.6	6.1	5.6	7.9
Fracturability						
Blanched						
8 hr/140°F	10.3	2.6	3.9	4.7	8.6	6.0
12 hr/120°F	10.0	10.8	12.2	14.3	13.1	12.1
Unblanched						
9 hr/140°F	1.6	2.4	3.3	5.7	6.3	3.9
12 hr/120°F	3.4	1.7	9.0	7.7	8.6	6.1

Table 13-Green pepper flavor, bitterness, and sweetness of the dried green peppers after 8 wk storage

	Block					
Factor	1	2	3	4	5	Mean
Green Pepper Flavor						
Blanched						
8 hr/140°F	5.5	6.1	4.9	7.9	4.5	5.8
12 hr/120°F	6.9	4.9	6.5	7.4	5.6	6.3
Unblanched						
9 hr/140°F	6.2	8.6	8.0	9.9	8.5	8.2
12 hr/120°F	7.2	6.4	8.2	8.3	5.9	7.2
Bitterness						
Blanched						
8 hr/140°F	5.0	2.5	3.9	4.6	2.8	3.8
12 hr/120°F	4.9	4.2	4.8	3.9	2.8	4.1
Unblanched						
9 hr/140°F	11.2	4.7	8.5	6.9	6.5	7.6
12 hr/120°F	10.6	10.5	6.4	8.8	5.3	8.1
Sweetness						
Blanched						
8 hr/140°F	8.1	7.5	7.8	6.4	5.8	7.1
12 hr/120°F	7.0	5.9	6.9	7.0	5.4	6.4
Unblanched						
9 hr/140°F	8.4	8.6	9.4	9.8	8.4	8.9
12 hr/120°F	8.9	5.8	11.6	6.8	7.7	8.2

Table 14-Hay-like aroma, green pepper aroma, and firmness of the rehydrated and heated green peppers after 8 wk storage

Factor	Block 1	2	3	4	5	Mean
Hay-like Aroma						
Blanched						
8 hr/140°F	6.4	6.8	10.0	8.8	6.0	7.6
12 hr/120°F	8.4	7.7	9.5	7.8	7.6	8.3
Unblanched						
9 hr/140°F	9.5	7.8	8.0	6.4	8.7	7.8
12 hr/120°F	8.3	11.0	11.2	8.7	5.8	9.0
Green Pepper Aroma						
Blanched						
8 hr/140°F	11.0	5.8	6.1	6.7	7.3	7.3
12 hr/120°F	6.8	6.0	6.0	6.5	8.6	6.5
Unblanched						
9 hr/140°F	13.0	10.4	8.0	9.4	8.0	9.9
12 hr/120°F	7.8	8.4	6.4	8.2	10.9	8.2
Firmness						
Blanched						
8 hr/140°F	5.4	4.1	6.2	7.2	7.4	5.9
12 hr/120°F	3.3	4.3	9.1	3.9	8.7	5.9
Unblanched						
9 hr/140°F	8.9	8.9	10.5	6.9	9.1	9.1
12 hr/120°F	8.8	8.3	11.1	9.0	9.3	9.6

Table 15-Green pepper flavor and bitterness of the rehydrated and heated green peppers after 8 wk storage

	Block					
Factor	1	2	3	4	5	Mean
Green Pepper Flavor						
Blanched						
8 hr/140°F	8.2	4.4	7.8	7.3	6.0	6.7
12 hr/120°F	5.5	5.2	9.1	6.0	8.3	6.7
Unblanched						
9 hr/140°F	9.3	9.5	6.7	8.3	7.3	8.0
12 hr/120°F	7.6	10.4	7.5	8.5	7.1	8.0
Bitterness						
Blanched						
8 hr/140°F	6.3	4.9	3.5	3.8	1.9	4.0
12 hr/120°F	7.6	5.9	5.3	4.6	4.1	5.6
Unblanched						
9 hr/140°F	9.2	5.3	8.4	5.8	7.9	7.5
12 hr/120°F	7.9	8.1	8.6	11.1	7.4	8.9

ASCORBIC ACID CONTENT AND SENSORY CHARACTERISTICS
OF DEHYDRATED GREEN PEPPERS

by

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Moisture content, water activity, total and reduced ascorbic acid content and color of blanched and unblanched green peppers, dried for 8 or 9 hr at 140°F or 12 hr at 120°F were determined before and after 8 wk storage at room temperature. Sensory characteristics of the dehydrated peppers were evaluated after 8 wk storage. Unblanched peppers contained more ($p < 0.001$) reduced and total ascorbic acid before storage; were darker ($p < 0.001$), more ($p < 0.001$) green, and less ($p < 0.001$) yellow in color than blanched peppers. Dry, unblanched peppers were more ($p < 0.01$) bitter than blanched, but after rehydration and heating they were more ($p < 0.01$) firm and less ($p < 0.05$) yellow than the blanched peppers. Unblanched peppers dried for 9 hr at 140°F were sweeter ($p < 0.05$), had more ($p < 0.01$) green pepper flavor, and more ($p < 0.01$) hay-like aroma than blanched peppers. After rehydration and heating, they had more ($p < 0.05$) green pepper aroma than the blanched peppers.

Blanched peppers dried for 12 hr at 120°F had the lowest ($p < 0.01$) moisture content; were the least ($p < 0.001$) chewy and most ($p < 0.001$) fracturable. During storage, they were the only peppers that did not lose ($p < 0.01$) reduced or total ascorbic acid. After 8 wk of storage, only the blanched peppers dried for 8 hr at 140°F contained less ($p < 0.001$) reduced or total ascorbic acid than the blanched peppers. Peppers dried for 12 hr at 120°F, with or without blanching, had lower ($p < 0.05$) water activities than peppers dried for 8 or 9 hr at 140°F. All of the peppers decreased in moisture content ($p < 0.01$) and water activity ($p < 0.05$) during storage, and were darker ($p < 0.05$), less ($p < 0.001$) green, and less ($p < 0.05$) yellow in color after storage. After rehydration and heating, there was no significant difference between the treatments in greenness, darkness, intensity of hay-like aroma or green pepper flavor in the peppers.