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DEPARTMENT OF BACTERIOLOGY.

OREGON AGRICULTURAL EXPERIMENT STATION,

CORVALLIS, OREGON.

Notes on Vinegar Making.

By E. F. PERNOT.

The Bulletins of this Station are sent Free to all Residents of Oregon who request them.

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NOTES ON VINEGAR MAKING.

As the prune industry in this state develops, growers realize that there is an increased amount of prunes, which through many causes, become unfit for drying purposes, prunes which are over ripe, and those bursted open, under sized prunes, and unsaleable ones, all go to make up a large product which is annually wasted. The utilization of waste products goes far towards defraying the expenses of raising the crop. With this in view, an experiment was begun September 25th, 1901, in making vinegar from the waste prunes which were rejected for drying at the experiment station. No prunes were used that were in any way decomposed. The first problem that arose, was, how to extract the clear liquid, the prunes being of such peculiar structure that the juice could not be extracted by pressure, without being thick and turbid. In order to overcome this difficulty a vat was constructed of the following dimensions, which answered the purpose admirably, although it was too large for the amount of prunes available.

The foundation of the vat consisted of cross pieces 3 feet 10 inches long varying in heighth from 8 in. to 13 inches which gave an incline to the tank bottom, to these cross pieces fir flooring was toe-nailed and the joints were painted with thick white lead, the surface was painted and a second floor laid on top in a similar manner, making a double floor, water tight, 13 ft. 2 in. long, 3 ft. 10 in. wide. Near the edge of this floor, a strip 1x2 inches was leaded and nailed all around except at the lower end, where two strips were nailed diagonally so as to form a spout. A second strip 2x4 was fastened to the floor two inches inside of the outer one, so as to form a gutter between the two, instead of nailing it tight to the floor it was provided with thin cross strips at intervals of about eight inches so as to allow the liquid to pass into the gutter. On the inner side of this strip, flooring four feet long was toe-nailed in an upright position, but before nailing, a strip of burlap about two inches wide was placed between the ends of the boards and tank bottom so as to form a filter. Midway up and at the top, the sides were toe-nailed to frames of 2x4 material, thus forming a strong tank free from obstructions inside. No nails were allowed to be exposed nor to come in contact with the prunes or juice.

On the top of the vat, a large hopper was constructed provided

at its lower end with a large wooden roller in which were driven nails projecting about three-fourths of an inch from its surface, a crank was fastened to the end of the roller and allowed to extend across the outside of the vat.

The prunes, after being washed and weighed, were put into the hopper, and by turning the crank they were torn and passed to the vat below. After several bushels of prunes had accumulated in the vat, they were inoculated with a pure culture of yeast *saccharomyces cerevisia*, which caused a strong and rapid fermentation, the cell walls of the prunes were thus broken down, liberating the clear juice, which poured into the receptacle below the vat. The object of lacerating the prunes with the spiked roller, was to allow the erment to more readily destroy the cell walls. This method of extracting the prune juice was inexpensive and perfectly satisfactory. In this experiment 10,482 pounds of Italian prunes was used, from which 630 gallons of juice was obtained, a yield of over three gallons per bushel, greatly exceeding expectations.

As the prune juice was collected, it was emptied into open barrels and there allowed to remain undisturbed for ten days, when fermentation ceased. An analysis at that time showed ten per cent alcohol.

After the liquid in all the barrels had ceased fermenting, a pure culture of acetic acid germs, *bacilli Pasteuranum*, which had previously been prepared in the laboratory, was floated on the surface of the liquid by the aid of thin pieces of cork, weighted, so as to bring the culture in contact with the liquid, in course of time a delicate scum spread over the entire surface of the liquid and the formation of acetic acid began. Every month the material was tested for acetic acid and was found to vary considerably although the barrels were kept under similar conditions, the highest test at the present time is 3.43 per cent acid.

At the same time that the prune juice was placed in the barrels, several half-gallon jars were filled and kept in the laboratory; one jar in which the liquid has evaporated to a considerable extent tests as high as 8.59 per cent acid, and another one tests 6.73 per cent; this was due to the volume of material being smaller than in the barrel, and the temperature higher. The barrels were left in the dryer until the latter part of October, when it was found that the formation of acetic acid had almost ceased, owing to the low temperature, they were then moved to the cellar of the horticultural

building where a warmer atmosphere prevailed. The progress of vinegar making was thus very much impaired by the liquid having been disturbed; as the barrels had no heads, it was necessary to use the syphon in conveying it from the barrels above ground to those in the cellar, consequently the cultures which had formed a scum on the surface, were destroyed, necessitating a reinoculation to form a new scum. The vinegar is of an excellent quality, possessing a fruity flavor, it has a good body, analyzing 6.87 per cent total solids, and the only objection that can be raised is to the color, which is that of very dark wine.

There can be but little objection to its color however, since it is but little, if any, darker than the imported malt vinegar which finds ready sale in our markets, and it is probable that some way will yet be found to clarify it and reduce the color. Experiments are now in progress for making vinegar from Petite prunes, and from Italian prunes from which the skins were removed, to see if the dark color could be obviated. A new vat was constructed on the principle of the old fashioned ash leech and it is found to work very satisfactorily.

It is perhaps not out of place here to give a brief description of the formation of vinegar (acetic acid) from fruit juices.

To obtain the best results, or highest per cent of acetic acid from fruit, it should be fully ripened so as to contain the maximum amount of saccharine matter, this is first acted upon by ferments, which find it a suitable material to grow in, and in so doing the sugar is consumed, being split up into other elements, the principal one being alcohol, carbonic acid gas being liberated at the same time, passes away, leaving a liquid composed of water, alcohol, organic and mineral solids; the amount of alcohol varying according to the amount of saccharine matter in the fruit juice. After the alcoholic fermentation takes place, other organisms find the material conducive to their development, and begin their activities. They consume alcohol, converting it into acetic acid. It is absolutely necessary that these organisms have unobstructed access to all the air that they desire, or oxidization through their activities will be impaired. Therefore a barrel filled with fruit juice and bunged can not form vinegar as rapidly as one half filled, and with the bung taken out.

It is the habit of many people to fill a barrel with cider which they intend for vinegar, and in place of the bung, to insert an empty

quart bottle in the bunghole. This is not only useless, but detrimental, as it excludes the organisms necessary to form vinegar and shuts out the air which is requisite for those which may already happen to be in the liquid.

There is a small yellow fly, *Drasophila ampelophila*, commonly known as pomace fly, vinegar fly, and drunkards, which frequent the vicinity of vinegar barrels and decomposing fruit. They are instrumental in carrying from place to place the acetic acid germs and ferments, doing more good than harm to material which is intended for vinegar. This was demonstrated in the laboratory in the following manner: Some of these small flies were caught by the wings with sterile forceps while they were at work on the open barrels of prune juice, they were conveyed to the laboratory and liberated under the cover of shallow dishes which contained sterile culture media, and there allowed to remain long enough to walk several times across the surface of the material, and then liberated; the dishes were then placed in an incubator for twenty-four hours, after which time there was a visible growth of acetic acid germs where their feet had touched the media. The bodies of these flies were then taken and crushed between a microscope slide and cover glass, and examined under a high power microscope; it was found that the digestive tract contained an immense number of acetic acid germs, and yeast plants, which the fly had taken up with its food. In order to determine whether the organisms had lost their vitality in passing through the digestive organs of the fly, several flasks of fresh cidar were sterilized, the flasks were provided with the usual cotton plug, with the exception of having a small glass tube passing through the center, which was also plugged with cotton at its outer end. When all were perfectly sterile, flies were caught under aseptic precautions, and one fly dropped into the liquid of each flask through the small tube, the plugs were replaced and the flasks placed in the incubator, after remaining there for forty-eight hours, a fermentation had taken place and they were removed to the temperature of the laboratory. After eight months the flasks were opened and the material tested for acetic acid, one flask testing as high as 3.29 per cent acid, a fairly good vinegar, the other flasks were of a lower percentage. A check flask was prepared in the same manner as the others, with the exception of not being inoculated with a fly and being kept under the same condition, it remained sterile.

While it appears that the pomace fly renders a valuable service in inoculating fruit juices with the necessary germs for producing vinegar, they are also apt to carry spores of moulds and other organisms, which impart a bad odor or taste to the finished product.

Therefore instead of relying upon accidental inoculations, vinegar of standard taste may be produced by using cultures of selected ferments, in the same manner as the flavor of wine and beer is controlled by the manufacturer. In the bacteriological laboratory of this station, pure cultures of the acetic acid ferments are constantly kept on hand, and will be furnished to anyone in this state upon application.

Most of the pure fruit-juice vinegars, contain *angnilla aceti*, commonly known as vinegar eels, which are large enough to be seen with the naked eye, and resemble eels both in form and movement. They are a detriment to the vinegar inasmuch as they consume the material, and at death sink to the bottom of the receptacle, where, if they decompose, unpleasant odors and tastes are imparted to the product in consequence. It is difficult to prevent their entering the material and still more difficult to remove them when established.

Fruit juices, especially apple cider, contain a certain amount of albuminous matter, which, as the acetic acid fermation increases, becomes coagulated, forming a scum which gradually thickens as it becomes older, if one surface of this is exposed to the air, it dries and becomes a leathery mass familiarly termed, "mother of vinegar," it contains an immense number of the acetic acid germs, and is useful in inoculating fresh material which is to be converted into vinegar.

The process of making vinegar for home use, or even for market, is simple and quite within reach of everyone, the first requisite is to have perfectly clean barrels or vats. This may be accomplished by thoroughly scalding several times with boiling water or live steam, so as to destroy the spores of moulds which may be present. Well ripened fruit should be used, because it contains a greater amount of sugar, and will yield a higher per cent of acetic acid. Fruit that is decomposed, should not be used. After the juices have been obtained and emptied into the receptacles, dissolve a yeast cake in a small amount of liquid, pour it into the mass and thoroughly stir with a clean stick, a strong fermentation will soon take place which should be allowed to continue undisturbed until

it ceases of its own accord, then procure some "mother of vinegar" from a sample which suits the taste, or a pure culture of acetic acid germs, and float it upon the surface of the liquid by means of a few clean straws, and leave undisturbed in a warm place. A delicate scum, which must not be broken, will soon form on the surface of the liquid. The rapidity of the transformation to vinegar will depend upon the temperature at which the material is kept. A temperature of 80 degrees F. will give the most rapid results.

Apple vinegar has been made in this manner at the station, which, in four months, yielded a delicious tasting article, that tested six per cent acetic acid, and five gallons of vinegar from pears made last year, in five months, tested 8.89 per cent acetic acid. This was strong enough to be diluted one half with water, and still be stronger than the law of this state requires, which is four per cent. To recapitulate—there are several conditions to be considered in making vinegar in this way. The barrels must be free from must and mould, the depth of the liquid should not exceed the surface measure, free air must be continually admitted, an even, warm temperature should be maintained and, last but not least, the fruit that is used should be free from decay and mould.

There is no reason why all the fruit which annually goes to waste in this state, cannot be made into good, wholesome vinegar for our home consumption and for export trade, instead of importing an unwholesome article, made from distillery refuse, which floods our markets. Not only would it become a source of income, but it would remove from our orchards material which decays and becomes an asylum for insect pests and fungus diseases.

There are other methods of making vinegar from fruit juices, *i. e.* with generators, which are much more rapid in their action. The principle is simply to expose to the air broad surfaces of liquid to increase the action of oxidization through the activities of acetic acid ferments. Any device so constructed, as to allow a small stream of inoculated cider to flow slowly over a series of inclined surfaces, in the presence of warm air, will form acetic acid much more rapidly than if the same material were placed in deep vats or barrels, because the organisms which are instrumental in the conversion of acetic acid, require an abundance of oxygen. Beech shavings are sometimes used, because their many surfaces in the aggregate present a large area and no bad taste is imparted to the vinegar from that wood.