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CONTROL OF DRIED-FRUIT INSECTS IN CALIFORNIA.[1]

By

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INTRODUCTION.

The State of California is especially adapted to the raising of fruits. It is manifest that only a part of the great crop which is annually produced may be marketed in a fresh condition, since it is impossible to preserve semitropical and other soft fruits for more than a very limited time in the fresh state. The fruit canneries and the dried-fruit industry have accordingly been formed with a view to the utilization of the surplus fruit and have assumed large proportions, the production of dried fruits for the State of California being estimated at 140,000 carloads annually.

The importance of this industry and the fact that numerous inquiries are made concerning the control of the insects which attack dried fruits warrant investigation of the insect enemies of dried fruits in California. This was undertaken in a preliminary way in 1908, but owing to lack of funds was discontinued until 1911, at which time the writer, working under the direction of Dr. F. H. Chittenden, was assigned to this project. The investigation has been continued to the time of publication, and the preliminary notes are herewith submitted.

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[1] The observations in this bulletin and the data on life history and habits were obtained in central California, the author having his headquarters at Sacramento, but it is probable that these particulars do not differ materially in other fruit-growing sections of the United States, especially in the eastern and southern fruit regions.

[2] Resigned Aug. 31, 1914.

NOTE.—The writer has been assisted in this investigation by the Roeding Fig Packing Co., the Rosenberg Co., Mr. D. L. Smith, of the Schuckl Co., the California Dried Fruit Exchange, the Robt. Gair Co., and the Petterson Carton Wrapping & Sealing Machine Co., who by their cooperation have greatly facilitated the prosecution of this project. He also wishes to acknowledge the assistance of Mr. R. E. Campbell, of the Bureau of Entomology, who brought to completion some of the experiments detailed in this paper.

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INSECTS CONCERNED IN THE INJURY.

During the progress of this investigation a study of the insect forms most injurious to dried fruits in California has been pursued, with the result that the following species have been collected, the more important being considered later in separate paragraphs.

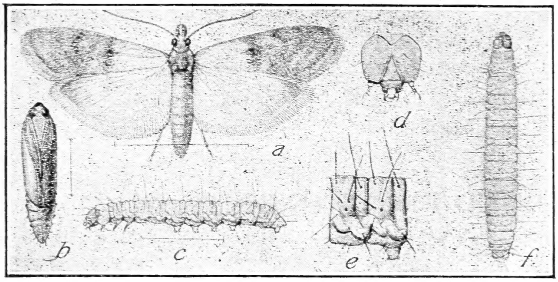

FIG. 1.—The Indian-meal moth (*Plodia interpunctella*): *a*, Moth; *b*, chrysalis; *c*, caterpillar; *d*, head of same; *e*, first abdominal segment of same; *f*, caterpillar, dorsal view. *a*, *b*, *c*, *f*, Somewhat enlarged; *d*, *e*, more enlarged. (From Chittenden.)

The Indian-meal moth (*Plodia interpunctella* Hübn.) (fig. 1) is probably the most common and destructive of these pests, its large size making it particularly conspicuous, while the nature of its attack renders infested fruit most disgusting in appearance. (See Pl. I, figs. 1, 2.) The fig moth (*Ephestia cautella* Walk.) (fig. 2) is next in importance among the moths, while a variety of beetles, including the dried-fruit beetle (*Carpophilus hemipterus* L.), the saw-toothed grain beetle (*Silvanus surinamensis* L.), the foreign grain beetle (*Cathartus advena* Waltl), and a fungus beetle (*Henoticus serratus* Gyll.), are generally injurious. Two sugar mites (*Tyroglyphus siro* Gerv. and *T. longior* Gerv.) are also frequently found. The pomace flies (*Drosophila ampelophila* Loew) attack only the sweet, watery fruits, or those that are fermenting, and can hardly be considered as dried-fruit insects. Ants are occasionally found in dried fruits, but do not breed therein, and can usually be best attacked by destroying their nests outside the packing house.

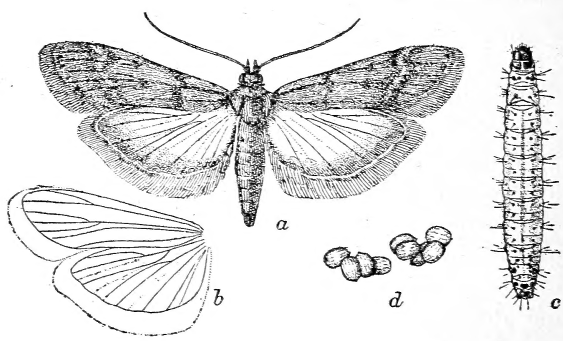

FIG. 2.—The fig moth (*Ephestia cautella*): *a*, Moth; *b*, denuded wing, showing venation; *c*, larva, dorsal view; *d*, two egg masses. *a*, *b*, *c*, Enlarged about four times; *d*, more enlarged. (From Chittenden.)

ECONOMIC IMPORTANCE OF DRIED-FRUIT INSECTS.

The annual financial loss to all who handle dried fruits from the Pacific coast would be very difficult to estimate, since these products are rapidly distributed by the packers over a large territory, and the injury is first noticed by the retailer or the consumer. Moreover, the retailer is inclined to be somewhat reticent regarding the presence of wormy fruit in his establishment, although an examination frequently shows such to be the case. A few retail grocers stated that the "worms" were especially troublesome during the summer months, and while the majority of those interrogated admitted with reluctance that they ever received wormy fruit, it was, no doubt, present in their stores at the time. Many companies claimed that it would be difficult to secure the exact figures, but admitted that they usually sold a considerable quantity as hog feed during the season. A wholesale grocer stated that his annual loss on dried fruits returned because of insect infestation was about $50, but that the loss in 1912 approximated $150. These are only a few individual instances, and the greatest aggregate loss is through small quantities of infested fruit which are thrown away or sold as hog feed, the retailer preferring the loss of a small quantity of fruit to the trouble of returning it to the wholesaler. It is readily apparent, however, that the annual loss must in the aggregate be considerable.

For the reason that no estimates can be made of the injuries by the Indian-meal moth to fruits in California, it is worth stating that according to figures furnished by Dr. Chittenden in 1910, there was a loss to the peanut industry, through the ravages of this species, amounting to 20 per cent, or, at a conservative estimate, $3,000,000.[1]

PRELIMINARY OBSERVATIONS.

Observations begun in 1911 in central California, with headquarters at Sacramento, with special reference to insects attacking dried figs, were soon extended to all dried-fruit insects. It was found that in most cases insects were present in the field where the fruit is dried, that they were quite numerous around the packing houses, and that they were present in warehouses and stores in sufficient numbers to threaten severe infestation to boxes of dried fruit that might be stored there. There are usually one or more cracks or openings in the boxes (Pl. II, fig. 2) through which an insect or mite can readily crawl. The paper used in lining the boxes does not to any extent prevent their entrance.

These preliminary observations led to the conclusion that the problem could not be successfully combated by attacking it at any one point, but that the methods of drying, storing, processing, packing, and shipping should be investigated.

THE INDIAN-MEAL MOTH.

The life history of the Indian-meal moth (*Plodia interpunctella* Hübn.) will vary with the prevailing temperature, but was deter-

[1] Popenoe, C. H. The Indian-meal Moth and "Weevil-cut" Peanuts. U. S. Dept. Agr., Bur. Ent., Cir. 142, 6 p., 1 fig., Sept. 16, 1912. See p. 1.

mined at the Sacramento laboratory during June, July, and August, 1913, as follows: Egg stage, 6 days; larval stage, 35 days; pupal stage, 12 days; adult, about 14 days. Total, from egg to adult, 53 days, or 1 month and 23 days.

While the subject of this article is practical and based on conditions at Sacramento, Cal., it should be added that in the case of the life history of this species Dr. Chittenden has pointed out [1] that "experiment shows that the insect is capable of passing through all its several stages from egg to adult in five weeks, which furnishes a possibility of six or more generations in a well-heated atmosphere, although in a moderately cool granary or other storehouse four or five broods is probably the normal number per annum."

The sudden appearance of large numbers of larvæ in dried fruit is readily explained by Table I, which shows the number of eggs deposited by six moths which were confined in the laboratory to determine the rate of oviposition.

TABLE I.—*Egg-laying records of the Indian-meal moth.*

No.	Days.								Total.
	1st.	2d.	3d.	4th.	5th.	6th.	7th.	8th.	
1	46	79	36	23	24	16	11	....	235
2	56	65	27	36	36	21	9	....	250
3	39	43	34	18	16	6	....	....	156
4	16	33	47	64	45	56	12	13	286
5	59	51	55	38	26	5	....	....	234
6 [1]	....	....	....	....	....	....	....	....	168

[1] The number of eggs in this vial was determined as total and not by days.

Average number of eggs deposited by the six moths, 221.3.

These eggs were deposited mostly during the night.

The life cycle during the summer, as given in a preceding paragraph, is only 53 days. Starting with one fertile female in a packing house on June 15 (provided all of the insects matured), there would be 221 moths by the following August 15, and by August 30 (provided that half of these moths were females) there would be a total of 23,310 larvæ in the dried fruit.

Under natural conditions some of the eggs do not hatch and many of the larvæ fail to mature, but from the foregoing data it is readily understood that a few moths of this species are capable of producing a very severe infestation within a relatively short time, provided that temperature and other conditions are favorable.[2]

[1] Chittenden, F. H. Some Insects Injurious to Stored Grain. U. S. Dept. Agr., Farmers' Bul. 45, 24 p., 18 fig., 1897. See p. 10.

[2] The hymenopterous parasite *Habrobracon hebetor* Say is frequently found attacking the larvæ of the Indian-meal moth, but it has not been observed appreciably to affect the infestation in California.

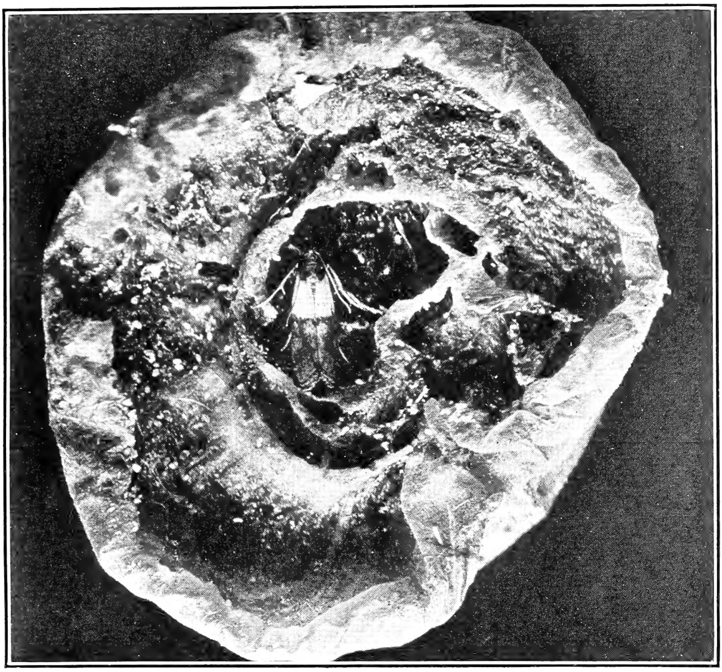

FIG. 1.—THE INDIAN-MEAL MOTH (PLODIA INTERPUNCTELLA): MOTH ON A DRIED APRICOT. (ORIGINAL.)

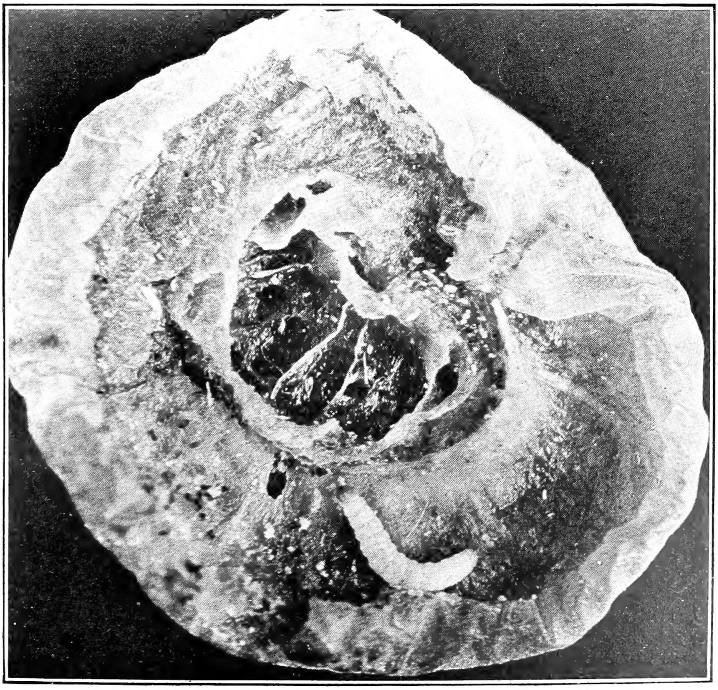

FIG. 2.—THE INDIAN-MEAL MOTH: LARVA ON A DRIED APRICOT. (ORIGINAL.)

DRIED FRUIT INSECTS IN CALIFORNIA.

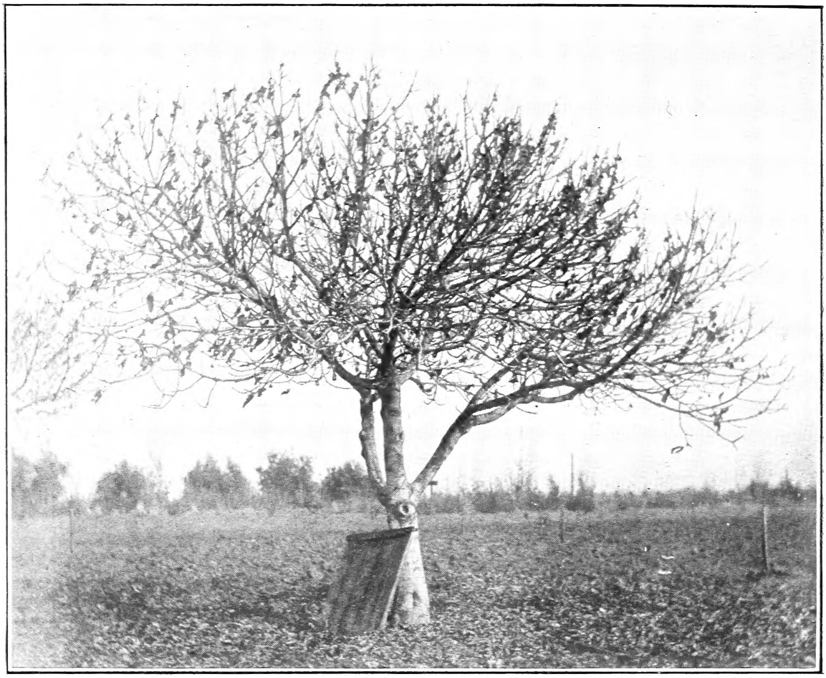

FIG. 1.—FIGS HANGING ON TREES DURING THE WINTER CONTAINING HIBERNATING ADULTS OF THE DRIED-FRUIT BEETLE (CARPOPHILUS HEMIPTERUS). (ORIGINAL.)

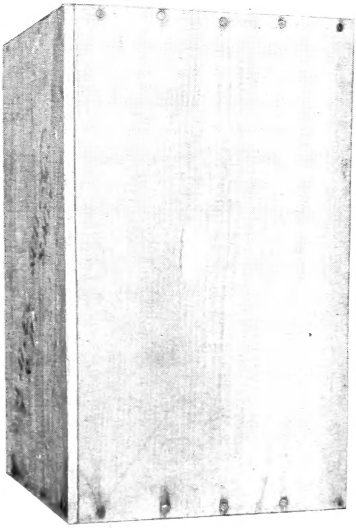

FIG. 2.—THE AVERAGE PACKING BOX, SHOWING CRACKS THROUGH WHICH DRIED FRUIT MAY BECOME INFESTED. (ORIGINAL.)

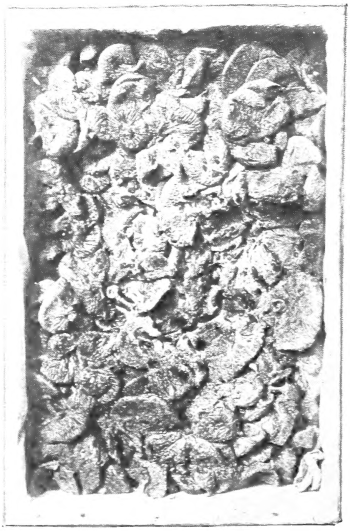

FIG. 3.—AN INFESTED BOX OF FIGS IN THE ORDINARY PACKING CASE. (ORIGINAL.)

HIBERNATION.

Partly grown larvæ brought into the laboratory October 10, 1913, spent the winter in that stage, pupated in the early spring, and emerged as adults April 16, 1914. Larvæ were observed at various times during the winter in dried fruit and partly spun up in corners and cracks of warehouses. Adults were not observed in warehouses until April 15, when many were found to be emerging. In California this insect appears to hibernate in the larval stage, pupate in the early spring, and emerge as an adult about the middle of April.

THE DRIED-FRUIT BEETLE.

The dried-fruit beetle (*Carpophilus hemipterus* L.) is probably the next in importance as a destructive dried-fruit insect. It is found in large numbers in the figs before they drop from the trees and in bins of figs and other dried fruits. The adults often frequent the packing houses in large numbers, where they swarm over and deposit eggs on the fruit which has been dipped and put out to cool. They breed readily in the moisture of the dried fruits, but apparently can not live in fruit that is moderately dry.

The adult insect hibernates in stored fruit in the packing houses, in figs, and probably in other fruits which are not gathered from the field at the time of harvest. Plate II, figure 1, shows figs which were allowed to remain on the trees during the winter, and which were later found to be highly infested with *Carpophilus hemipterus*.

On September 3, 1911, 5 pounds of dried figs, taken at random from each of seven different dryers in the vicinity of Fresno, Cal., were placed in boxes made insect-proof by plugging all cracks with cotton and wrapping carefully in stout paper. When examined January 13, 1912, the fruit in three of the seven boxes was badly infested. The results of this experiment prove that many figs are infested before they are shipped to the packing house and that the drying sheds are one of the sources of infestation. These conclusions will apply equally well to other fruits. The processing may kill the insects in the fruit at the time of processing but will not protect them from infestation while they are being dried or held in the drying sheds prior to shipping to the packing houses.

It has been found that infestation takes place in the field, in the packing house, in the warehouse, and in the grocery store.

PROCESSING DRIED FRUIT.

Dried fruit from the bins of the packing house is usually quite dry and not particularly attractive or appetizing in appearance. In order to improve its texture so that it will pack well and be attractive to the consumer, it is processed. In Table II will be found the formulas for processing fruit that are in common use in California.

TABLE II.—*Formulas for processing fruit in common use in California.*

Fruit.	Treatment in field.	In packing houses.	Processing.	Packed.
Peach	Cut in half, sulphured 1½ hours, dried in sun on trays.	Graded and placed in bins not over 4 or 5 feet deep; sweating takes place.	Dipped in cold or lukewarm water, drained, and sulphured.	Moist.
Apricot	Same as peach	Same as peach	Same as peach	Do.
Pear	do	Same as peach, but handled more carefully.	do	Do.
Prune	Picked from ground, dipped in lye solution, rinsed in clear water, dried on trays in sun.	Graded and placed in bins.	Dipped 1 to 3 minutes in clear water at 212° F., drained.	Moist; warm.
Fig	Picked from ground and dried on trays; or dipped in hot brine, drained, dipped in cold brine-soda solution, drained, and spread on trays, placed in sun until excess moisture is removed, then stacked to complete drying.	do	Black figs, dipped in boiling brine, drained and packed. White figs, dipped in cold water, drained, and packed; or dipped in boiling brine, drained, and packed. Some are dipped and sulphured.	Do.

FORMULAS.

Brine formula for prunes: Lye, 1 pound to 20 gallons.

Formula for dip for figs before being packed: Salt, 50 pounds; soda, 3 to 4 pounds; water, 150 gallons.

Formula for raisins before drying: One quart olive oil and three-fourths pound powdered caustic soda; water, 1 gallon; cook 30 minutes, add 100 gallons of boiling water with 4½ pounds caustic soda; add more caustic soda if desired.

Amount of sulphur to use and time of exposure based on 1,000 pounds of fruit.

THE EFFECT UPON INSECTS OF PROCESSING FRUIT.

It will be observed in Table II that the processing includes either dipping in boiling brine or sulphuring.

In the case of figs, when removed from the dipping vat they were too hot to be handled. When opened the interior was steaming hot, and it was assumed that no insects could pass through the dip alive. To prove this point, the following experiments were conducted:

On September 3, 1911, 100 pounds of dried figs, thoroughly infested by the dried-fruit beetle and Indian-meal moth, were dipped in the regular dipping solution heated to boiling. Fifty pounds of these figs were immersed in the dip 45 seconds, and 50 pounds were immersed 90 seconds. The figs were protected from insects when cooling, and were later put into boxes and sealed. That this dipping was sufficient to kill all animal life was proved by the total absence of living insects or of any trace of them when the fruit was examined four months later, January 14, 1912.

That sulphur fumes are more or less effective in killing insects has long been known, but in order to prove their efficiency the following experiments were conducted:

On September 4, 1911, 100 pounds of black figs, which were badly infested by the dried-fruit beetle, were separated and sulphured in the regular manner. Upon being removed from the sulphur box they were immediately placed in cartons and sealed to prevent reinfestation. They were examined January 14, 1912, and no insects or evidence of recent work were observed. The sulphuring killed all insects present in the figs at the time.

An experiment to determine the effect of sulphur fumes upon the eggs of insects was conducted at Sacramento during the summer of 1913. About 25 eggs of the Indian-meal moth, deposited on a dry fig in a vial, were placed in the top of a sulphur box and given the usual treatment. None of these eggs hatched, while the eggs kept as checks hatched in due time.

From the foregoing experiments it is evident that sulphuring the fruit has a tendency to kill any insects infesting it. In case eggs or larvæ are well inside of the fruit, however, it is probable that they would not be injured; and since the use of sulphur is not sanctioned by the authorities, and the use of heat, either wet or dry, is so very effective, the use of a belt heater is recommended.

A BELT HEATER TO DESTROY INSECTS IN DRIED FRUIT.

The belt heater is composed of a chamber in which is run a tier of belts, each running in the opposite direction to the one above it. These are so arranged that the fruit can be fed in at the top and will travel on the top belt until it reaches the roller, when it will fall to the belt below and be carried in the other direction, and so on down, the last belt carrying the fruit out of the chamber. A heater, either electric or steam, is arranged to maintain a temperature of 180° F., and by adjusting the speed of the belts the time that the fruit remains in the heater can be regulated.

An experimental machine consists of six belts, 10 feet long and 5 feet wide, running on 3-inch wooden rollers. The rollers are set on cold-rolled axles, turned by cast-iron sprockets connected by No. 25 chain, which is so arranged that it reverses the direction of alternate rollers. To insure even heating an electric fan is so adjusted that the hot air is blown along the belts, and guides are arranged to direct the air current onto the belts above. Thus, as the fruit is carried along by the belts, the hot air is blown over it. Such a machine arranged to deliver the fruit into a screened packing room (fig. 3) would insure the fruit against contamination before packing.

The fruit should remain in the heater sufficiently long to raise it to 180° F. This temperature will kill all insect life.

PROTECTING DRIED FRUITS FROM INFESTATION.

Although some damage results from the infestation of dried fruit stored in bins in the packing house, the greatest loss occurs after the fruit has been packed.

The fruit which is separated and dipped into hot solutions (212° F.) before being packed is by this process sterilized so far as insects are concerned. It has been found that such fruits as peaches, pears,

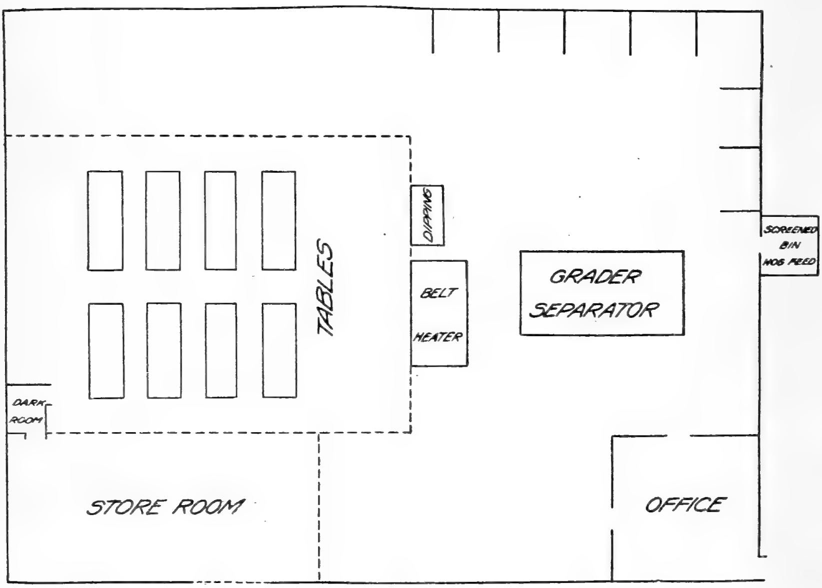

FIG. 3.—Diagram of screened packing room showing belt heater at center. (Original.)

and apricots, which are not dipped in such solutions, can be sterilized by dry heat before they are moistened, preparatory to packing. The major problem is one of preventing infestation after the fruit is sterilized and packed. Successful experiments with the use of a sealed carton (fig. 4) to protect cereals from insect attack[1] led the writer to work out a similar process for dried fruits.

Figs put up in small packages were found convenient for the following preliminary experiments begun at Fresno, Cal., October 1, 1913. Hot figs were taken from the dipping vat, pressed into bricks, wrapped in the regular paper, and placed in cartons. Careful watch was kept for infesting insects, and none was seen near the figs during the packing process.

[1] Parker, William B. A Sealed Paper Carton to Protect Cereals from Insect Attack. U. S. Dept. Agr., Bul. 15, 8 p., 8 fig., Oct. 16, 1913.

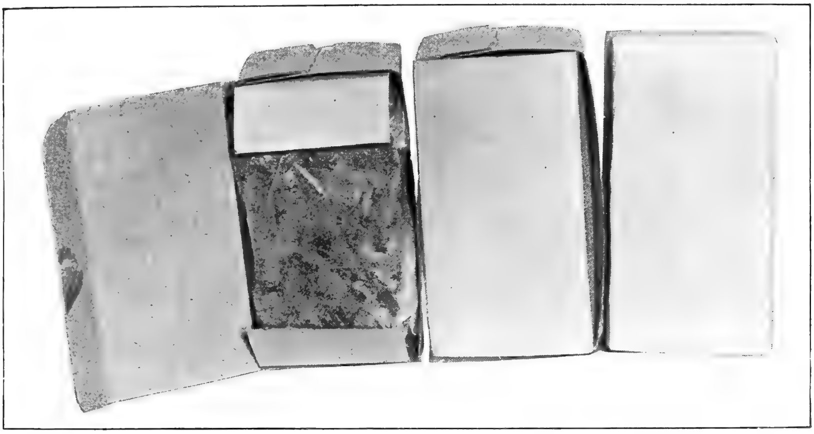

FIG. 1.—PATTERN OF THE INNER SEAL. (ORIGINAL.)

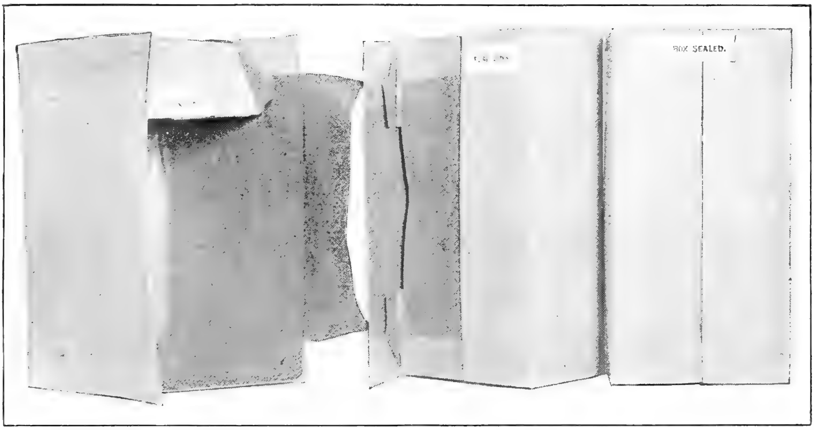

FIG. 2.—METHOD OF USING THE INNER SEAL. (ORIGINAL.)

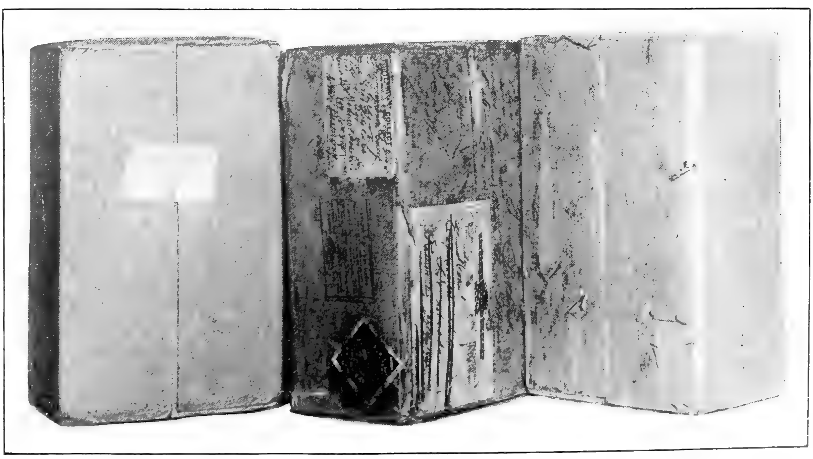

FIG. 3.—HOW THE PACKAGES STOOD THE SHIPPING TEST. (ORIGINAL.)

THE INNER SEAL: A SANITARY INSECT-PROOF PACKAGE.

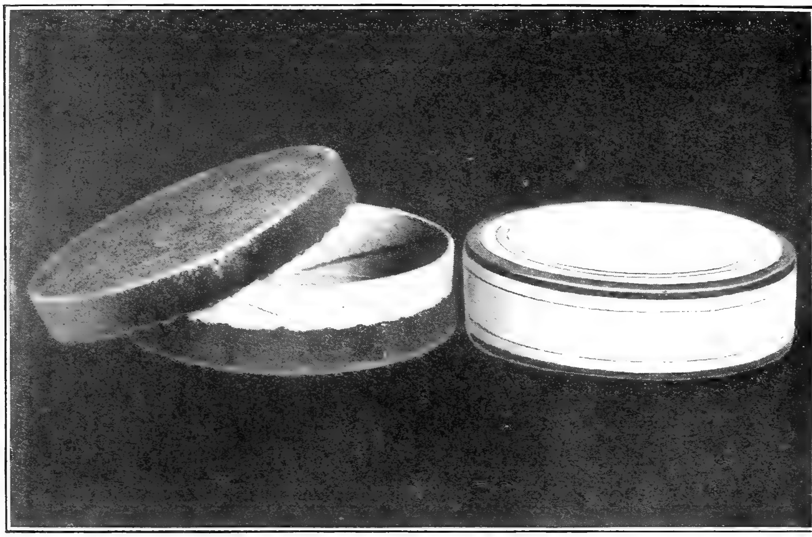

FIG. 1.—ROUND PACKAGES FOR DRIED FRUIT WHICH CAN BE SEALED. (ORIGINAL.)

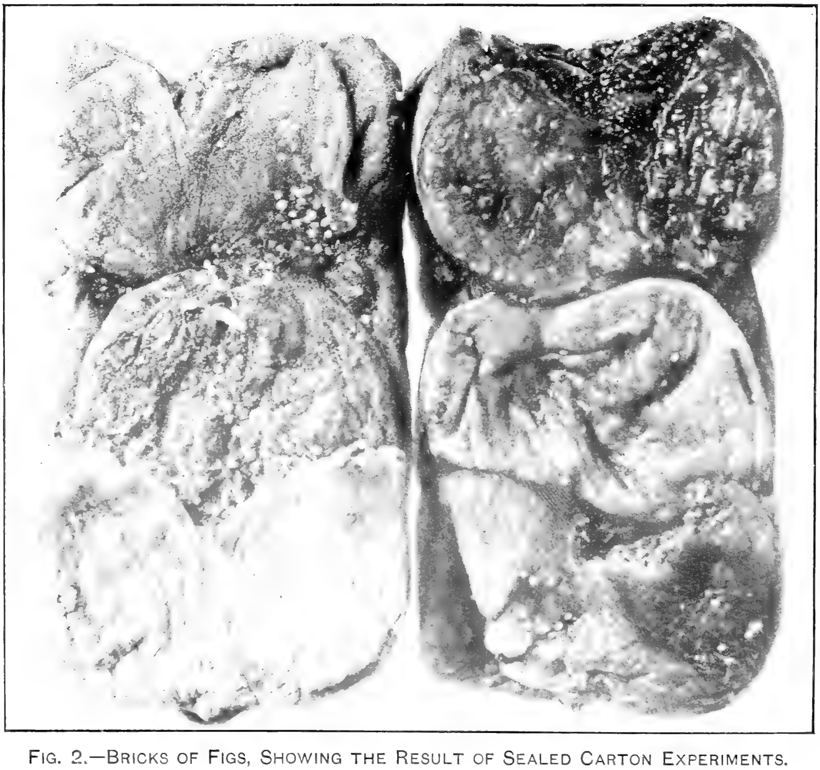

FIG. 2.—BRICKS OF FIGS, SHOWING THE RESULT OF SEALED CARTON EXPERIMENTS.

At left, unsealed brick. Note dried sugaring and infested condition. At right, sealed brick. Note moist condition. (Original.)

PROTECTING DRIED FRUITS AGAINST INSECTS.

Of these cartons 16 were sealed as shown in Plate III, figure 1, and 16 left unsealed. Of the unsealed ones, 8 were so prepared that the wrapping paper was slightly torn. This condition is one frequently found in packages of figs put up by the girls in the packing house.

The 32 cartons prepared as described above were brought to Sacramento and placed in an insect-tight box in which were then placed large numbers of larvæ and adults of *Plodia interpunctella*, *Carpophilus hemipterus*, and *Gnathocerus* (*Echocerus*) *maxillosus* Fab. The box was then sealed so that the insects could not escape, and they were given every chance to infest the cartons.

At the conclusion of these experiments, April 16, 1914, all but two of the unsealed cartons were found to be infested, while the sealed ones showed no evidence of insects having entered. It was observed that the larvæ of *Plodia interpunctella* had in some places broken through the thin paper used to wrap the bricks of figs before they are placed in the cartons.[1] It had previously been supposed by the packers that this paper if preserved intact would prevent insects from reaching the fruit.

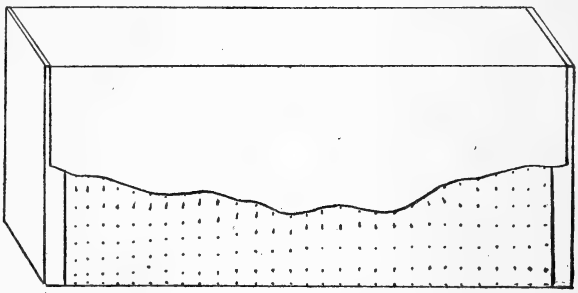

FIG. 4.—Diagram of carton, showing method of applying label to protect inclosed cereal from insect attack. (Author's illustration.)

The foregoing experiments will serve to prove the efficiency of a sealed carton in protecting packed dried fruit from insect attack.

SEALED PACKAGES FOR DRIED FRUIT.

Packages of dried fruit weighing less than 5 pounds are so nearly the size of the cartons used for cereals that, except for the high labor cost of sealing, the method used with the cereal carton could be readily applied to dried fruits. With the 10, 25, and 50 pound packages, however, the cost of such sealing is excessive, and the wooden boxes used can not be thus sealed to advantage, as the seal is easily broken by rough handling. To obviate this difficulty a light paper carton fitting inside the wooden box, and sealed before the top was nailed on, was constructed, but the cost of these cartons and the additional labor required to pack them prohibited the employment

[1] A heavy paraffined paper appears effective in preventing insects from eating through.

of this method. A fiber-board carton was then selected which could be sealed, or in which had been placed an inner seal, to prevent the entrance of insects. Such a package to be successful should stand the same shipping conditions as a wooden box and should not, when sealed, greatly exceed the latter in cost. A carton of the following specifications was tested to determine its shipping qualities:

Certificate of box maker.—This box is made of three-ply or more, fiber board or pulp board, outer ply waterproofed.

Each ply .... inch..	0.016
Thickness not less than combined board .... do....	.080
Resistance (Mullen test), combined board .... pounds per square inch..	200
Dimension limit, length, width, and depth added .... inches..	65
Gross weight limit .... pounds..	65

SHIPPING TESTS OF FIBER-BOARD PACKAGES.

Three 25-pound boxes (Pl. III) made according to the foregoing specifications were filled with 25 pounds of dried peaches, sealed, and given the following shipping tests:

Box No. 1 was shipped by express from Sacramento, Cal., to Portland, Me., and back, or about 6,000 miles, during which trip it was handled by at least 18 men. This box arrived in Sacramento in good condition and is shown in Plate III, figure 3.

Box No. 2 was shipped from Sacramento, Cal., to Fargo, N. Dak., as one of the bottom boxes in a car of 25-pound boxes of dried fruit. Except for one place where the sharp edge of a wooden box had worked up the edge, this box arrived at its destination in fine condition, as illustrated in Plate III, figure 3. This rubbing would not occur in a carload of fiber-board boxes.

Box No. 3 was sent to San Francisco by Parcels Post, where it was trucked around the wharves, given a thorough test, and examined by several packers and by the agent of one steamship company. It arrived in Sacramento in good condition, after having stood the test and having been pronounced a good shipping package for dried fruit. (Pl. III, fig. 3.)

The foregoing tests proved that the 25-pound package of dried fruit could be shipped long distances, and its shipping qualities compared very well with the wooden box.

These fiber-board boxes (Pl. III) weigh much less than the wooden box, and the saving on the freight would be considerable. In the case of the 25-pound box the saving per car on the basis of $1.10 per 100 (freight rate) is about $23. It was estimated that the adoption of this style of package would save one company approximately $40,000 annually.

THE SEAL.

The fiber-board package was found to be tight, except at the corners and where the flaps meet in the middle of the sides. An attempt was made to seal these places with gummed tape, but the labor required to do this increased the cost of packing to such an extent as to make the method unfeasible.

An inner seal was then so constructed that when the carton was regularly sealed there would be no cracks or openings at the corners. (See Pl. III, fig. 1.)

The inner seal appears practical from the packer's point of view, but the carton manufacturer claims that it would be difficult to make it cheaply enough without special machinery, although this would probably be made were there a demand for such cartons.

ADVANTAGES OF THE SEALED CARTON FOR DRIED FRUIT.

As long as dried fruit can be processed so that mold is no more prevalent in sealed packages than in unsealed ones the disadvantages of this type of package, with the possible exception of the extra cost, are negligible. The advantages, on the other hand, are several.

The main object of the sealed carton is the exclusion of infesting insects. This is accomplished very successfully and so solves a large portion of the present problem.

It also prevents the evaporation of moisture from the fruit, and thus for a long time preserves the fruit in the same moist condition in which it was packed. Plate IV, figure 2, shows two bricks of figs packed October 1, 1913, and opened April 16, 1914. The brick on the left was put up in an ordinary carton, and, as will be observed, it was dried, sugared, and became infested, while the one on the right, which was put into an ordinary carton, but sealed, is in practically the same condition as when packed. These two bricks were kept under the same conditions; in fact, were in the same box. From the foregoing data it is evident that fruit properly packed in sealed cartons will be protected from infestation and will remain in a moist condition much longer than when packed in an ordinary carton or box.

OTHER SEALED PACKAGES.

In an attempt to find a small and attractive package for their fruit one packing company in California evolved a round carton with a cover that fitted over the end like the cover of a baking powder can, as shown in Plate IV, figure 1. A printed label pasted around the edge of the carton formed in experiment a very effective seal. This carton appears to be satisfactory for small packages, but the shape is such that more room is required for shipment than is the case with the square package, and it is not as practical for the larger sizes.

When objections to the inner seal were presented the writer immediately investigated other possible methods. Among several which were suggested, the use of a waxed sealing paper wrapped around bricks of fruit and sealed with a hot iron seemed very promising.[1] It was found that bricks of apricots, prunes, and pears up to 10 pounds in weight could be successfully made and wrapped in the waxed paper, and that by placing a piece of sheet iron on top of the brick of fruit before folding the paper over, a smooth surface could be obtained for the application of the sealing iron. After the top is sealed the sheet iron should be quickly removed. The hot iron may then be applied to the ends of the paper, making them tight, and afterwards the ends may be folded up and the brick placed in a large carton. Plate V, figures 1 and 2, shows the effect obtained by using such a paper seal, which, when properly sealed, renders the package insect proof. The cost of packing dried fruit in such a package has not been determined, but the writer believes that it will be found economical in many packing houses.

This method combines the advantages of an insect-proof package, a 5 or 10 pound unit, and a 25 or 50 pound fiber-board carton, which is lighter and probably cheaper than the wooden box.

While in the field the writer observed a package formed of an ordinary raisin carton which was sealed in a waxed sealing paper. The sealing was done by machinery which, except for the initial expense of the machine, would make the process very rapid and economical. Such a package might prove very efficient for dried fruits put up in from 1 to 5 or even 10 pound packages.

Several packers have reported the presence of mold in the ordinary wooden boxes of dried figs. Plate VI, figure 1, shows such a condition. This was observed to occur more frequently in the sealed round boxes previously mentioned, and it appears that if the sealed carton is to be used for dried fruit the problem is a very important one.

From examinations of moldy fruit and from investigations of the condition of the fruit when packed, the writer concludes that conditions favorable to the growth of mold occur only when the fruit is too wet when packed, either through excessive processing or improper drainage. One packer stated that when the fruit was taken directly from the hot dip and packed in sealed boxes a large percentage of the cartons became moldy. On the other hand, if the fruit was allowed to drain thoroughly and stand in lug boxes or in a heap for several hours before being packed, the moisture became equalized and mold rarely developed. (Pl. VI, fig. 2.) To establish these statements and observations finally the following experiments were conducted:

On July 28, 1914, four lots of figs were processed by dipping in boiling water for one minute. Lot No. 1 was dried in the sun until

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[1] Suggested by Mr. J. H. Green, of San Francisco.

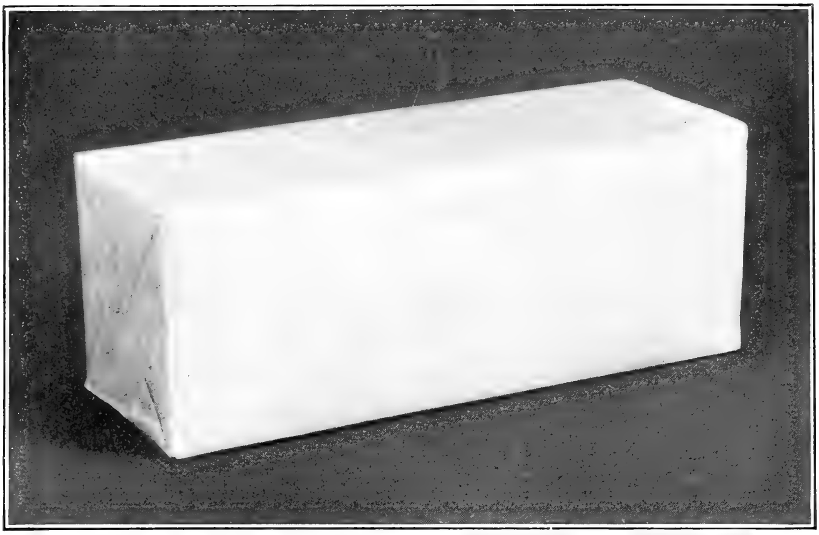


FIG. 1.—A CARTON WRAPPED AND SEALED BY THE MACHINE. (ORIGINAL.)

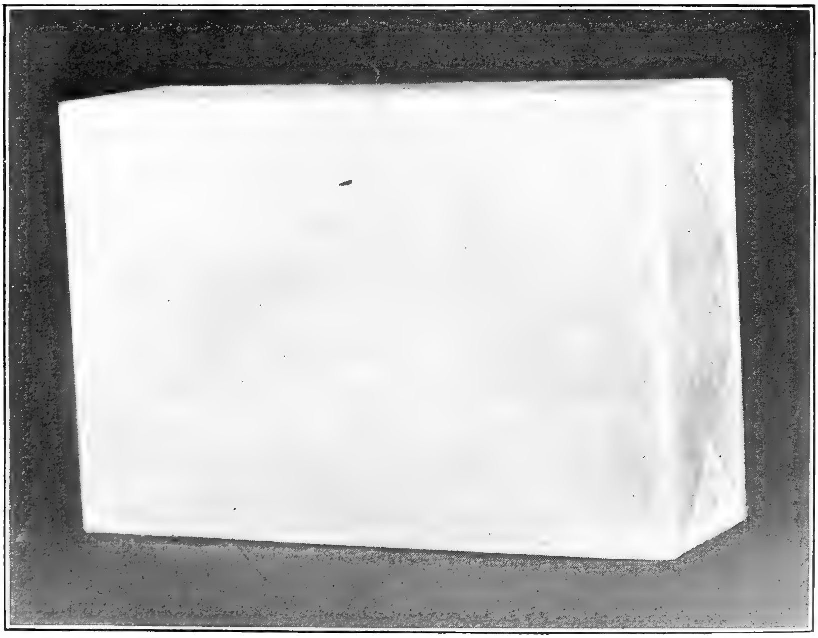


FIG. 2.—CLEAN AND WHOLESOME; MOISTURE AND INSECT PROOF. PARAFFIN-WAXED PAPER SEAL APPLIED TO A CARTON OF RAISINS. (ORIGINAL.)

INSECT-PROOF PRODUCTS OF THE WRAPPING AND SEALING MACHINE.

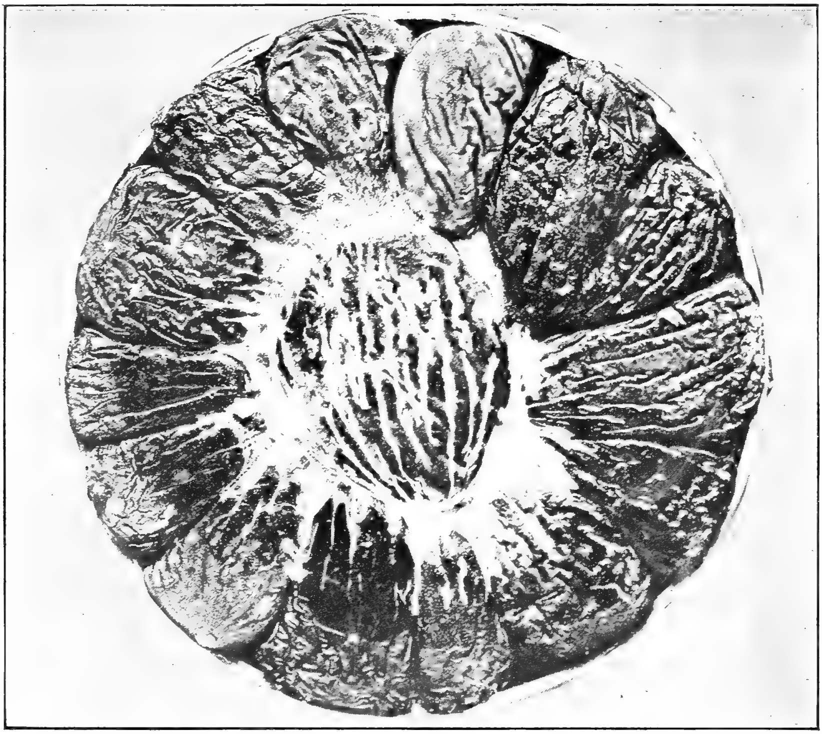


FIG. 1.—MOLDY CONDITION OF FIGS IN ROUND SEALED CARTON. FIGS PACKED TOO WET. (ORIGINAL.)

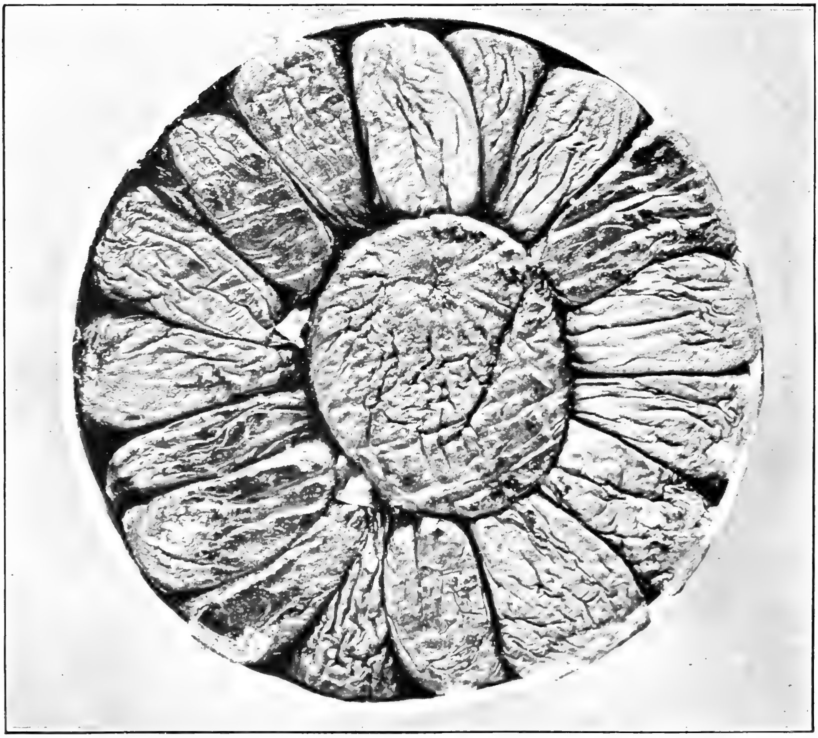
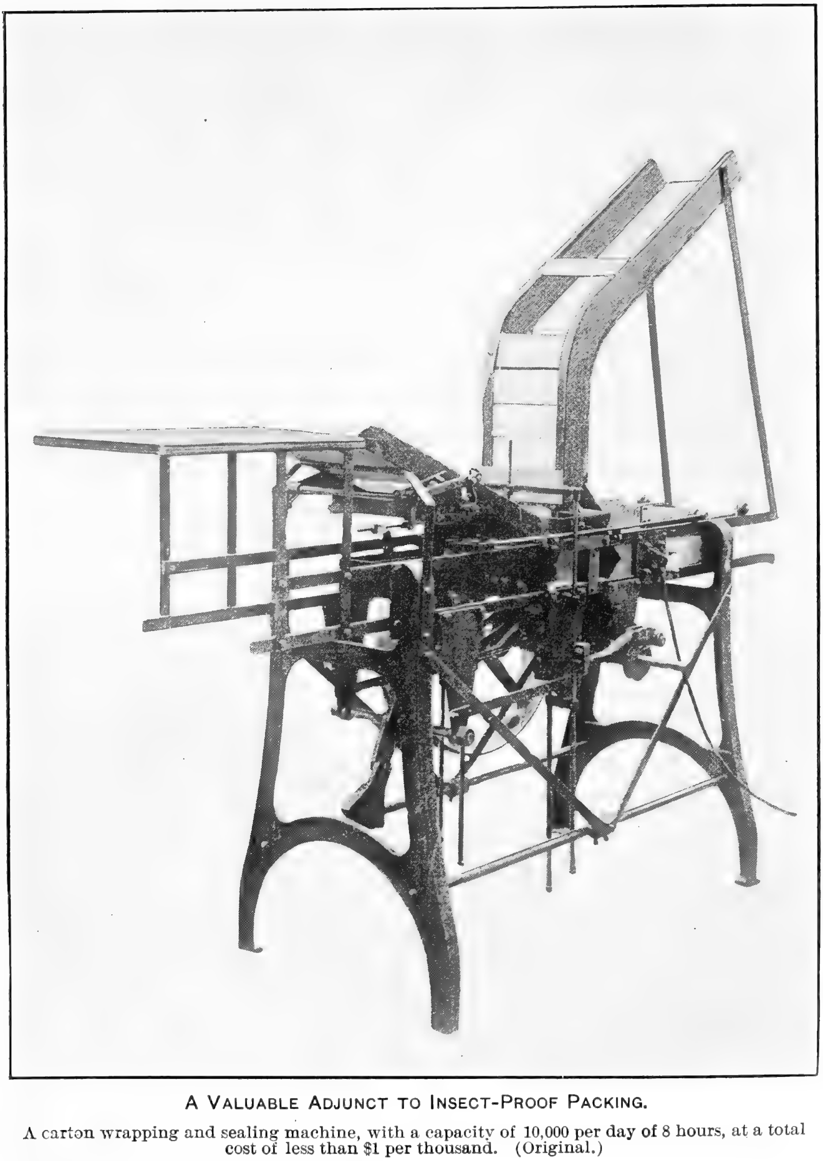


FIG. 2.—PERFECT CONDITION OF FIGS PACKED IN ROUND SEALED CARTONS. EXCESS MOISTURE REMOVED BEFORE PACKING. (ORIGINAL.)

PRESENCE OR ABSENCE OF MOLD IN SEALED CARTONS OF DRIED FIGS.



A VALUABLE ADJUNCT TO INSECT-PROOF PACKING.

A carton wrapping and sealing machine, with a capacity of 10,000 per day of 8 hours, at a total cost of less than $1 per thousand. (Original.)

all the surface moisture was gone. Lot No. 2 was dried in the sun a few minutes. Lot No. 3 was allowed to drain and cool thoroughly in the shade. Lot No. 4 was allowed to drain a few minutes and was packed while still hot and damp. All were packed in Mason jars, infected with spores from growing fungus, and sealed up.

On examination one month later no fungous growth was found to have developed on Nos. 1, 2, and 3, but No. 4, the lot which was packed wet and hot, had a very good growth of the fungus.

The experiment was repeated on September 1, dipping the figs in the hot water three minutes instead of one. On examination two weeks later it was found that in lot No. 1 no growth of fungus had developed. In lots 2 and 3 slight growths were present, and in lot 4 a heavy growth. The same figs were used in both experiments, and by the time they had been put through the boiling water the second time their surfaces were softer and stickier than they should be, and hence were good media for fungous growth.

These experiments confirm the earlier observations, namely, that figs thoroughly drained or dried and cooled before packing are less likely to develop fungous growth than those packed while still damp and warm.

A CARTON WRAPPING AND SEALING MACHINE.

Several machines are now being manufactured which do away with the slow and expensive method of wrapping and sealing cartons by hand. Such a machine is shown in Plate VII. The cartons are fed into the hopper at the top and the waxed paper is fed automatically or by hand. The machine wraps the waxed paper neatly and tightly around the carton and seals it air-tight by means of electrically heated plates. One operator is required when equipped with the automatic paper feed, and two without. This particular machine was made to wrap cartons 8 by 3 by 3 inches. It will wrap and seal a minimum of 25 to 30 per minute, or about 10,000 per day of eight hours. The cost based on this output, including the waxed paper, wrapping, sealing, power to operate, and wages of the operator, will be less than $1 per 1,000. The maximum output will be from 15,000 to 20,000 cartons per day, with a cost at this rate of from $0.80 to $0.90 per 1,000.

At present, by the hand-wrapping method, one girl will average 1,000 cartons per day. Thus the machine will easily do the work of a dozen or more girls.

The cost of hand-wrapping the package referred to is given as $1.75 per 1,000. Using the minimum output of the machine for comparison, the saving in one day's run would be over $7, at which rate the machine would pay for itself in less than four months, since it may be purchased capable of handling any size of carton desired by the purchaser at a retail price of about $600.

A machine of this nature would be available and practical not only for wrapping and sealing cracker and cereal cartons, but also for raisins, currants, figs, prunes, and all small packages of other dried fruits.

PREPARATION OF A STERILE PACKAGE OF DRIED FRUIT.

A description has been furnished of a method of preparing packages of cereals so that they will not become infested. This process is being successfully carried out by several large mills, the only real difficulty arising from the cost of sealing the carton. This objection is being gradually overcome.

The process consists in running the cereal through a sterilizer and then through a clean chute directly into an insect-free packing room, where it is packed in sterilized cartons and sealed. The writer believes that such a process can be applied to dried fruit, and the following suggestions are made to that effect:

In order to sterilize the fruit so far as insects are concerned it is necessary to heat it to 180° F. With the fruits which are regularly dipped in hot solutions this heating is readily accomplished, but in the case of those which are dipped in cold solutions before being packed the use of the belt heater described on pages 7–8 is suggested.

After sterilization by one of the foregoing processes the fruit must be protected from reinfestation, and the use of the screened packing room, a plan for which is shown on page 8, figure 3, and described below, will serve this purpose nicely.

The fruit should be run directly from the sterilizer or dipping vat into the packing room, where it is packed and sealed. It may then be removed to a warehouse, and if properly sealed it will not become infested by insects.

THE SCREENED PACKING ROOM.

A simple packing room (fig. 3) can be cheaply constructed by covering a light framework with lath, cloth, and paper. The windows, the floor, and all corners and joints should be made tight, and ventilation accomplished by blowing air through an opening covered with cheesecloth or No. 20 screen wire. Such a packing room can be constructed to admit plenty of light and air and still be free from insects. Whenever necessary the openings may be closed and the room thoroughly fumigated.

NOTE.—The writer has observed as many as 10 eggs of insects on the inside of a carton in a cereal mill. It is advisable, therefore, to sterilize all cartons before filling them. This may be readily done by placing a truck load in a heating chamber over night or during the day.

SUMMARY AND CONCLUSIONS.

The foregoing observations and experiments have brought out the following points:

A considerable financial loss due to the infestation of dried fruit by insects is experienced by packers, wholesale men, and retail dealers.

There are several species of insects which attack dried fruits on the Pacific coast, but of these the most common and destructive are the Indian-meal moth and the dried-fruit beetle.

Infestation takes place in the packing house, in the warehouse, and in the grocery store. The insects find their way to the fruit through small cracks in the boxes and between the folds of the paper.

All insect life is destroyed in fruits that are put through the boiling dip, and the processing of other fruits can be accomplished by the addition of the belt heater to sterilize all fruit so treated.

The use of an insect-free packing room and sterilized cartons or containers which are sealed before being placed in the warehouses or cars will protect the fruit from infestation unless the package is broken.

There are several cartons and methods of sealing that can be applied to dried fruit, but their cost will determine their practicability.

The secret of preparing an insect-free package of dried fruit is to sterilize it at a temperature of 180° F. and protect it from future infestation by the use of the insect-free packing room and sealing in sterile cartons or packages.

The sealed carton not only protects the fruit from infestation, but it prevents it from drying out and preserves it for long periods in the moist and attractive condition in which it was packed.

Moist fruit can be successfully packed in sealed cartons, provided attention is paid to the moisture content. The fruit must be carefully drained and must not be packed too hot.

Machines have been invented which will successfully wrap and seal small packages of dried fruit at a moderate cost per thousand.

It is probable that the time is coming when it will be as necessary to put up dried fruit in sealed packages as it is to pack cereals in that form to-day.

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