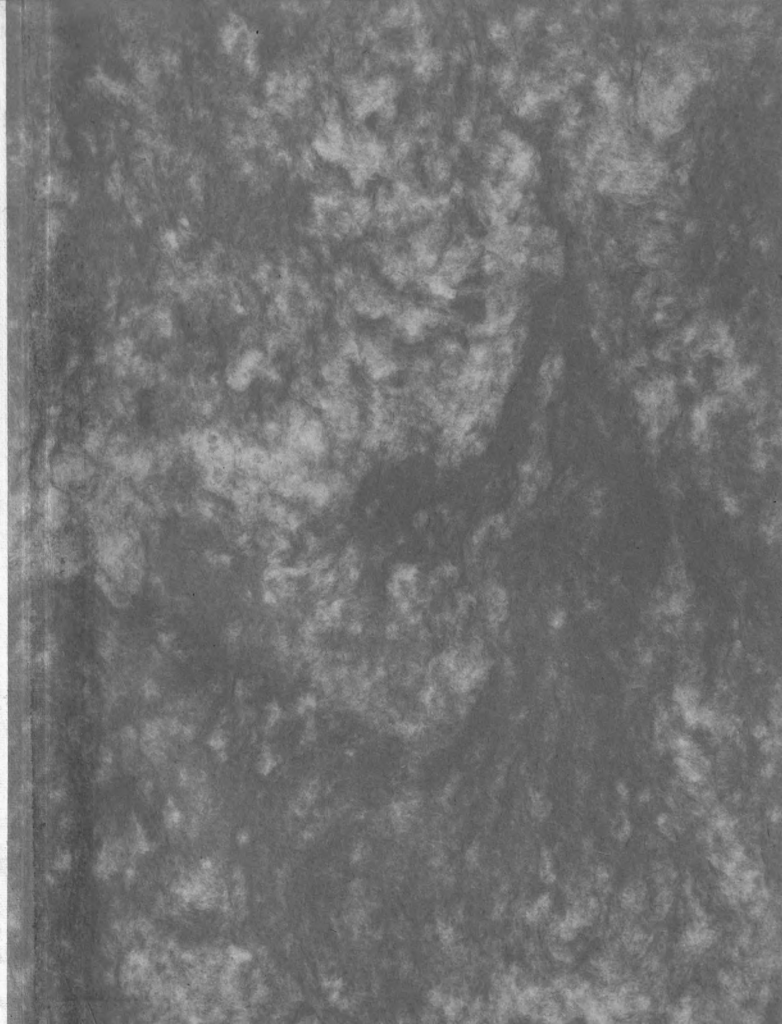

A STUDY OF THE EFFECTS OF WAX EMULSIONS ON THE KEEPING QUALITIES OF VEGETABLES

Thesis

Submitted to the faculty of the Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of Master of Science

by
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THESIS

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Introduction

Waxes and wax emulsions have been used successfully in preventing transpiration losses from nursery stock, Christmas trees and certain plant products. Oils and wax-oil mixtures (1, 8, 12, 17, 18)[1] have also been tried with varying success on stored vegetable and fruit products. Various wax emulsions have been recommended for the prevention of desiccation in fruits and vegetables and are now offered on the market by several commercial companies.

The purpose of this investigation was to study the effects of these emulsions on the keeping quality of vegetables and to make comparisons of several of the commercial wax emulsions and other types of materials.

Review of Literature

Wax materials have been used to prevent desiccation in nursery stock and cuttings during transportation or while in storage for a considerable time. Neilson (11) working on roses and heartnut trees reported that paraffin aided the growth of transplanted trees. He found that the shoots developing from the buds on paraffined areas grew faster and better than those on unparaffined areas. He found also that transplanted apple trees which were dying from desiccation could often be revived by painting a coat of melted paraffin on the trunk and branches.

Tukey and Brase (19), using paraffin wax and two cold miscible paraffin emulsions on roses, obtained results similar to those of Neilson.

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[1]References to literature cited are given at the end of this paper.

In contrast to this experiment, however, initiation of growth by cherry trees was delayed by these treatments. The cherry trees painted with paraffin made poor growth. The stock sprayed with paraffin emulsion was delayed two weeks and the trees were severely injured by one of the emulsions.

Miller, Neilson and Bandemer (10) sprayed a paraffin emulsion on a large number of different species of plants. They found that most evergreens benefited by applications of the emulsions at transplanting time. However, they obtained some injury on Larch and Red Spruce. They concluded that wax emulsions would aid transplanted trees only if the moisture supply was inadequate but if it became too low or was normal no benefit could be expected.

In addition to preventing desiccation in nursery stock, paraffin has been used as an aid in winter storage of sugar beets. Kohls (8) used paraffin in place of the usual moist sand in preventing sugar beets from drying in storage. He reported that there is no material decrease in the total sucrose content of beets dipped in paraffin and that a thick coat, applied at 55° - 60° C., was more effective in preventing the loss of moisture than a thin coat applied at higher temperatures. No deterioration was found in either case. He found that removing the paraffin from the sutures of the mother beets before planting significantly increased the percentage of beets producing seed and the average yield of seed per plant.

Paper, waxed paper and other similar materials have been used for some time in preventing desiccation and storage diseases of certain fruits and vegetables. Edmond (5) wrapped tomatoes in standard wrapping

paper to determine change of flavor in wrapped fruits. He concluded that neither bad flavors nor change in color were produced by the treatment.

In contrast to this work, Sando (16) performed a similar experiment with tomatoes, using the sugar-acid ratio as an index to quality. He found that wrappers gave poor quality, especially where two layers of paper were used.

Hawthorn (6), working with cucumbers, wrapped them in moisture-proof cellophane, two intermediate grades of cellophane, and wax paper prior to storage at 80° F. He found that for control of desiccation moisture-proof cellophane gave the best results followed by wax paper. The other two were no better than the checks. However, with the moisture-proof cellophane and wax paper, moisture collected inside the wrapper and a large number of cucumbers decayed. In the checks, transpiration losses decreased rapidly after a few days due to a hardening of the epidermis. This did not occur in the wrapped treatments because the high humidity kept the epidermis soft.

Golden Delicious and Grimes Golden apples were wrapped in moisture-proof cellulose sheets before storage by Baker (2). He kept Golden Delicious in a crisp edible condition until early summer while the checks were worthless by the first of the year. However, Grimes Golden under the same conditions scalded badly, had a dull color, and a bad flavor. Baker made no mention of moisture collecting inside moisture-proof cellulose wrappers as was found to be the case by Hawthorn (6).

Thus far, there has been a decided lack of uniformity in results from the use of oils, waxes and oil-wax mixtures on fruits and vegetables in storage.

Allen (1), working on the oiling of melons before storage, put them at 38° F. for three days. The oiled melons were found to develop an undesirable flavor due to anaerobic respiration. In the 72° F. storage the untreated melons lost sucrose but this reduction showed a marked decrease in oiled melons. The ratio of reducing sugars to sucrose remained about the same in both cases.

Oil and waxes applied prior to storage were used in the control of apple scald by Brooks (3). He treated a number of varieties with mineral oils of paraffin origin, mixtures of oil and beeswax, and oil and paraffin. He reported that the oiled fruit had lost its natural bloom and developed a high percentage of mold. The fruit treated with oil and paraffin wax mixture was greener and firmer than the checks, but the color and flavor varied directly with the concentration. Those treated with beeswax-paraffin-oil mixture were entirely normal in color, taste and firmness, and showed no stickiness.

Magness (9) worked along the same line by coating apples with a light odorless oil and a solution of paraffin in a volatile solvent. He found that the retardation of ripening varied with the thickness of the coat of either oil or paraffin. He reported that anaerobic respiration will occur at 32° F. if the coating is heavy enough and at 64° F. even if a very light coating is applied. Magness also found that the treated fruit did not increase in red and yellow pigments while in storage.

Neller (12) treated Winesap and Delicious apples by brushing on a mixture of paraffin and mineral oil. After four months storage he found that the untreated Winesap apples respired carbon dioxide 40 per cent faster, and 17 per cent faster after eight months, than the treated fruit.

The untreated Delicious respired 46 per cent faster after four months and 43 per cent faster after eight months in storage. In contrast with some other workers, he reported this oil-paraffin treatment resulted in no significant difference in the dessert quality of the fruit.

Stewart (18) used the Brogdex System for preventing shrinkage in citrus fruit. He waxed fruit, previously soaked in a 5 per cent borax solution, with a solution of paraffin in an odorless and tasteless mineral oil of low viscosity. This mixture was sprayed on in a heavy fog and the fruit then brushed to improve appearance. He reported no anaerobic respiration in any trials and a large decrease in blue mold (Penicillium). This is thought to be brought about by coverage with the wax of the small cracks, through which the blue mold spores gain entrance.

A paraffin-beeswax-mineral oil mixture was found to be useful in delaying the time of ripening in tomatoes by Brooks (4). He found that by covering the stem-end with the above mixture the storage period was more than doubled. He also found that leaving a short stem caused definite delay in the ripening process. The carbon dioxide content of tomatoes so treated increases with maturity, although no bad flavor was reported.

Emulsions of various waxes have been tried as desiccation preventatives in stored fruit and vegetables. A number of these products have been put on the market and are recommended for this purpose. Smock (17) treated pears and apples with two emulsions (546D and 489A). They were treated by dipping in 546D full and half strength and in 489A in full strength only. He reported that in general wax treatments retard respiration in all fruits studied. However, Smock found that in pears, when a

heavy enough coat was applied to retard respiration, poor color developed and a distinct alcoholic flavor was apparent. He reported that waxed Yellow Newtown apples were marketable at the end of 23 days in 67° F. storage while unwaxed apples were full yellow in 17 days and remained marketable for only 20 days.

Miller, Neilson and Bandemer (10) treated Golden Delicious, Winesap, and Stayman apples with Dowax (a commercially prepared wax emulsion) and paraffin. The paraffin-treated apples showed distinct breakdown and were a complete loss. The apples treated with Dowax were in fair condition and no off flavors were discernable. However, some injury resulted in the spots where drops of this emulsion had collected.

Wax emulsions are thought to be useful in delaying ripening of tomatoes. Jackson (7) has shown that wax emulsions will reduce the shrinkage of tomatoes by half on trips from California to the East. Platenius (13) recommends waxing of the fruit in the northern states as a solution for late tomatoes which would otherwise be killed by late frost. He found that the effectiveness of these emulsions was directly proportional to their paraffin content. Platenius found, however, that wax emulsions favor the growth of Penicillium and other molds on fruit. Adding borax, formaldehyde and calcium hypochlorite (13, 14) was found to be ineffective in preventing the growth of these molds. These disinfectants also showed a tendency to increase the transpiration rate of vegetables and the hypochlorite hastened slightly the rate of ripening.

Other vegetables for which Platenius (15) recommends the use of emulsions are cucumbers and egg plants. Topped carrots, turnips and rutabagas can be treated to advantage after storage before going on the

market. He reports no advantage in dipping the pulse crops, leaf crops, pepper and southern grown carrots, beets and turnips.

Materials and Methods

The objective of this study was to apply wax emulsions to fresh vegetables immediately before storage to determine their effect on desiccation, length of storage, type of coating formed, and injury to vegetable tissues.

Eleven different emulsions and one wax were used. They are, with their concentrations, as follows:

1 - Dowax[1] - a commercial wax emulsion prepared by the Dow Chemical Company.

A. Concentrations:

1. Dow Paste (no dilution)
2. 1 part plus 2 parts water
3. 1 part plus 5 parts water
4. 1 part plus 10 parts water

2 - An emulsion[2] prepared by the Section of Chemistry of the Michigan Agricultural Experiment Station.

A. Concentrations:

1. 1 part plus 2 parts water
2. 1 part plus 5 parts water

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[1]Dowax was developed by Dr. E. J. Miller of Michigan State College. The patent for its preparation is now held by the Michigan State College and it is manufactured by the Dow Chemical Company, Midland, Michigan. The Dowax used in this experiment was furnished by this concern.

[2]Emulsions Nos. 2, 3, 4, 6, 7 and 8 were prepared by Dr. E. J. Miller of the Michigan Agricultural Experiment Station and furnished by him for this experiment.

3 - An emulsion prepared by the section of Chemistry of the Michigan Agricultural Experiment Station.

A. Concentrations:

1. 1 part plus 2 parts water

2. 1 part plus 5 parts water

4 - An emulsion prepared by the section of Chemistry of the Michigan Agricultural Experiment Station.

A. Concentrations:

1. Undiluted

5 - An emulsion furnished by Dr. Miller of the Experimental Chemistry Division at Michigan State College.

A. Concentrations:

1. 1 part plus 1 part water

2. 1 part plus 2 parts water

6 - An emulsion prepared by the section of Chemistry of the Michigan Agricultural Experiment Station.

A. Concentrations:

1. Undiluted

7 - An emulsion prepared by the section of Chemistry of the Michigan Agricultural Experiment Station.

A. Concentrations:

1. Undiluted

8 - An emulsion prepared by the section of Chemistry of the Michigan Agricultural Experiment Station.

A. Concentrations:

1. 1 part plus 1 part water

489A - An emulsion[3] prepared by the Franklin Chemical Company.

A. Concentrations:

1. 1 part plus 4 parts water

2. 1 part plus 6 parts water

284D - An emulsion[3] prepared by the Franklin Chemical Company.

A. Concentrations:

1. 1 part plus 5 parts water

2. 1 part plus 6 parts water

3. 1 part plus 7 parts water

333B - An emulsion[3] prepared by the Franklin Chemical Company.

A. Concentrations:

1. 1 part plus 2 parts water

12 - Paraffin - This was commercial paraffin (Parawax) which was purchased on the market.

A. Concentrations:

1. Single coat of melted Parawax

In the remaining portion of this paper, the above materials will be designated by their numbers in the preceding outline, i.e., Paraffin as 12.

Vegetables

The preliminary studies were made with vegetables purchased on the open market and followed by vegetables grown locally during the 1938 season. The vegetables used were carrots, turnips, beets, radishes, onions, asparagus, green peas, lima beans, snap beans, wax beans, cucumbers, tomatoes, sweet potatoes, eggplant, summer squash, peppers and sweet corn.

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[3]These emulsions are products of the Franklin Chemical Company, Wilber White Division, Philadelphia, Pa. and were furnished by them for this experiment.

Method of Applying Materials

In all cases where dilutions of the emulsions used were required, the materials were measured to the nearest mille-liter and distilled water was used to prevent possible error due to impurities carried in tap water. Dilutions in all cases are given by volume.

Two general types of applications were used: spraying on the emulsion, and dipping the vegetables in the emulsion. On the vegetables which were sprayed, the following procedure was used:

> The vegetables were washed and allowed to dry. They were then sprayed with a small constant pressure hand atomizer, placed on a screen, and allowed to drain and dry.

On the vegetables which were dipped, the following procedure was used:

> The vegetables were washed and allowed to dry. They were then immersed in the emulsion, brought out, allowed to drain back into the container for a few seconds, and then put on a drying screen. An electric fan was used in some cases to speed up drying with some of the slower drying emulsions.

After treating, the vegetables were weighed and stored. In some cases such as carrots, cucumbers, and squash, weights were kept on individual vegetables but in other cases such as peas, beans, radishes, etc., when the individuals were small, weights were made of a sample of 20 grs. or more.

The coat left on the vegetables after drying was so thin that in weighing to 0.1 gr. no appreciable difference in weight could be found in treated as compared with the few untreated materials. For this reason, in a few cases the vegetables were weighed before the emulsion was applied.

Weighings were made at different intervals to determine loss by drying out. Notes were kept on each lot of material used as to drying time, general appearance, effect on plant tissue, and coverage. Temperature and humidity records were made on all except five lots of vegetables.

The tables I to V inclusive show the pre-storage treatments of each vegetable used in this experiment.

Table I. Methods of application, sizes of sample, concentrations of materials and storage conditions of Root Crops treated with wax emulsions.

Vegetable	Treatment Number	Number of plants used in each treatment	Material	Concentration of Materials Material : Water	Method of Application	Storage Temp. o F.	Results Found Table
CARROTS	1	40	1	1 : 2 1 : 5	Spray	70	VI
			2	1 : 2 1 : 5			
			3	1 : 2 1 : 5			
			5	1 : 2			
	2	40	1	1 : 2 1 : 5	Spray	34	VI
			2	1 : 2 1 : 5			
			3	1 : 2 1 : 5			
	3	16	1 333B 2 333B 333B 333B	1 : 2 1 : 2 1 : 2 1 : 2 1 : 2 1 : 2	Dip entire plant Dip tops Dip roots (4)	Alternating temp. (1)	VI
TURNIPS	1	5	(2)	(2)	Spray	34	VII
BEETS	1	10	(2)	(2)	Spray	34	VIII
RADISHES	1	20	(2)	(2)	Spray	34	IX
	2	60	1	1 : 2(3)	Spray	70	IX
	3	30	1 489A 333B	1 : 5 1 : 4 1 : 2	Dipped	Alternating temp. (1)	IX

(1) Alternating temperatures were 70° F. for 12-hour intervals and 34° F. for 12-hour intervals. This simulated market conditions.
(2) Materials and concentrations were same as treatment No. 2 under carrots.
(3) A second coat was applied after the first had dried.
(4) Tops cut off at crown - roots then dipped.

Table II. Methods of application, sizes of sample, concentrations of materials and storage conditions of Pulse Crops treated with wax materials.

Vegetable	Treatment Number	Quantity used in each treatment grams	Material	Concentration of Materials Material / Water	Method of Application	Storage Temp. o F.	Results Found Table
GREEN PEAS	1	75	1	1 / 2	Spray	34	X
				1 / 5			
			2	1 / 2			
				1 / 5			
			3	1 / 2			
				1 / 5			
			4	1 / 0			
			5	1 / 2			
			6	1 / 0			
			7	1 / 0			
	2	350	1	1 / 2(3)	Spray Dipped	70	X
			5	1 / 5(3)			
			8	1 / 1(3)			
			12	1 / 0			
	3	675	1	1 / 2	Dipped	34 / dryer (4)	X
			1	1 / 5			
			1	1 / 10			
	4	125	1	1 / 2	Dipped	Alternating temp.	X
			1	1 / 5			
			333B	1 / 2			
			489A	1 / 4			
SNAP BEANS	1	135	(2)	(2)	Spray	70	XI
	2	135	(2)	(2)	Spray	34	XI
	3	400	(5)	(5)	Dipped	34 / dryer	XI
	4	350	6	1 / 5	Dipped	Alternating temp. (1)	XI
			6	1 / 2			
			1	1 / 5			
			489A	1 / 4			
			333B	1 / 2			
			2	1 / 2			
WAX BEANS	1	350	(2)	(2)	Spray	70	XII
	2	350	(2)	(2)	Spray	34	XII
LIMA BEANS	1	1250	1	1 / 2	Dipped	70	XIII
			1	1 / 5			
			333B	1 / 2			
			489A	1 / 4			

(1) Alternating temperatures were 70° F. for 12-hour intervals and 34° F. for 12-hour intervals. This simulated market conditions.
(2) Materials and concentrations were same as treatment No. 2 under carrots.
(3) A second coat was applied after the first had dried.
(4) The dryer was a sealed box containing calcium chloride to increase desiccation.
(5) Materials and concentrations were same as treatment No. 3 under green peas.

Table III. Methods of application, sizes of samples, concentrations of materials and storage conditions of Cucurbitaceous Crops treated with wax materials.

Vegetable	Treatment Number	Number of fruit used in each treatment	Material	Concentration of Materials Material : Water	Method of Application	Storage Temp. o F.	Results Found Table
CUCUMBERS (slicing type)	1	5	1	1 : 2 1 : 5	Spray	34	XIV
			2	1 : 2 1 : 5			
			3	1 : 2 1 : 5			
			4	1 : 0			
			5	1 : 2			
			6	1 : 2			
			7	1 : 0			
	2	5	(2)	(2)	Spray	70	XIV
CUCUMBERS (National Pickling variety)	1	108	1	1 : 5 1 : 5 1 : 6	Dipped Spray Dipped	34	XV
			284D	1 : 6	Spray		
SUMMER SQUASH	1	6	1	1 : 0 1 : 2 1 : 5	Rub-Cloth Dipped	70	XVI
			489A	1 : 4			

(2) Materials and concentrations were same as treatment No. 2 under carrots.

Table IV. Methods of application, sizes of sample, concentration of material and storage conditions of Solanaceous Crops treated with wax materials.

Vegetable	Treatment Number	Number of fruit used in each treatment	Material	Concentration of Materials Material	Water	Method of Application	Storage Temp. o F.	Results Found Table
TOMATOES (ripe)	2	25	4	1	0	Spray	70	XVII
			5	1	2			
			6	1	0			
			7	1	0			
			5	1	1(3)			
			6	1	0			
			1	1	2(3)			
			12	1	0	(6)		
	3	5	1	1	5	Dipped	Alternating temp. (1)	XVII
			489A	1	4			
			284D	1	5			
TOMATOES (green) (approx. 5% color)	1	25	1	1	0	Rub-cloth	70	Page 28
				1	2			
				1	5	Dipped		
			489A	1	4			
	2	20	1	1	2	Dipped	50	Page 28
				1	5			
			489A	1	4			
			284D	1	5			
EGG PLANTS	1	6	1	1	0	Rub-cloth	70	XVI
				1	2			
				1	5	Dipped		
			489A	1	4			
PEPPERS	1	10	1	1	2	Dipped	70	XIV
				1	5			
			489A	1	4			
			284D	1	7			

(1) Alternate temperatures were 70° F. for 12-hour intervals and 34° F. for 12-hour intervals. This simulated market conditions.
(3) A second coat was applied after the first had dried.
(6) No. 12 was melted at 180° F. and poured in the stem-end of the tomato.

Table V. Methods of application, sizes of sample, concentrations of materials and storage conditions of Miscellaneous Crops treated with wax emulsions.

Vegetable	Treatment Number	Quantity used in each treatment	Material	Concentration of Materials Material Water	Method of Application	Storage Temp. o F.	Results Found Table
ONIONS	1	16 plants	1	1 ∠ 2 1 ∠ 5	Spray	70	XX
ASPARAGUS	1	40 tips	1	1 ∠ 2 1 ∠ 5 1 ∠ 10	Dipped	34 and dryers (4)	XXI
SWEET POTATOES	1	6	1 12	1 ∠ 2 1 ∠ 0 1 ∠ 0	Spray Rub-cloth Dipped	70	XXII
CORN	1	15 ears	1 333B	1 ∠ 2 1 ∠ 5 1 ∠ 2	Dipped	34	Page 34

(4) The dryer was a sealed box containing calcium chloride to increase desiccation.

Characteristics of the Materials

All of the emulsions were tested as to coverage and run-off on tomatoes as they have a heavy waxy cuticle which causes poor coverage of most spray materials. The drying times stated are an average of all the vegetables used. An emulsion was considered dry when all visible moisture had disappeared.

The drying times given in the tables are those in which a fan was not used. The record of these results will be found in Table XXXII.

Cooking Trial

A cooking test was made on snap beans. Three lots of approximately 400 grs. each were used for this test. One was left as a check, one dipped in No. 1 (1 ∕ 5), and one dipped in No. 489A (1 ∕ 4). They were stored at 34° F. for three days and then cooked under the supervision of the Home Economics Department of the Michigan State College. Four judges were used for this test.

Presentation of Data

I. Root crops show slight reduction in transpiration losses.

The data on the effects of the emulsions on root crops are given in Tables VI, VII, VIII, and IX.

In most cases the emulsions applied to these root crops decreased transpiration. However, this decrease was not enough to result in any material or marked difference in the length of the storage period. The reduction of transpiration was irregular in this group of crops. Carrots with tops removed were the only root crops which showed any appreciable difference in the length of storage. In general it can be said that No. 2 in Concentrations of (1 ∕ 2) and (1 ∕ 5) gave the poorest results, with the remaining emulsions all being about the same.

Dowax caused injury in all concentrations on both carrots and radishes. The carrots showed cell injury on the roots caused by drops of the emulsion forming a heavy coating over a small area which turned a deep red color. The injury increased with the concentration of the emulsion. The tops of the radishes became shriveled and curled. This was noticeable about two hours after the emulsion had been applied. None of the other emulsions showed injury on any of these root crops.

II. Emulsions lengthen the storage period of peas and beans.

From Tables X, XI, XII, and XIII it may be seen that the transpiration losses were reduced from 40 to 60 per cent with the best emulsion tried. The treated peas and beans were in a salable condition from one to two days longer than were the checks.

In this case No. 1 reduced transpiration more than any other product although Nos. 3, 333B, 489A and 284D reduced it almost as much.

Table VI. Transpiration Losses of Carrots as Affected by Wax Emulsions.

Treatment	Trial No.	Methods of Application	Ave. Hum. %	Ave. Temp. °F.	Transpiration Loss- Percent by Weight Stored at Room Temperature		
DAYS					3rd	8th	11th
CHECK	1	--	50	68	20.2	--	--
	2	--	78	72	23.4	40.7	--
	3	--	80	75	6.7	20.8	26.00
Av.					16.8	30.7	--
1 (1+2)	1	Spray	50	68	12.9	--	--
	2	"	78	72	15.3	28.0	--
Av.					14.1	--8	--
1 (1+5)	1	"	50	68	14.6	--	--
	2	"	78	72	22.3	34.9	--
	3	"	--	--	4.6	20.3	24.2
Av.					13.8	27.6	--
2 (1+2)	1	"	50	68	17.0	--	--
	2	"	78	72	22.3	26.0	--
Av.					19.6	--	--
2 (1+5)	1	"	50	68	19.3	--	--
	2	"	78	72	36.7	38.5	--
Av.					28.0	--	--
3 (1+2)	1	"	50	68	14.7		
	2	"	78	72	17.8	28.3	
Av.					15.3		
3 (1+5)	1	"	50	68	11.9		
	2	"	78	72	11.1	18.9	
Av.					11.5		
5 (1+2)	3	"	80	75	4.6	7.0	20.2
					Stored at alternate temperatures		
DAYS					2nd	4th	6th
CHECK	1	--	80 86	73 35	26.7	35.4	
	2	--	68 85	78 35	33.9	40.3	
Av.					30.3	37.8	
1 (1+2) Entire plant	1	Dip	80 86	73 35	17.1	24.9	
2 (1+2) Entire plant	1	"	80 86	73 35	19.6	29.7	
333B (H2) Entire plant	1	"	80 86	73 35	17.1	24.5	
333B (1+2) Tops only	2	"	68 85	78 35	23.2	32.0	
333B (1+2) Roots only	2	"	68 85	78 35	27.0	34.7	
333B (1+2) Roots only	2	"	68 85	78 35	10.7	14.2	23.1 Tops cut Roots dipped

Table VI. Continued.

Treatment	Trial No.	Methods of Application	Ave. Hum. %	Ave. Temp. °F.	Transpiration Loss-Percent by Weight Stored in Cold Storage			
DAYS					4th	8th	12th	15th
CHECK	1		80	35	8.5	13.2	16.6	20.5
	2		86	35	--	22.4	31.5	33.7
Av.					--	17.8	24.0	27.1
1 (1+2)	1	Spray	80	35	4.6	6.9	11.7	14.6
	2	"	86	35	--	8.5	14.8	17.8
Av.					--	7.7	13.2	16.2
1 (1+5)	1	"	80	35	5.6	8.7	11.8	14.7
	2	"	86	35	--	8.4	14.2	15.1
Av.					--	8.5	13.0	14.9
2 (1+2)	1	"	80	35	7.3	11.4	13.9	17.4
	2	"	86	35	--	13.0	16.5	18.8
Av.					--	12.2	15.2	18.1
2 (1+5)	1	"	80	35	8.5	14.5	19.1	21.9
	2	"	86	35	--	12.5	17.8	21.8
Av.					--	13.5	18.5	21.9
3 (1+2)	1	"	80	35	6.5	10.4	12.5	15.6
	2	"	86	35	--	9.5	14.1	16.6
Av.					--	9.9	13.3	16.1
3 (1+5)	1	"	80	35	5.8	11.3	15.1	18.5
	2	"	86	35	--	10.1	15.8	18.4
Av.					--	10.7	15.5	18.5

Table VII. Transpiration Losses in Turnips as Affected by Wax Emulsions.

Treatment	Trial No.	Method of Application	Ave. Hum. %	Ave. Temp. °F.	Transpiration Loss- Per Cent by Weight Stored at Room Temperature			
DAYS					4th	8th	12th	14th
CHECK	1	Spray	80	35	2.9	5.5	10.3	15.1
1 (1+2)	1	"	"	"	5.4	6.9	11.5	13.9
1 (1+5)	1	"	"	"	4.2	6.7	12.1	14.0
2 (1+2)	1	"	"	"	3.3	5.8	9.4	11.3
2 (1+5)	1	"	"	"	7.9	11.7	15.6	18.5
3 (1+2)	1	"	"	"	7.1	9.2	14.3	15.9
3 (1+5)	1	"	"	"	5.1	7.3	11.1	12.6

Table VIII. Transpiration Losses in Beets as Affected by Wax Emulsions.

Treatment	Trial No.	Method of Application	Ave. Hum. %	Ave. Temp. °F.	Transpiration Loss- Per Cent by Weight Stored in Cold Storage			
DAYS					4th	8th	12th	14th
CHECK	1	Spray	80	35	10.4	13.7	12.2	27.1
1 (1+2)	1	"	"	"	8.8	11.9	24.1	27.4
1 (1+5)	1	"	"	"	6.9	9.8	14.0	17.0
2 (1+2)	1	"	"	"	7.0	11.0	15.4	16.6
2 (1+5)	1	"	"	"	5.9	10.5	14.6	16.7
3 (1+2)	1	"	"	"	6.5	10.0	12.3	14.4
3 (1+5)	1	"	"	"	6.0	13.5	18.8	22.2

Table IX. Transpiration Losses in Radish as Affected by Wax Emulsions.

Treatment	Trial No.	Method of Application	Ave. Hum. %	Ave. Temp. °F.	Transpiration Loss- Per Cent by Weight Stored in Cold Storage			
DAYS					4th	8th	12th	15th
CHECK	1		80	35	26.8	33.1	42.5	49.3
1 (1+2)	1	Spray	"	"	21.8	27.6	42.0	46.3
1 (1+5)	1	"	"	"	20.9	25.4	33.9	37.4
2 (1+2)	1	"	"	"	21.5	23.9	27.6	31.4
2 (1+5)	1	"	"	"	29.2	35.4	46.4	49.3
3 (1+2)	1	"	"	"	24.2	30.1	36.4	39.6
3 (1+5)	1	"	"	"	22.7	33.5	43.6	50.7
					Stored at Room Temperature			
DAYS					3rd	5th		
CHECK	1		71	75	19.7	38.0		
1 (1+2) (2 coats)	1	Spray	"	"	10.2	31.5		
					Stored at Alternating Temp.			
DAYS					2nd			
CHECK	1		55 80	80 35	46.8			
1 (1+5)	1	Dip	55 80	80 35	52.1			
489A (1+4)	1	"	55 80	80 35	34.0			
333B (1+2)	1	"	55 80	80 35	32.3			

Table X. Transpiration Losses in Green Peas as Affected by Wax Materials.

Treatment	Trial No.	Method of Application	Ave. Hum. %	Ave. Temp. °F.	Transpiration Loss- Per Cent by Weight Stored at Room Temperature				
DAYS					2nd	4th	6th	8th	
CHECK	1		70	75	18.2	42.1	50.4		
1 (1+2) (2 coats)	1	Spray	"	"	10.3	20.0	25.8	29.6	
5 (1+1) (2 coats)	1	"	"	"	6.5	16.5	19.6	27.9	
12	1	Dip	"	"	3.2	5.9	--	--	
8 (1+0) (2 coats)	1	Spray	"	"	3.0	12.4	20.1	--	
					Stored in Cold Storage				
DAYS					2nd	4th	8th	13th	16th
CHECK	1		86	35			12.8	19.3	24.1
	2		85	36	8.2	14.9	27.4	42.4	
Av.		Spray			--	--	20.1	30.8	--
1 (1+2)	1	"	86	35			5.3	9.3	11.6
1 (1+5)	1	"	"	"			5.3	9.9	10.6
2 (1+2)	1	"	"	"			7.5	11.5	14.2
2 (1+5)	1	"	"	"			8.1	12.9	17.1
3 (1+2)	1	"	"	"			5.2	10.0	11.6
3 (1+5)	1	"	"	"			5.1	8.7	9.9
4 (1+0)	2	"	85	36	1.3	2.2	6.8	11.4	13.6
5 (1+2)	2	"	"	"	1.9	3.5	9.8	16.5	21.7
6 (1+0)	2	"	"	"	6.5	12.1	24.1	--	--
7 (1+0)	2	"	"	"	2.1	4.1	10.3	16.1	20.8
					Stored at Alternating Temp.				
DAYS					2nd	4th	6th		
CHECK	1	Dip	53 80	80 35	25.4	33.8	--		
1 (1+5)	1	"	53 80	80 35	11.6	14.8	24.7		
333B (1+2)	1	"	53 80	80 35	7.1	8.9	13.1		
489A (1+4)	1	"	53 80	80 35	7.9	9.8	15.7		
284D (1+7)	1	"	53 80	80 35	8.4	10.8	16.8		
					Stored at Cold Storage & Dryer				
DAYS					3rd	5th	7th	9th	
CHECK	1	Dip	--	35	14.5	19.3	--	--	
1 (1+2)	1	"	--	"	2.3	4.1	5.0	6.3	
1 (1+5)	1	"	--	"	2.5	5.3	6.7	8.2	
1 (1+10)	1	"	--	"	2.7	4.9	8.9	9.9	

Table XI. Transpiration Losses of Snap Beans as Affected by Wax Emulsions.

Treatment	Trial No.	Method of Application	Ave. Hum. %	Ave. Temp. °F.	Transpiration Loss Per Cent by Weight Stored at Room Temperature			
DAYS					3rd	8th		
CHECK	1	--	78	72	21.0	50.7		
1 (1+2)	1	Spray	"	"	15.2	33.3		
1 (1+5)	1	"	"	"	19.2	36.4		
2 (1+2)	1	"	"	"	23.6	43.9		
2 (1+5)	1	"	"	"	22.7	41.6		
3 (1+2)	1	"	"	"	12.5	26.4		
3 (1+5)	1	"	"	"	8.7	20.6		
					Stored in Cold Storage			
DAYS					8th	13th	16th	22nd
CHECK	1		86	35	19.4	27.5	51.8	--
1 (1+2)	1	Spray	"	"	6.2	11.7	16.4	22.1
1 (1+5)	1	"	"	"	6.8	11.8	14.2	21.8
2 (1+2)	1	"	"	"	12.8	19.8	24.3	40.8
2 (1+5)	1	"	"	"	10.4	16.4	21.5	29.1
3 (1+2)	1	"	"	"	4.3	9.8	11.6	20.1
3 (1+5)	1	"	"	"	6.9	11.2	13.9	32.0
					Stored at Alternating Temp.			
DAYS					2nd	4th	6th	8th
CHECK	1		55 86	80 35	17.6	22.5	--	--
1 (1+5)	1	Dip	86 55.	35 80	7.3	13.3	17.6	22.9
489A (1+4)	1	"	55 86	80 35	9.0	12.5	16.4	21.1
333B (1+2)	1	"	55 86	80 35	13.7	18.0	22.8	26.7
2 (1+2)	1	"	55 86	80 35	13.1	19.8	27.7	35.1
6 (1+2)	1	"	55 86	80 35	14.0	22.1	33.8	--
6 (1+5)	1	"	55 86	80 45	14.6	21.2	29.4	--
					Stored in Cold Storage and Dryer			
DAYS					3rd	5th	7th	9th
CHECK	1	--	--	36	9.0	11.3	14.5	18.9
1 (1+2)	1	Dip	--	"	2.6	5.1	7.8	9.2
1 (1+5)	1	"	--	"	2.8	4.6	6.8	8.1
1 (1+10)	1	"	--	"	2.8	4.5	5.9	9.2

Table XII. Transpiration Losses of Wax Beans as Affected by Wax Emulsions.

Treatment	Trial No.	Method of Application	Ave. Hum. %	Ave. Temp. °F.	Transpiration Loss Per Cent by Weight Stored at Room Temperature			
DAYS					3rd	8th		
CHECK	1	--	78	72	24.0	43.0		
1 (1+2)	1	Spray	"	"	17.1	34.3		
1 (1+5)	1	"	"	"	16.5	31.0		
2 (1+2)	1	"	"	"	25.9	48.3		
2 (1+5)	1	"	"	"	21.9	45.1		
3 (1+2)	1	"	"	"	13.8	28.8		
3 (1+5)	1	"	"	"	13.4	29.2		
					Stored in Cold Storage			
DAYS					8th	13th	16th	22nd
CHECK	1	--	86	35	15.1	22.1	26.9	39.0
1 (1+2)	1	Spray	"	"	8.2	15.0	19.3	29.9
1 (1+5)	1	"	"	"	8.5	14.7	16.9	25.3
2 (1+2)	1	"	"	"	13.5	21.4	25.4	38.0
2 (1+5)	1	"	"	"	10.9	18.9	23.2	31.9
3 (1+2)	1	"	"	"	9.4	16.1	17.8	26.4
3 (1+5)	1	"	"	"	9.0	13.8	16.3	24.3

Table XIII. Transpiration Losses of Lima Beans as Affected by Wax Emulsions.

Treatment	Trial No.	Method of Application	Ave. Hum.	Ave. Temp.	Transpiration Loss Per Cent by Weight Stored at Room Temperature			
DAYS					1st	2nd	3rd	4th
CHECK	1	--	--	--	9.8	16.9	32.2	43.6
1 (1+2)	1	Dip	--	--	3.0	6.8	14.1	21.1
1 (1+5)	1	"	--	--	3.2	7.6	17.1	26.1
333B (1+2)	1	"	--	--	4.5	9.2	17.8	25.7
489A (1+4)	1	"	--	--	4.5	8.9	18.4	27.4

A slight browning was noticed on snap beans treated with No. 1, although there is no certainty that this was caused by the emulsion as a very slight case of browning was found on the checks. No injury was found with any of the other materials except No. 12 on green peas. Here anaerobic respiration started two days after the material was applied and by the fourth day the peas were completely decayed.

In the cooking trials with snap beans no off-taste was found by the judges. They could detect no waxy flavor in any treated lot nor any other difference in their cooking qualities.

III. Emulsions preserve the color and crispness of cucumbers.

On slicing cucumbers, as may be seen in Table XV, No. 1 gave the best results followed by No. 3. Eighteen days after treatment at 70° F. storage the treated cucumbers showed no pithiness in the walls and little shrinkage was apparent in the flesh. In the check treatments the cucumbers were yellow, pithy and the flesh had a crystalline and very shrunken appearance. Very little difference could be seen in the treated groups, except those treated with No. 2. This emulsion showed very poor results.

On the National Pickling cucumbers (XV) Nos. 1, 333B, 284D, and 489A gave about the same results. The storage period was increased by these treatments approximately two days. No appreciable difference in transpiration losses could be found between the dipped and sprayed cucumbers. The chief difference found here was in the amount of material used. The dipping method did not require nearly as much material or time as did the spraying method. In the dipping method the same material can be used repeatedly and complete coverage is very simple.

No. 1 (1 ∠ 2) gave the best result on summer squash, as may be seen in Table XIV, followed closely by No. 1 concentrated. No injury was produced by any treatment on any of these cucurbitaceous crops.

IV. Emulsions gave varied results with Solanaceous fruits.

Transpiration losses were reduced by the emulsions on all the solanaceous crops except pepper, as may be seen in Tables XVI, XVII, XVIII. On green tomatoes No. 1 (1 ∠ 2) retarded ripening the most, followed closely by Nos. 489A and 284D. Some injury was caused by No. 1 concentrated where it penetrated cracked areas around the stem. The ripening process was retarded from 2 - 5 days by the application of the emulsions.

The results obtained from treating ripe tomatoes were almost negative. No appreciable difference could be seen in the length of storage time. No. 1 (1 ∠ 2) showed a small amount of cell injury where heavy spotting occurred on cracks at the stem-end. No. 12, applied to the stem-end only, reduced transpiration as much as the emulsions and caused no injury.

On egg plant (Table XVIII) No. 1 (1 ∠ 2) showed the best results. The treated fruits were in salable condition 3 - 5 days longer than were the checks. No injury was obtained from any of the treatments.

The transpiration losses of pepper were not decreased any appreciable amount (Table XIX). No lengthening of the time in storage was produced by application of any of these emulsions.

V. Results with asparagus, green onions and sweet potatoes were found to be very variable.

Although the transpiration of onions was reduced by treating with the emulsions (Table XX), the reduction was so small that no lengthening

Table XIV. Transpiration Losses of Cucumbers as Affected by Wax Emulsions. (Slicing).

Treatment	Trial No.	Method of Application	Ave. Hum. %	Ave. Temp. °F.	Transpiration Loss Per Cent by Weight Stored in Cold Storage					
DAYS					2nd	4th	8th	12th	14th	16th
CHECK	1	--	80	35		1.2	1.7	2.7	3.5	
	2	--	85	36	.7	1.1	2.2	3.6	4.3	4.9
Av.					--	1.2	1.9	3.2	3.9	--
1 (1+2)	1	Spray	80	35		.34	.53	1.1	1.4	
1 (1+5)	1	"	"	"		.35	.51	.81	1.1	
2 (1+2)	1	"	"	"		.83	1.5	2.2	2.6	
2 (1+5)	1	"	"	"		.8	1.6	2.4	2.8	
3 (1+2)	1	"	"	"		.59	1.1	1.6	2.0	
3 (1+5)	1	"	"	"		.5	.95	1.4	1.9	
4 (1+0)	2	"	85	36	.42	.98	2.4	3.4	3.9	4.4
5 (1+2)	2	"	"	"	.41	.58	1.3	2.1	2.5	2.9
6 (1+2)	2	"	"	"	1.2	1.8	4.2	6.1	7.0	7.6
7 (1+0)	2	"	"	"	.47	.9	2.2	3.1	3.7	4.0
					Stored at Room Temperature					
DAYS					2nd	7th	11th			
CHECK	1		50	68	4.0	8.5	12.3			
1 (1+2)	1	Spray	"	"	.59	2.6	5.3			
1 (1+5)	1	"	"	"	1.6	4.1	4.8			
2 (1+2)	1	"	"	"	1.2	3.3	6.4			
2 (1+5)	1	"	"	"	2.6	4.4	8.0			
3 (1+2)	1	"	"	"	1.5	3.2	5.3			
3 (1+5)	1	"	"	"	1.5	3.5	6.4			

Table XV. Transpiration Losses of Cucumbers as Affected by Wax Emulsions. (National Pickling).

Treatment	Trial No.	Method of Application	Ave. Hum. %	Ave. Temp. °F.	Transpiration Loss Per Cent by Weight Stored in Cold Storage					
DAYS					5th	8th				
CHECK	1	--	85	35	12.9	17.4				
1 (1+5)	1	Dip	"	"	6.3	9.9				
284D (1+6)	1	"	"	"	5.0	7.7				
1 (1+5)	1	Spray	"	"	6.3	9.1				
284D (1+6)	1	"	"	"	5.9	9.1				
1 Conc.	1	Rub	"	"	5.2	8.9				

Table XVI. Transpiration Losses of Summer Squash as Affected by Wax Emulsions.

Treatment	Trial No.	Method of Application	Ave. Hum. %	Ave. Temp. °F.	Transpiration Loss Per Cent by Weight Stored at Room Temperature					
DAYS					4th	9th	17th	21st	31st	41st
CHECK			--	--	3.5	5.5	8.5	9.5	10.4	14.1
1 (1+2)		Dip	--	--	1.2	2.0	3.6	4.4	5.8	6.9
1 (1+5)		"	--	--	2.7	4.2	6.4	8.1	10.8	12.6
1 Conc.		Rub	--	--	1.9	2.6	3.9	4.7	5.9	6.8
489A (1+4)		Dip	--	--	2.5	3.6	5.6	6.5	8.6	10.5

Table XVII. Transpiration Losses of Tomatoes as Affected by Wax Materials.

Treatment	Trial No.	Method of Application	Ave. Hum. %	Ave. Temp. °F.	Transpiration Loss Per Cent by Weight Stored in Cold Storage						
DAYS					8th	13th	16th	22nd	24th	26th	
CHECK	1		86	35	.76	1.16	1.3	1.7	2.4	3.3	
1 (1+2)	1	Spray	"	"	.093	.191	.328	.55	.821	1.2	
1 (1+5)	1	"	"	"	.20	.3	.348	.48	.96	1.4	
3 (1+2)	1	"	"	"	.26	.33	.36	.41	.74	1.1	
					Stored at Alternating Temperatures						
DAYS					2nd	4th	6th	8th	10th	12th	
CHECK	1	--			.2	.89	1.5	1.7	2.1	2.5	
1 (1+5)	1	Dip	55 80	80 35	.4	.96	1.3	1.8	2.0	--	
489A (1+4)	1	"	55 80	80 35	.37	.92	1.4	1.8	1.8	2.0	
284D (1+2)	1	"	55 80	80 35	.43	1.0	1.4	1.6	1.6	1.9	
					Stored at Room Temperature						
DAYS					3rd	5th	9th	11th	13th	15th	17th
CHECK	1		71	75	.63	1.7	2.9	3.9	4.8	5.3	6.3
	2		70	"	.94	1.9	3.2	4.1	5.2	5.6	--
Av.					.79	1.8	3.1	4.0	5.0	5.5	--
1 (1+2)	2	(2 coats)	70	75	.88	1.2	2.1	2.6	3.1	3.5	
5 (1+1) (2 coats)	2	Dip	"	"	.83	1.7	3.0	3.6	4.2	--	
8 (1+0) (2 coats)	2	Spray	71	"	1.9	2.5	3.2	3.8	4.4	4.7	
4 (1+0)	1	"	"	"	.65	1.3	2.9	3.0	3.4	--	
5 (1+2)	1	"	"	"	.72	1.8	3.0	3.9	4.6	5.1	5.5
6 (1+0)	1	"	"	"	.71	1.8	3.1	4.1	5.6	6.1	
7 (1+0)	1	"	"	"	.42	1.5	2.8	3.5	3.8	4.2	4.7
12 (stem end)	2		70	"	.79	1.4	2.4	3.3	3.3	4.1	

Table XVIII. Transpiration Losses of Egg Plant as Affected by Wax Emulsions.

Treatment	Trial No.	Method of Application	Ave. Hum.	Ave. Temp.	Transpiration Loss- Per Cent by Weight Stored at Room Temperature		
DAYS					4th	8th	16th
CHECK			--	--	7.6	11.4	--
1 (1+2)	1	Dip	--	--	4.5	7.5	11.6
1 (1+5)	1	"	--	--	2.6	5.0	10.5
1 Concen.	1	Rub	--	--	3.9	6.6	11.6
284D (1+7)	1	Dip	--	--	6.6	10.8	--

Table XIX. Transpiration Losses of Pepper as Affected by Wax Emulsions.

Treatment	Trial No.	Method of Application	Ave. Hum.	Ave. Temp.	Transpiration Loss- Per Cent by Weight Stored at Room Temperature		
DAYS					5th	10th	14th
CHECK	1		--	--	6.7	9.4	--
1 (1+2)	1	Dip	--	--	5.0	9.4	11.0
1 (1+5)	1	"	--	--	4.5	9.5	12.2
489A (1+4)	1	"	--	--	5.2	10.2	14.4
284D (1+7)	1	"	--	--	8.3	15.2	20.4

Table XX. Transpiration Losses of Green Onions as Affected by Wax Emulsions.

Treatment	Trial No.	Method of Application	Ave. Hum. %	Ave. Temp. °F.	Transpiration Loss Per Cent by Weight Stored at Room Temperature					
DAYS					3rd	5th	7th	9th	11th	
CHECK	1	--	70	75	11.1	21.1	26.8	30.5	35.2	
1 (1+2)	1	Spray	"	"	10.3	20.0	25.8	29.6	35.9	
1 (1+5)	1	"	"	"	7.2	14.6	20.7	25.8	32.0	

Table XXI. Transpiration Losses of Asparagus as Affected by Wax Emulsions.

Treatment	Trial No.	Method of Application	Ave. Hum.	Ave. Temp. °F.	Transpiration Loss Per Cent by Weight Stored in Cold Storage & Dryer					
DAYS					3rd	5th	7th	9th		
CHECK	1		--	35	4.3	6.9	8.3	--		
1 (1+2)	1	Dip		"	1.7	2.8	5.1	6.5		
1 (1+5)	1	"	--	"	2.5	5.0	6.5	8.7		
1 (1+10)	1	"	--	"	2.5	4.0	6.4	8.1		

Table XXII. Transpiration Losses of Sweet Potatoes as Affected by Wax Emulsions.

Treatment	Trial No.	Method of Application	Ave. Hum. %	Ave. Temp. °F.	Transpiration Loss Per Cent by Weight Stored at Room Temperature					
DAYS					3rd	5th	7th	9th	11th	13th
CHECK	1	--	70	75	.98	2.2	3.6	4.5	4.5	4.5
1 (.+2)	1	Dip	"	"	.24	.57	.98	1.2	2.0	2.0
1 Concen.	1	Rub	"	"	.43	1.0	1.6	2.0	2.7	2.7
12	1	Dip	"	"	.25	.59	.93	1.1	1.9	2.4

of the time in storage could be observed. No injury was apparent in any of the treatments.

On asparagus (Table XXI) better results were obtained. No. 1 (1 ⊀ 2) reduced transpiration approximately 40 per cent and lower concentrations gave lower reduction of transpiration. As in onions, no injury was apparent in any of the treatments.

On sweet potatoes (Table XXII) No. 12 gave the best reduction of transpiration followed by No. 1 (1 ⊀ 2). Sweet potatoes were the only vegetable in which complete coverage by No. 12 did not cause anaerobic respiration. No. 12 caused a slight retardation of bud development which was not noticeable with the other emulsions.

No advantage was found in applying emulsions to sweet corn. The emulsion which penetrated the husk did not dry within 48 hours. The treated corn after 48 hours had a strong emulsion odor although no injury to husk or grain was apparent.

VI. Emulsions differ widely in their physical properties.

The physical properties of the emulsions are given in Table XXIII.

In general No. 1 reduced transpiration more than any of those tried. However, it dries very slowly, the coat is very dull and it adheres poorly to tomatoes, egg plants and cucumbers. No. 1 dries clear at 70° F. but when parts of the vegetable were still wet when put at 34° F. this area dried white. No. 1 was also found to cause injury to some of the more tender vegetables. The best results with No. 1 were those obtained on cucumbers, squash, green peas, etc.

Nos. 2, 6, 7, and 8 were ineffective in reducing transpiration. The chief objection to these emulsions is that the white colored residue of wax left on the surface renders the product less attractive.

Nos. 3 and 4 dried clear and caused no injury. No. 3 reduced transpiration almost as much as No. 1. The chief objection to these two products is the length of time required to dry.

Nos. 333B, 284D, 489A and No. 5 dried in a short time compared to the others. They dried clear both at 70° F. and at lower temperatures. These emulsions increased the glossiness of the surfaces, increasing attractiveness. However, they did not reduce transpiration as much as No. 1.

No anaerobic respiration was found in any of the trials except with No. 12 on peas. No. 12, however, resulted in no pronounced anaerobic respiration in sweet potatoes or tomatoes. The chief objection to applying this material to sweet potatoes and to the stem-end of tomatoes is the cracking of the material on handling, which results in an opening in the protective film.

Table XXIII. Coverage and Drying Time of Emulsions.

Material	Conc.	Drying Time	Coat	Coverage	General Appearance	Remarks
1	1+2	1-6 hr.	Clear	Medium	Poor - Finish - Dull and Unattractive	Spots of collected material dried white
	1+5	½-4 hr.	"	"	"	"
	1+10	½-2 hr.	"	"	"	Very few white spots
2	1+2	3/4-2 hr.	White	"	Very Poor	--
	1+5	½-1 hr.	Grey	"	" "	--
3	1+2	½ 1 hr.	Clear	"	Poor - Finish - Dull and Unattractive	Very little spotting
	1+5	½-1 hr.	"	"	"	No spotting
4	1+0	6-8 hr.	"	"	"	Heavy spotting
5	1+1	30 min.	"	"	Shiny - Good	No spotting
	1+2	"	"	"	"	"
6	1+0	½-1½ hr.	Grey	"	Very Poor	"
7	1+0	3/4-1½hr.	White	"	"	Heavy spotting
8	1+0	3/4-1 hr.	Slightly Grey	Good	"	Slight Spotting
439A	1+4	20 min.	Clear	"	Shiny - Very Attractive	No spotting
	1+6	"	"	"	"	"
284D	1+5	"	"	"	"	"
	1+6	"	"	"	"	"
	1+7	"	"	"	"	"
333B	1+2	"	"	"	"	"

* Drying time reduced approximately 25% by use of fan.

Discussion

Platenius (15) recommended the use of emulsions on late green tomatoes, cucumbers and egg plant. He also recommended them on topped carrots, turnips and rutabagas. He reported no benefit on pulse crops. The writer found that on green tomatoes, egg plants and cucumbers an apparent lengthening of the time of storage was produced by the application of the emulsions. However, contrary to Platenius, treated lots of peas and beans were in a salable condition from one to two days longer than were the checks. The green peas treated with No. 1 (1 ∠ 2) gave the most marked reduction of transpiration of any of the vegetables tried.

In general wax emulsions can be applied to advantage on the pulse crops, green tomatoes, cucumbers, squash and similar vegetables. No benefit was found on root crops having leafy tops although good results are obtained when the tops are removed and the roots alone are treated.

Dipping vegetables is much faster, more economical and just as effective as spraying. No difference was found in drying time or injury between the two methods. The chief objection to the wax emulsions used in these investigations was the length of drying time required. Many perishable vegetables will wilt if kept out of cold storage this length of time. However, the time can be shortened approximately 25 per cent by a fan or other type of air circulating equipment.

It is evident that new or different types of emulsions or materials of other types must be brought out before they can be used to aid commercial vegetable storage.

Summary

I. Twelve wax materials were applied to various types of vegetables. Reduction of transpiration by each material was determined by measuring loss of weight while in storage. The vegetables were kept under four different storage conditions.

II. The application of certain of the emulsions were found to be advantageous on the pulse crops, some of the solanaceous crops, cucurbits and topped carrots.

III. No marked reduction of transpiration was produced by the emulsions on the root crops with tops, certain solanaceous crops and corn.

IV. Injury was caused by Dowax on carrots and snap beans and by paraffin on green peas.

V. The Franklin emulsions were found to dry much faster, give a similar coverage and a much better appearance than any of the other emulsions tried. However, their reduction of transpiration was less than that given by Dowax.

VI. Before emulsions can be used on the commercial scale in vegetable storage, improved materials must be found which have better drying and coverage properties than those used in this experiment.

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