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# PLANT REQUIREMENTS FOR MANUFACTURE OF CAROB MOLASSES

TECHNICAL AIDS BRANCH

INTERNATIONAL COOPERATION ADMINISTRATION

Washington, D. C.

## FOREWORD

This brochure is one of a series of reports resulting from overseas technical inquiries on factory or commercial establishments, operation, management, and engineering. The report is designed to provide only a general picture of the factors that must be considered in establishing and operating a factory of this type. In most cases, plans for actual installations will require expert engineering and financial advice in order to meet specific local conditions.

Mention of the name of any firm, product, or process in this report is not to be considered a recommendation or an endorsement by the International Cooperation Administration, but merely a citation that is typical in its field.

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This brochure was prepared in September 1957 by the Wolf Management Engineering Company, Chicago, Illinois.

* * * * * *

For further information and assistance, contact should be made with the local Productivity Center, Industrial Institute, Servicio, or United States Operations Mission.

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# CAROB MOLASSES

## THE CAROB

Historically, the origin of the carob tree and its native habitat are lost in antiquity. It generally is accepted that the "locusts and wild honey" St. John, the Baptist, subsisted upon during his sojourn in the wilderness were, in reality, wild carobs; also, that the subsistence for the Prodigal Son referred to Biblically as "husks," was carob. The authenticity of this, however, is questionable.

The cultivated plant evidently had its origin on the southeastern coast of Anatolia and in Syria, and perhaps also in Cyrenaica. Its cultivation began within historic reckoning and was introduced into Greece and Italy by the Greeks and into northern Africa and Spain by the Arabs.

Commercial culture of the carob, while distributed more or less generally throughout the Mediterranean basin, is limited almost wholly to warm sections near the coasts and to the islands of the Mediterranean Sea which are particularly adapted to its culture. It also is grown to some extent on the Atlantic coasts of Portugal, Spain and in Palestine, Tunisia and Algeria.

The most important areas of commercial culture now are in Cyprus, Crete, southern Greece, Sicily, Sardinia, Majorca, Malta and areas of French Morocco.

In 1854, the carob was introduced into the United States in such subtropical areas as lower California, Arizona and southern Texas where climatic conditions were favorable. Its introduction, however, was not commercial but for decorative purposes. As in other parts of the world where environment was favorable, the tree was commonly grown as an ornamental, shade or avenue tree.

The tree belongs to the legume family and, like many of its species, bears a fruit similar to the locust tree. The pod-like structure is eight to ten inches long and one inch wide, flat, dark brown-black in color and contains seeds similar to a lima bean. These seeds are very uniform in size, so much so that in ancient times they were used as units of weight.

Some historians attribute the "carat" unit of weight for gems as having originated from this source.

The pods and seeds from the ordinary carob tree grown for decorative and shade purposes are of such poor quality that they are practically worthless from a commercial viewpoint and must not be confused with the cultivated type with which this report is concerned.

The Spanish called the tree "algarroba," and in the United States and Great Britain it is commonly called "St. John's Bread." The large pods and the seeds within them are quite rich in protein and sugar and in the more intensely cultivated areas are an important forage crop for livestock. They also are used for human consumption in times of other food scarcity.

## PRODUCTION

Cultivation of the carob is very definitely a seasonal business. The pods usually ripen in October and November. The tree itself attains a height of 50 feet, is evergreen and has a large diameter shade coverage. It is more resistant to cold than the average tree and will withstand winter temperature as low as 20 degrees, Fahrenheit. It is drought-resistant and thrives best in areas with 12 to 15 inches of rainfall. It does, however, require a near rainless ripening and harvesting season of approximately three months.

In the Old World, the carob is grown to a very limited extent in regular orchard formation and then usually in combination with grapes or other crops of small stature. It is more commonly regarded as a waste land crop, occupying the more or less stony slopes above the irrigated plains. Such areas are generally used for pastures.

In the United States, orchard formations are experimental, and only a few of these are now in existence. The tree is being cultivated, however, in desert areas and waste lands for the purpose of conserving and improving the soil and retarding soil erosion. Commercial development in the United States is nonexistent.

Orchard formation usually is patterned 30 feet on center, and fertilizing is generally not necessary, although the addition of one pound of

sulphate of ammonia to 400 gallons of water used to basin-water young trees the first summer after planting, stimulates growth and gives the young orchard a better start.

Despite the unusual sturdiness of the tree, it, like all plant life, has its pests, chief of which is the "pocket gopher," a small animal burrowing and living underground and especially fond of the roots. Likewise, orchards cannot be pastured until the trees are tall enough to be beyond the reach of cattle which especially like the leaves.

The finer varieties of carob are as follows:

| | |
|---|---|
| Roja Vera ) | |
| Nacho ) | Spain, Italy and Palestine |
| Castelano ) | |
| Bravie ) | |
| Banturia ) | Crete and Cyprus |
| Bolser ) | |
| Excelsior ) | |
| White ) | |
| Santa Fe ) | United States |
| Victoria ) | |
| Anaheim ) | |
| Horne ) | |
| Nichols ) | |

The cultivation of carob in the United States, as previously mentioned, is in the experimental stages. There are no commercial orchards in bearing from which figures on actual yields may be obtained. It is possible, however, to arrive at fairly reliable estimates by using yields of the small areas that have been working with the problem and by using the yields of certain yard and experimental areas.

The carob tree should begin to bear at the end of five years and at that time yield about five pounds of pods with seeds per tree. The size of crop per tree would increase gradually and at the end of the 12th year would reach an average of 100 pounds per tree. Normally, additional increase can be anticipated until the trees are full grown (25th year) when an average yield of 250 pounds per tree may be attained.

No figures are available on the limit of the productive life of the tree, but it is estimated that it is fully productive up to its 45th year, if given proper care. From then on, life begins to decline along with productive capacity.

With trees planted 35 to the acre, an expected yield of 8,750 lbs. per acre is the average. The trees, however, are alternate bearers (heavy one year, light the next), so this fact must be taken into consideration in any calculation. Many trees in proper locations, under suitable climatic conditions and with appropriate care, produce 450 to 550 lbs. per tree for several alternate peak years. Some trees reach this production peak the 18th year but this is the exception.

Commercial carob orchards, to be successful, must be planted with trees budded to continually improved varieties, and the fruits must be cultured toward the intended end usage commensurate with the markets involved.

Any appreciable increase in the development and production of commercial orchards will undoubtedly, in time, result in propagation of two or more varieties of the tree, one for all types of livestock feeding and the other for the seed to be used in the manufacture and processing of by-product derivatives for the various industrial and commercial products which can utilize the fruits of this tree of many talents. In the latter case, the pod, consisting mostly of sugars and the seed germ, which is high in protein, would be available as a fattening food for livestock.

Carob culture offers a profit motive as well as erosion control and soil conservation. However, any appreciable amount of commercial planting, aside from these and other industrial and commercial by-product uses enumerated elsewhere in this report, should be based upon use of the fruit as domestic animal food. This is especially true, unless the producer is prepared to assume the inherent risks in manufacturing, advertising and promotion of the many other uses.

Also, it should be recognized that the full amount of any higher returns through special products, of which there are many, are not likely to accrue to the grower unless he furnishes the capital for and controls the manufacturing enterprise.

The same is true of carob molasses, syrups and gums, and the prospective investor, before embarking on such an enterprise, is cautioned first to secure the services and advice of a reputable firm of consulting management engineers who would prepare a complete administrative, operational and financial analysis and projected plan of development commensurate with the local conditions involved. History in the United States reveals that during the past 25 years many investors suffered heavy losses because they did not take this precaution.

## USES AND CHARACTERISTICS

Since ancient times, the primary use of carob pods and seeds has been the feeding of livestock. Human food has always been a secondary usage.

Inasmuch as the commercial development of carob culture in the United States is nonexistent, the pods and seeds are imported. This import of pods and seeds by United States manufacturers and processing mills is small, since other leguminous crops, with similar commercial, chemical and industrial properties and resultant end usage, are more economical and readily accessible.

Further, the processing mills using the raw product do so only as a minor segment of their by-product or specialized industrial product business or as an addition to other raw materials in such end products as animal food pellets, processed fodders, etc., where a high sugar nutritive element is involved. Even these usages are limited, as evidenced by the following tabulation of three years' duty-free imports into the United States:

| Source | Pods and Seeds | |
|---|---|---|
| | Pounds | Dollar Value (FAS) |
| **1955** | | |
| Malta | 542,440 | $ 34,114 |
| French Morocco | 461,349 | 52,708 |
| Italy | 5,600 | 1,400 |
| Total | 1,009,389 | $ 88,222 |
| **1954** | | |
| Malta | 2,047,590 | $ 104,375 |
| Portugal | 1,119,937 | 74,800 |
| Algeria | 941,520 | 56,000 |
| French Morocco | 603,872 | 37,833 |
| Greece | 21,605 | 792 |
| Italy | 18,863 | 2,067 |
| Switzerland | 6,600 | 2,450 |
| Total | 4,759,987 | $ 278,317 |
| **1953** | | |
| Malta | 2,098,053 | $ 126,719 |
| Italy | 376,353 | 23,103 |
| Algeria | 285,717 | 17,313 |
| Greece | 250,045 | 20,961 |
| French Morocco | 77,500 | 4,450 |
| Portugal | 56,000 | 3,750 |
| Switzerland | 55,300 | 14,733 |
| Spain | 4,409 | 850 |
| Total | 3,203,377 | $ 211,879 |

Actually, the principal use by the United States manufacturers and processors is in the field of industrial chemistry in products such as those enumerated on pages 10 and 11.

Another factor which has affected the importation as well as the development of the carob commercially in the United States, is that during World War II when all kinds of importations were difficult, a fairly satisfactory substitute for carob gum was found in Manogalacton from the seeds of the guar plant. This annual leguminous plant (Cynopsis Tetragonolbus) (Taub) was grown commercially in Arizona and Texas as a field crop. Guar gum differs from carob gum in the proportions of mannose and galactose, having 32% anhydrogalactose and 59% anhydromannose. The practical value of this difference is still under investigation.

While the two gums are interchangeable for some uses and may be considered, to a certain extent, competitive, carob gum usually is preferred for use in food products.

The table on the following page illustrates the general composition of the carob pod and seed.

The chemical composition, of course, of both seeds and pulp of the carob varies considerably with variety and locality. The seeds have a higher nutritive value than the pulp, being 76.89 as against 58.7 (Kellner starch units per 100 kg). The residue pulp is almost entirely lacking in digestible protein. Further, both seed and pod are practically valueless as a source of vitamins.

All cultivated varieties of the carob fruit (pods and seeds) contain more sugar, by equal weight of raw material, than either sugar cane or sugar beets. Some varieties of carob contain twice as much. In the crystallized sugars obtained, no difference can be detected between carob and cane sugar. All attempts, however, to produce sucrose from carobs, by diffusion or extraction with water have failed. It does, however, very readily crystallize with the use of ethyl or methanol, and this latter process is now in use.

The reader is reminded that this report <u>does not</u> include the refinery process of the sugars but is confined to the acquisition of the raw syrup only.

## Composition of the Carob Pod and Seed

| | Water | Ash | Protein | Fat | Sugars | Nitrogen Extract Other Than Sugars | Crude Fiber |
|---|---|---|---|---|---|---|---|
| I - Carob pod and seeds (average 8 seedlings) | 12.28% | 2.57% | 6.75% | 2.17% | 29.52% | 38.80% | 8.29% |
| II - Carob seeds (average 6 seedlings) | 11.74 | 3.18 | 16.46 | 2.50 | - | 58.61 | 7.50 |
| III - Carob pods without seeds, water free basis (average of 17 seedlings) | - | 3.09 | 5.03 | 2.62 | 39.06 | 40.56 | 9.78 |
| IV - Horne variety, Oceanside, California, 1948 crop | 10.00 | 2.95 | 5.88 | 1.44 | 30.86 | 40.09 | 8.78 |
| V - Bolser variety, Vista, California, 1949 crop | 10.00 | 2.39 | 5.50 | 0.53 | 39.69 | 33.56 | 8.33 |

The average chemical analysis of the carob fruit is as follows (highly variable with variety and location):

| | Pod | Seed |
|---|---|---|
| Water | 11.50 | 11.74 |
| Ash | 2.72 | 3.18 |
| Protein | 4.50 | 16.46 |
| Ether extract | 2.37 | 2.50 |
| Fiber | 8.78 | 7.50 |
| Invert sugar | 11.24 | 10 - 20 |
| Sucrose | 23.17 | 20 - 34 |
| Nitrogen free extract | 36.30 | 58.61 |

The seed constitutes approximately 11%, by weight, of the fruit. Because of the extreme variations of the fruit in its chemical constituents, only general conclusions can be assumed on the breakdown by weight of the basic products obtained, namely, molasses or syrup, gum and pulp residue.

In one ton of the fruit, the following can be assumed for estimating purposes:

| | |
|---|---|
| Molasses (honey or raw syrups with sucrose or sugars still included) | 800 lbs. |
| Gum (dry powdered)* | 35 |
| Pulp (dried)* | 600 |
| Waste (dried)* | 265 |
| Evaporated and diffused moistures, skins of seeds, etc. | 300 |

Some mention should be made of a few of the various uses to which the carob is put in modern industrial and chemical fields. Obviously, it is not possible in this report to introduce the ramifications of all the methods and processes involved in obtaining these special by-products. They are shown herein as a matter of information to illustrate some of the uses of the carob.

1. From the pod

Human and animal foods and other uses:

1. Flour
2. Honey
3. Syrups
4. Sugars
5. Animal meals
6. Alcohol
7. Glucose - starches
8. Oils
9. Beverages
10. Confections
11. Pharmaceuticals
12. Coffee substitute

* These factors are highly variable, dependent upon by-product use. In many items, much of the waste is used as well as the molasses, gums and pulp.

2. From the seed

Note: Surrounding the endosperm of the seed is a layer of gum or manogalaston (Fragasol) resembling mucilage in the manner of forming gels. It is polysaccharide composed of D-galactose (20%) and D-mannose (80%).

The carob gum, although of considerable commercial importance, is still controversial between processors and users when its chemical analysis is questioned. Also, there is considerable variation between countries in nomenclature applied. In several areas of the world, carob and locust are considered the same. For example, designated native names applied to the gums are as follows:

| Name | Place of Origin | Type | Classification |
|---|---|---|---|
| Carob and seed | South Europe, North Africa, Mediterranean | Ceratonia | Locust |
| Gatto | " " " " | " | " |
| Hevo | " " " " | " | " |
| Jandagum | " " " " | " | " |
| Lakoe | Africa, South Europe, Mediterranean | " | " |
| Locust bean | " " " | " | " |
| Lupogum | " " " | " | " |
| Luposal | " " " | " | " |
| Rubigum | " " " | " | " |
| St. John's Bread | " " " | " | " |
| Swines | " " " | " | " |
| Tragon | " " " | " | " |
| Tragasol | " " " | " | " |

Chemically, the gum from the carob or locust is classed among the so-called water-soluble gums, though this designation is a misnomer in many ways. Such gums as arabic, ghatti, karaya, agar, quince, carob and locust fall within this class. Actually, the gums are not soluble in the strict scientific sense as salt, sugar and other crystallizable materials are soluble and are not crystalloids at all, but colloids. They do not show crystal form but, in a strict sense, are amorphous in that they do not have melting, freezing or boiling point characteristics.

In the manufacture of carob gum, the skin of the seeds is removed either chemically or by rollers which turn in opposite directions. This is followed by roasting, boiling in water, filtering, evaporating of the liquors, pulverizing and packaging of the dried gums. The seed represents about 10% of the weight of the entire pod.

Imports of carob seed gum (Tragasol) into the United States amounted to more than four million pounds in 1939 and to approximately seven million pounds in 1948. Since that time, they have declined due to the substitutes found, such as those mentioned on page 6 of this report.

The seeds contain a central hard, brittle and comparatively large layer of white, semi-transparent endosperm, which is the source of the gum. The endosperm is surrounded by a tenacious dark brown husk.

Successful production of the gum involves separation of the endosperm from the embryo, and the quality of the germ (i. e., whiteness and freedom from brown specs) depends on efficient removal of the outer husk or skin. As mentioned above, this is removed by either chemical attack or mechanical abrasion.

Then by an ingenious mechanical process, the dehusked kernels are split lengthwise and the embryo separated from the germ by taking advantage of differences in hardness and friability of the two components. Presence of the yellow embryo in the gum increases the rate of fermentation of the gum solution, and its removal, therefore, is important.

Finally, the gum is powdered and graded according to its particle size and color. The yield of gum approximates 35% of the weight of the kernel

The gum portion is then ground into a powder between 100 and 300 mesh. As a thickening agent, it is about five times as effective as starch.

The following are uses for carob seed gum:

(a) Human foods

Cheese spreads, ice cream and frozen desserts, salad dressings, chocolate milks, mustard, pie fillings, sausage and sausage casings, etc.

(b) Industrial usage

Textiles - Printing pastes, warp sizes, finishing.
Cosmetics - Wave set lotion, hand lotion, creams.
Leather - Finishing, tanning.
Pharmaceuticals - Laxatives, pills, lubricating jellies, shaving cream, tooth paste.
Rubber latex - Creaming and thickening agent.
Photographic film - Emulsions.
Matches - Head binder, striking binder.
Paints - Water emulsion paints.
Inks - Lithograph, writing.

Polishes - Metal polishes, liquid automobile polish, liquid shoe polish.
Ceramics - Binder, plasticizer (bricks, porcelain, tile, pottery).
Petroleum - Drilling mud.
Adhesives - Mucilage, hand paste ingredient.
Miscellaneous - Sanitary napkins, flotation agents, boiler compounds, insecticides.

From the foregoing, it is obvious that the carob fruit can be broken down into many uses and factors. The following economic analysis, however, is confined to utilization of the fruit in producing syrup or molasses from the pods, with the seeds and residual pulps bulk-marketed to the user or subsequent processor. Any other ramification heretofore mentioned would, of course, require separate reports.

## MOLASSES OR RAW SYRUP PROCESSING

To facilitate clarity in the mind of the reader, it should be mentioned that molasses as an industry (of which carob could be no part) is (a) a by-product of sugar mills, (b) an adjunct of animal feed producing or mixer mills, and (c) one source of basic raw material in the production of ethyl alcohol. In all instances, molasses, regardless of its source or origin, is considered as a part of either the sugar, feed mill or ethyl alcohol industry.

In reality, "industrial molasses" encompasses blackstrap molasses (the remaining liquids after removal of as much sugar as possible from the cane), beet molasses (similar by-product of beet sugar), hydrol (corn), citrus molasses, and others.

Despite the decline of molasses usage in making ethyl alcohol due to synthetic developments, the molasses industry today is prospering, not only because of the increase of molasses in animal feed (from 75 million gallons in the United States in 1946 compared to 400 million gallons consumed today) but also because of the many products in which molasses is used.

It should be made clear that carob molasses cannot be considered as "industrial molasses" in the same sense as blackstrap molasses, beet molasses, hydrol, etc. Carob molasses is used chiefly as an ingredient in human and animal food. (See other uses under "1. From the pod." page 8.)

In this report, consideration is given to a modern plant of modest capacity which would most likely be applicable to the average economic location where carob is grown and harvested on a limited commercial basis.

As previously mentioned, due to the absence of specific data as to objectives, end usage, etc., certain assumptions must be made for this report. First, it is assumed that the basic production is carob molasses or syrup with sugars or sucrose still remaining in the raw liquid. The processing of gums from the seeds and other products from the residual pulps is not considered here and would require specific reports, particularly if the refined sugars, gums and residual usable pulp are to be considered end products.

This report is based on a daily processing capacity of 21,875 lbs. of unhulled pods. This would accommodate the average annual yield of 8,750 lbs. per acre from 300 acres, with the mill operating on the basis of 120 days per year, 24 hours per day.

There are 10 major considerations to be studied in planning a new processing plant:

1. The plant should be located in as close proximity to productive acreage as possible or where the flow of raw material to the plant from the harvesting areas entails the minimum of time delay and transportation costs in reaching the plant.

2. The plant should be housed in facilities of minimum size to keep the capital investment as low as possible.

3. Ingress and egress factors of transportation in relation to classes and types of markets served are also important elements of plant location, for distribution and units of sale of the finished molasses or syrups are by 1,000 to 4,000 gallon tank trucks, 55-gallon drums, or 5-gallon tins, to animal feed producers, mixing mills, farm users, or industrial and chemical refineries.

4. The plant should be located in an area where producers of the raw fruit (these would be small acreage producers) could deliver their product to plant site and have their deliveries paid for at time of inspection, grading, and weighing in.

5. Sanitation problems must be minimized.

6. Storage facilities of the raw fruit must be of a type to insure maximum control of moisture content and protection from heat, rodent, pest, disease, and mold.

7. Economy of power, water and fuel consumption must be considered.

8. Service factors of equipment must be high because the processing plant would be required to operate continuously on a greatly restricted operating cycle, for it is not considered economical to store the raw materials over any extended period of time. Shut-downs due to breakdowns could be more costly than the original price of a piece of equipment.

9. Off-seasonal maintenance is mandatory in plants of this type.

10. Automatic features should be incorporated to the greatest extent possible to further insure continuity of operation.

Cost data presented on subsequent pages of this report are based on the following assumptions:

1. The mill processes 21,875 lbs. of unhulled pods daily.

2. The processing plant operates 120 days per year, 24 hours a day.

3. Storage facilities will be constructed to accommodate a maximum of 30 days' supply of pods, or approximately 10,000 bushels. The storage structure should be of twin design, with one 5,000-bushel bin being filled by deliveries from the producers while the other is supplying the mill.

4. An expenditure of approximately $12,000 will be required to house the processing plant.

5. Power, water and other utilities are available locally.

## Processing Operations

Processing involves the following operations:

1. Storage
2. Cleaning and drying
3. Hulling or shelling
4. Separation
5. Molasses or syrup extraction
6. Seeds
7. Residual usable pulp
8. Packaging or container handling, warehousing and shipping

1. Storage

Obviously, the orchard production nature of carob precludes it being available from one centralized area or farm. As mentioned previously, it would be moved to plant site from various small acreage producers.

Generally, the producers would haul their harvest in open vehicles to the plant, and at harvest time this movement would be rather heavy. Therefore, adequate raw material storage facilities must be provided.

The principal factors which must be considered in relation to storage facilities are infestations from rodent, insect and fungi. Maximum control must also be assured in relation to moisture content, and storage facilities should be dust-proof and well ventilated.

Assuming the mill processed 21,875 lbs. of unhulled pods daily, it would utilize 2,625,000 lbs. of pods during a 120-day season. Converting this to the bushel unit of measurement, and on the assumption that storage facilities would be filled approximately five times in a plant operation season, a storage capacity of 10,000 bushels would be adequate.

In terms of the physical facilities necessary, whether they be of concrete, steel or wood, silo, flat or bin type, including simple auxiliary mechanized equipment for receiving, elevating or conveying, and moisture control, this would cost $0.65 to $1.25 for each bushel stored.

Steel and concrete type storage construction does permit the maintaining of better rodent and pest control, is easier to clean and requires less maintenance. Bulk storage can also be accomplished by flat storage structures, in lieu of silo or elevator type construction, or in buildings containing sheet metal bins.

The foregoing should give the reader the relative factors to consider in relation to storage requirements, location and crop availability.

Fumigation would not ordinarily be required, but some fumigation in certain areas might be economically advisable at such intervals when each major quantity stored is moved out.

## Buildings

The building for the type of mill described herein can be a one-story structure, preferably of sheet metal on wood or steel frame with concrete floor, approximately 40 ft. × 60 ft. in size. Regardless of the type of building used, the principal considerations are cleanliness, efficient equipment placement, and operating and storage housing that is rodent, insect and moisture protective to as great a degree as is economically feasible.

2. Cleaning and Drying

Generally, when the fruit is brought to the mill it is already field or sun dried, for it is allowed to ripen and dry "on the vine," so to speak, and harvested during dry seasons. Usually, it ripens, dries and falls to the ground from the trees before it is gathered. Nevertheless, some mill cleaning and drying operations are frequently necessary.

In some areas of the world, the delivered pods are spread on canvas or concrete platforms and allowed to thoroughly dry in the sun the same as coffee. However, for the quantity proposed, the mill could economically provide hot air blast drying as the pods come from the main storage facilities to hoppers within the plant and immediately prior to their delivery to the hulling and shelling machines. The extent of drying, however, is not a high temperature operation.

3. Hulling or Shelling

In this operation, the thoroughly dried pods are passed by conveyor from the dry storage hoppers direct to the huller or sheller machines. These machines operate on the same principle as a lima bean huller and separate the pods and seeds.

4. Separation

The machine consists of a rotating cylinder equipped with internal baffles and drum operating in opposite direction to the outside cylinder. The dried pods are subjected to just enough crushing action to fracture the hull and release the seeds. The seeds are carried to an opening where they drop into storage hoppers, fed into sacking equipment, and sold to subsequent gum processors or in some instances sack stored, depending upon marketability. The pods are carried to the end of the machine where they also enter hoppers, from whence they are conveyed to the pulverizer machine.

In some agricultural areas, the pods and seeds are separated by hand or through the use of regular combine or threshing machine equipment. Generally, such equipment is portable, and the separation is done at harvest site.

5. Molasses or Syrup Extraction

Carob syrup or molasses is made by reducing the dried pods (without seeds) to coarse powder, dissolving the sugars with water and then boiling the solution down to the thickness of honey. The syrup has a good color and high flavor. In some instances, the powdered carob is

sold as straight carob and subsequently mixed with wheat or other grain products in breakfast foods. Powdered carob is generally sold to health food stores. The percentage of fibers remaining in the powders is highly variable and too high for most stomachs. The pure powders are very light in color, very sweet and their fiber content is small. These powders are generally used in confections.

As previously mentioned, this report is concerned with the manufacture of the syrups or molasses only, with the sugars or sucrose still remaining in the raw liquids. The pods, therefore, would come from the hulling or shelling machine to a pulverizer or grinder where they are powdered. The powders and coarser fibers are separated in a sifting operation similar to flour mill sifting. Actually, this is a milling operation except that a much lesser degree of fineness is required.

The coarse powders thus derived are conveyed from the sifters to the dissolving tanks and cookers where the syrups are made and from whence the syrups are pumped to storage tanks or direct to shipping drums or tank trucks as the case may be.

6. Seeds

The seeds are generally sacked and stored for shipment to gum processors and extractors. The economics of this report is based upon the seeds being sold direct to outside processors. A separate report would be required to cover the processes involved.

In storing the seeds, precautionary measures should be taken to prevent deterioration and infestation.

7. Residual Usable Pulp

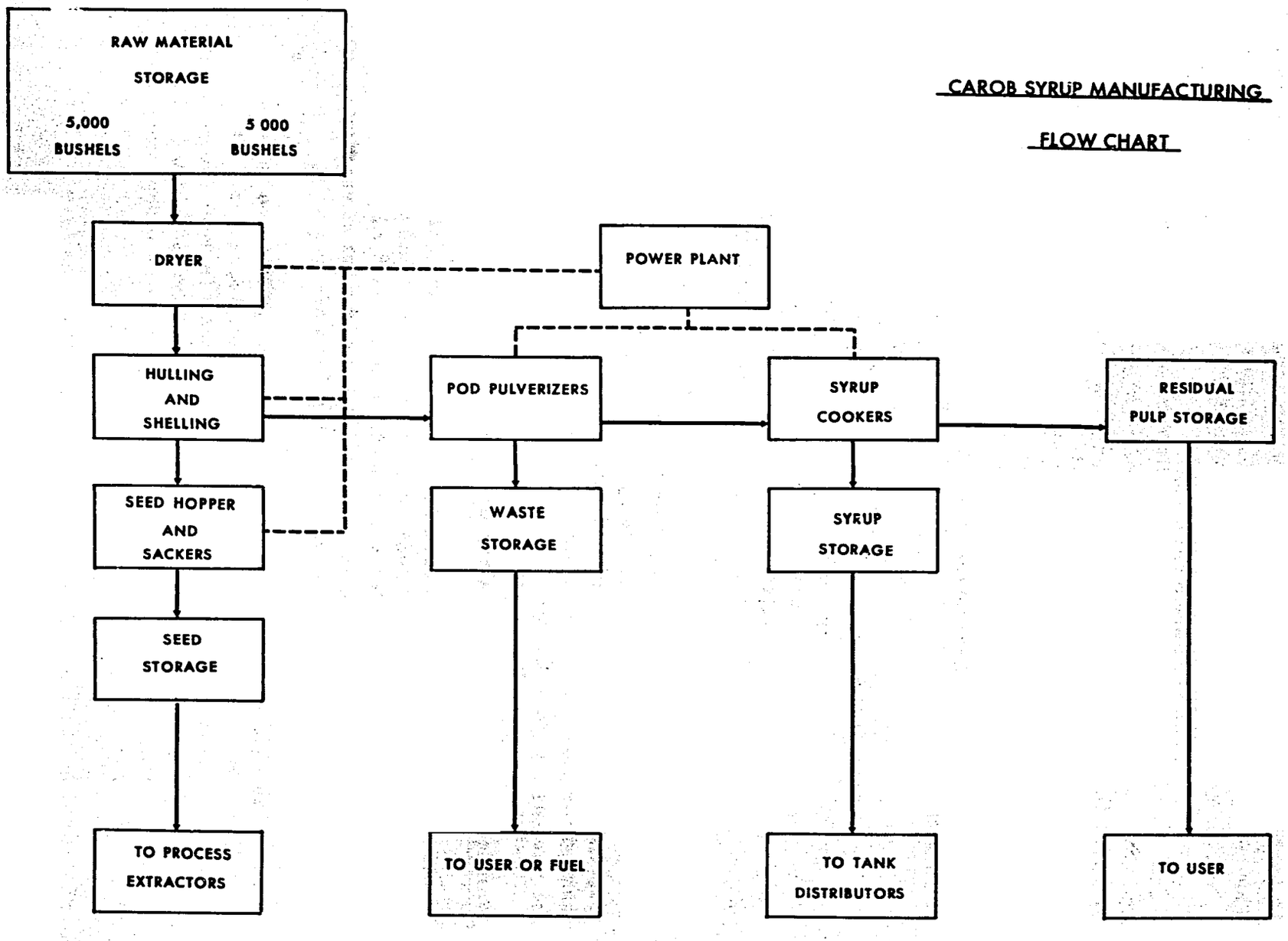
The pulps derived from the pulverizer, sifter, and syrup operations are not of much commercial value and are generally used as a roughage compound in other feeds for animal consumption.

8. Packaging or Container Handling, Warehousing and Shipping

The variables in these operations are such that it is difficult to do other than make certain assumptions based upon the estimated quantities of syrups, seeds and pulps that would be derived from one ton of the fruit. Based upon processing 21,875 lbs. of pods per day, the resultant syrups would equal approximately 1,047 gals; seeds would equal 2,400 lbs.; and residual pulp, 6,500 lbs.

## CAROB SYRUP MANUFACTURING

## FLOW CHART



In view of these variables, it is further assumed that tank storage should be provided for approximately 50,000 gal. of syrups and shed storage for approximately 1,500 one-hundred-pound sacks of seed. The residual pulp would be siloed, sold in truck quantities from stock piles, or burned as fuel if excess in quantity.

Further, the syrups would be sold direct to tank car or truck distributors. The seeds would be sold direct to gum processors or extractors in one-hundred-pound sacks, and the residual usable pulps would be sold to animal feed producers, mixing mills, farm users or industrial and chemical refineries, or simply burned as fuel where excesses are not disposable.

The flow chart on the preceding page illustrates the progressive steps in processing.

## ECONOMICS

In considering the relative economics of carob syrup manufacturing, there are many related factors to study. Costs are entirely relative, varying with location, availability of raw materials, climatic conditions, type and class of labor, transportation facilities, marketing of end products, etc.

This report, therefore, is based upon assumptions that raw materials are available in abundance and easily accessible; that the extent of processing involves production of raw syrups only; that seeds are to be sacked for sale to outside processors; and that residual pulps are to be used as indicated above.

### Storage Elevators and Auxiliary Equipment

Some 43,500 bushels of the carob fruit are needed annually to process 21,875 lbs. of unhulled pods per day. Assuming that the fruit is purchased under contract from the small acreage orchard producers, and that the harvest is variable and is delivered to the plant at varying intervals, it is estimated that a 30-day supply is adequate.

The storage structures should be of twin design. While one is being filled, the other is supplying the mill in alternate sequences. This would mean that twin 5,000-bushel storage structures would be adequate. Concrete, steel or wood construction would cost from $0.65 to $1.25 for each bushel stored. On this basis, calculation would approximate 10,000 bushel × $1.00 (average), or $10,000.

## Raw Material Requirements

Carob fruit is currently selling for approximately $4.00 a bushel. Since projected operations call for an annual usage of approximately 43,500 bushels, the annual cost of the fruit consumed in process would be $174,000.

## Building Requirements

In temperate zones, the building cost would be nominal. The building required would be used to enclose equipment which would be harmed by open installation and could be of the type described on page 14. Such a structure would cost approximately $10,000.

An additional structure of similar design would be required for salable seed storage and would cost approximately $2,000. Proper design and layout would permit both structures to be combined into one.

## Equipment Requirements

| | |
|---|---|
| Raw storage scales | $ 1,000 |
| Dryer and hopper | 1,500 |
| Hulling and shelling machines | 6,800 |
| Hopper and sackers | 2,200 |
| Pulverizers | 4,000 |
| Cookers, liquidifiers and dissolving tanks | 10,000 |
| Pumps and motors | 3,800 |
| Syrup storage tanks | 10,000 |
| Agitators | 2,000 |
| Pulp storage (silo type) | 4,600 |
| Clarifier | 2,000 |
| Conveyors | 4,100 |
| Power plant (complete) | 13,000 |
| Control devices and mechanism | 3,100 |
| Scales | 700 |
| Cyclone blowers and dust storage | 2,450 |
| Total | $ 71,250 |

## Direct Labor

Direct labor required for three-shift operation on basis of 120 days per year is as follows:

| | Annual Labor Cost |
|---|---|
| Raw storage elevator and receiving (1 man per shift @ $1.25 per hour) | $ 3,600 |
| Dryer, hulling, shelling, seed sacking and storage (2 men per shift @ $1.25 per hour) | 7,200 |
| Pulverizing and cooking operations (1 man per shift @ $1.25 per hour) | 3,600 |
| Total | $14,400 |

## Indirect Labor

| | |
|---|---|
| Power plant operation and maintenance | |
| (1 man, day shift, @ $1.75 per hour) | $ 1,680 |
| (1 man per shift, 2 shifts, @ $1.50 per hour) | 2,880 |
| General Manager - Supervisor | 8,000 |
| Stenographic, office and accounting (1 man) | 3,000 |
| Maintenance (12 months) (1 man, day shift, @ $1.25 per hour) | 2,700 |
| Total | $18,260 |

## Selling, General and Administrative Expense

| | |
|---|---|
| Sacking, general supplies | $ 1,100 |
| Electricity and power | 4,000 |
| Selling expense | 20,000 |
| Total | $25,100 |

## Sales Revenue

The yield figures after extraction process is completed would approximate:

| | |
|---|---|
| Syrups - 134,000 gals. @ $1.75 | $ 234,500 |
| Seeds - 288,000 lbs. @ $0.12 per lb. | 34,560 |
| Residual pulps - 780,000 lbs. @ $0.02 per lb. | 15,600 |
| Total annual sales revenue | $ 284,660 |

## Estimated Working Capital

| | | |
|---|---|---|
| Inventory: | | |
| Raw materials (1 month) | $ 43,500 | |
| Work-in-process | -- | |
| Finished products (5 days) | 11,860 | $ 55,360 |
| Direct labor (1 month) | | 3,600 |
| Indirect labor (1 month) | | 4,565 |
| Selling, general and administrative expense (1 month) | | 6,275 |
| Total | | $ 69,800 |

## Estimated Fixed Capital

| | |
|---|---|
| Land | - - |
| Storage | $ 10,000 |
| Building | 12,000 |
| Equipment | 71,250 |
| Total | $93,250 |

## Estimated Total Capital Requirements

| | |
|---|---|
| Working capital | $ 69,800 |
| Fixed capital | 93,250 |
| Total | $163,050 |

## Projected Profit and Loss Statement

### Six Months Operation Per Year

| | | |
|---|---|---|
| Net sales | | $ 284,660 |
| Less cost of goods sold: | | |
| Raw materials | $ 174,000 | |
| Direct labor | 14,400 | |
| Indirect labor | 18,260 | 206,660 |
| Gross profit | | 78,000 |
| Depreciation: | | |
| Elevator (3%) | 300 | |
| Buildings (5%) | 600 | |
| Equipment (10%) | 7,125 | |
| Total depreciation | 8,025 | |
| Selling, general and administrative expenses | 25,100 | 33,125 |
| Net profit (before taxes, insurance and miscellaneous expenses) | | $ 44,875 |

## CAROB CONSULTANTS

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Scott-Viner Co., Columbus, Ohio
Chisholm-Ryder Co., Niagara Falls, New York
Wolf Management Engineering Company, Chicago, Illinois