WOOD MOLASSES FOR STOCK AND POULTRY FEED

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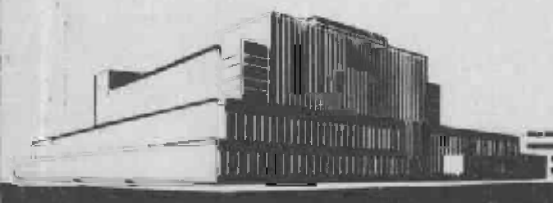

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

WOOD MOLASSES FOR STOCK AND POULTRY FEED[1]

Forest Products Laboratory,[2] Forest Service
U. S. Department of Agriculture

Summary

In 1946, the U. S. Forest Products Laboratory began work on a method of converting the dilute solutions produced by the Madison wood-sugar process to concentrated sugar solutions suitable for stock and poultry feed. By 1949, the Laboratory had prepared 200 tons of molasses, and an additional 25 tons had been prepared in a pilot plant of the Tennessee Valley Authority. This molasses was sent to universities, agricultural experiment stations, and other agencies for feeding tests with milk cows, beef cattle, calves, lambs, pigs, and poultry. In general, the tests indicated that wood-sugar molasses is a high-energy carbohydrate feed comparable to blackstrap molasses.

Introduction

Wood residues that result from the cutting of logs into lumber contain 50 to 70 percent carbohydrate material in the form of cellulose and hemicellulose, which can be converted by acid hydrolysis to sugar solutions suitable for use as animal feed.

Work at the Forest Products Laboratory has shown that 150 to 190 gallons of molasses may be produced from a cord of wood. The yield of sugar from wood, such as aspen or Douglas-fir, is 40 to 45 percent when calculated on the basis of ovendry, bark-free wood. When the solution is evaporated to a molasses consisting of 50 percent sugar and 50 percent water, about three-fourths of a ton of molasses is obtained from a ton of dry wood substance.

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[1] Part of the work here reported was financed with funds supplied under the Research and Marketing Act.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

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Virtually any type of wood waste is suitable. The amount of molasses obtainable depends on the amount of cellulose in the wood. Sawdust, slabs, shavings, woodworking mill waste, woods waste, cull trees, and wood residues from which rosin has been extracted have been successfully tested for the production of sugar. Bark, rotted wood, and wood containing large amounts of extractives may be used, but the yields are low because of the low cellulose content. Wood with high moisture content is also suitable.

The sugars present in the molasses prepared from softwoods or conifers differ from those prepared from hardwoods. Sugars from pine, spruce, or fir contain about 80 percent of glucose, 3 to 6 percent of other hexoses, and 10 to 15 percent of pentoses. Sugar from maple or aspen wood contains 65 to 75 percent of hexose, principally glucose, and 25 to 35 percent of pentose, principally xylose. The sugar from softwoods is more suitable for alcoholic fermentation or for stock feed for animals that cannot use 5-carbon sugars (nonruminant animals). The sugar from hardwoods is completely utilized in the production of fodder yeast. Sugars from hardwoods and softwoods appear to be equal in food value for cattle and sheep.

A description of the hydrolysis process and the costs involved in producing wood sugar are given in Forest Products Laboratory Report No. 2029, "Wood Hydrolysis for Sugar Production."

Composition of Wood Molasses

Wood molasses varies somewhat in nonsugar organic matter and ash. This variation is due to the wood from which the sugar is made. The type of sugar present in the molasses varies with individual species of wood. Average composition, as shown by the analysis of several samples from different species, is as follows:

	Percent
Total solid matter	60-62
Reducing sugar (as glucose)	48-50
Carbohydrate converted to simple sugar by inversion	0.5-1.5
Nonsugar organic matter	6.0-8.0
Ash	2.0-3.0
Nitrogen	0.065
Volatile organic acids	1.0-2.0
Insoluble fiber	None

The sugar in Douglas-fir molasses contains about 85 percent hexose and 15 percent pentose sugars. The sugar in a hardwood molasses, such as maple, contains about 65 percent hexose and 35 percent pentose sugars.

Storage of Wood Molasses

There is a storage problem with wood molasses that is not common with cane molasses. During the wood-hydrolysis process, soluble products are formed that are unstable. These products undergo chemical and physical changes during storage, and they slowly precipitate from the wood molasses, forming deposits that vary from a soft, spongy sludge to a hard, tarry substance. Figure 1 shows the rate at which this precipitate is formed in several samples of wood molasses. A significant amount of molasses is always entrained with the precipitate and is included as precipitate in figure 1.

The amount of material that is formed in a few weeks of storage is seldom enough to cause problems when pumping or otherwise transferring the wood molasses. When storage runs into months, however, troubles of this sort can be encountered. If fresh molasses is processed into mixed feeds, no problem is encountered.

Complete removal of the precipitating substance can be achieved by an ion-exchange process, but the added cost would be unfavorable for a feed molasses.

Yeast Production from Wood Sugar

Food yeast that is high in protein and vitamins and suitable for human or animal consumption can be produced rapidly and in good yields from the sugar obtained by wood hydrolysis. Dilute wood-sugar solution, to which is added ammonia or other inorganic nitrogen, phosphate, and potassium salts, is fed continuously into a yeast propagator where air is supplied. The yeast flows continuously with the spent solution from the propagator. It is recovered and washed in a yeast separator and dried in a drum drier. The yield of yeast is 40 to 50 percent of the sugar in solution, or 20 to 25 percent of the wood from which the sugar was made. This yeast contains 46 to 56 percent of protein, 2 to 7 percent of fat, and 6 to 12 percent of ash. Feeding tests indicate that this yeast is high in B-complex vitamins.

Feeding Tests with Wood Molasses

The value of blackstrap cane molasses as a carbohydrate feed is attested to by the fact that 380 million gallons were used as livestock feed in 1954. Six and a half gallons of molasses containing 50 percent of sugar have been found to be equivalent to 1 bushel of corn in feed value. When the cost of 6-1/2 gallons of molasses is less than the cost of a bushel of corn, it is usually economical to use molasses up to the recommended levels.

Since the sugar contained in wood molasses is principally glucose and is readily assimilated by animals, wood molasses should be equivalent to blackstrap in feed value if the extractives in the wood do not make it unpalatable or toxic.

Early in 1946, experiments were started to develop a method of producing a concentrated sugar solution from the dilute solutions produced by the Madison wood-sugar process. By the end of 1949, about 200 tons of molasses containing 50 percent of sugar had been prepared in the small pilot plant at the U. S. Forest Products Laboratory and set to agricultural experiment stations and other cooperating agencies for feeding tests. During the first months of 1950, about 25 tons of wood molasses were also prepared in the pilot plant of the Tennessee Valley Authority and sent out for tests. Feeding experiments have been conducted in all parts of the United States.

Many feeding tests have been made for palatability and to determine whether animals develop a desire or dislike for the molasses. Feeding tests have been made with molasses in mixed feed, sprayed on hay, or as a preservative for grass silage. Milk cows, beef cattle, calves, sheep, pigs, poultry, and rats have been fed in these experiments. Separate tests have been made with sugars from hardwoods and softwoods to determine whether the difference in amount of pentose sugars present in the hardwoods had serious effects on feed value.

Wood Molasses as a Feed for Cattle

Tests at Louisiana State University and Mississippi State College

The tests at Louisiana State University and Mississippi State College were arranged by the Forest Utilization Service of the Southern Forest Experiment Station. Molasses for these tests was prepared from southern pine, sawmill slabs of mixed oak, and blackjack oak cordwood.

Tests were made in cooperation with Louisiana State University to determine the palatability of oak molasses to range cattle. Cattle were found to eat the molasses best if it was fed with roughage, such as cottonseed hulls, at the rate of 2 gallons to 40 pounds of mixed cottonseed hulls and cottonseed meal.

Oak molasses was fed on a free-choice basis to heifers, along with hay and cottonseed meal, at Mississippi State College under the supervision of Dr. B. F. Barrentine. At the start, each heifer consumed an average of 5 pounds of molasses; later, 13 pounds of molasses were eaten daily in addition to hay and cottonseed meal. Oak molasses mixed with ground oats and cottonseed meal was readily consumed by the heifers. All cattle made normal gains in weight.

Tests at Mississippi State College were continued in 1949 by Dr. Barrentine. The molasses used for the feeding tests was prepared from blackjack oak cordwood that had been shipped from Mississippi to the Forest Products Laboratory for hydrolysis. The blackjack oak yielded 39 percent of sugar based on its dry weight, and the molasses shipped to Mississippi contained 58 percent of dry matter and 45 percent of sugar. Its feed value was comparable to ground corn containing 86 percent dry matter.

The feeding tests were conducted with three lots of steers. Lot I received cottonseed meal, hay, and 14 pounds of ground corn a day. Lot II received cottonseed meal, hay, a three-fourths ration of ground corn, and blackjack oak molasses equivalent on a dry-matter basis to one-fourth of the weight of the corn. Lot III received cottonseed meal, hay, and a three-fourths ration of ground corn per day. Table 1 presents the data for the feeding tests, which were continued for 120 days.

The only difference in feed between lots II and III was the molasses. As the average gain in weight of lot II was 53 pounds higher than that of lot III, it may be assumed that the increase was due to the feeding of 500 pounds of blackjack oak molasses. This would mean a gain of 0.106 pound for each pound of molasses fed. Since the molasses contained 45 percent of sugar, the sugar fed per steer was 225 pounds and the gain in weight 0.236 pound for each pound of sugar fed. The greater gain of lot II as compared to lot I may be due to a higher ratio of digestible material to dry matter in the molasses as compared to corn.

To check the gains against individual differences in animals, the steers that had been fed a three-fourths ration of corn had oak molasses equivalent in dry matter to a one-fourth ration of corn added to their feed, and those previously fed corn and molasses were fed only the three-fourths ration of corn. The results of a 30-day feeding trial on this reversal are given in table 2.

The results of the reversal test indicate a higher nutritional value for molasses than did the tests reported in table 1. The shorter period of the reversal test, however, provides only qualitative results. All steers were reported to be in about the same physical condition at the end of the experiment.

Tests at Michigan Experiment Stations

Feeding tests were started by C. F. Hoffman and C. W. Duncan at the Agricultural Experiment Station, East Lansing, Mich., and continued by W. B. Lutz at the Experiment Station, Chatham, Mich. The tests at East Lansing, which were conducted with oak molasses, showed that 6 pounds of molasses, containing 2.94 pounds of dry solids, were readily consumed with no apparent effect on the cow. Milk production was slightly less than with 3 pounds of corn a day. These tests were repeated at the Chatham

Station with molasses prepared from aspen. The feed containing the molasses was readily consumed. The wood molasses was effective in maintaining high milk production compared to cattle on hay alone, but production was not quite so high as when some corn was also fed.

Tests at Wisconsin Experiment Stations

Wood molasses was fed to milk cows and young stock at Experiment Stations in Madison, Ashland, and Marshfield, Wis., under the supervision of Drs. N. N. Allen and E. E. Heizer of the Dairy Husbandry Department of the University of Wisconsin. The tests were made to determine the effects of long-term feeding on the cattle and their offspring, and to compare the palatibility of wood molasses with blackstrap molasses and hydrol.

When wood molasses, blackstrap molasses, and hydrol were mixed with grain or roughage and offered on a free-choice basis, the wood molasses appeared equally acceptable. The wood molasses was also shown to be equal to blackstrap and hydrol on the basis of sugar content, and there were no detrimental effects to the cattle or their offspring.

Tests at Minnesota North Central Agricultural Experiment Station

Wood molasses prepared from aspen wood and neutralized with ammonia was sent by the Laboratory to the North Central Agricultural Experiment Station, Grand Rapids, Minn., where it was mixed with ground feed and fed to dairy cattle under the supervision of Don Dailey.

The molasses used in these tests was neutralized with ammonia because University of Minnesota investigators were interested in the utilization of ammonium salts as a source of nitrogen for protein production by ruminants. Moreover, if the sulfuric acid used for hydrolysis of wood were neutralized with ammonia instead of lime, it was felt that the equipment for producing sugar from wood could be simplified and made less expensive, and problems of filtering to remove calcium sulfate and scaling of evaporators due to deposits of calcium sulfate could be eliminated. The wood molasses contained 50 percent of sugar and 6 percent of ammonium sulfate. When fed 6 pounds of this molasses a day, the dairy cows received 0.36 pound of ammonium sulfate.

The feed mixture was accepted by the cattle, and no undesirable effects were evident. The tests did not show how the ammonia is assimilated, nor was the nutritional value of the ammonia-neutralized wood molasses established.

Tests at New Hampshire Agricultural Experiment Station

The nutritive value of wood molasses was compared with that of cane molasses at the New Hampshire Agricultural Experiment Station, Durham, N. H. The work was done by N. F. Colovos, H. A. Keener, J. R. Prescott, and A. E. Teeri. Arrangements for the tests were made by the Forest Utilization Service, Northeastern Forest Experiment Station.

Wood molasses containing 54.9 percent of sugar was prepared from southern yellow pine at the Forest Products Laboratory and sent to New Hampshire where it was added to a field-cured grass-legume mixture and fed to 6 heifers. The heifers, 4 Guernseys, 1 Ayrshire, and 1 Holstein, weighed between 630 and 900 pounds at the beginning of the experiment. The five largest were fed 6 kilograms of hay daily, and the sixth was fed 5 kilograms. Two kilograms of wood molasses or its equivalent of cane molasses were added to the hay ration of each animal except the sixth, for which the molasses was reduced in proportion to the hay.

Energy balances were conducted on a reversal basis. The cane molasses used was found to have a gross energy of 3.66 calories per gram of dry matter, the wood molasses had 3.87 to 4.05 calories per gram of dry matter, and the hay had 4.31 calories per gram and 10.644 percent nitrogen. Daily nitrogen balances and daily energy balances were determined.

The digestibility of the nitrogen, based on nitrogen in the hay alone, was 53.14 percent; in wood molasses plus hay, it was 41.02 percent; and in cane molasses plus hay, 48.34 percent.

The average digestibility based on energy balance of intake and output of the animals averaged, for hay alone, 59.4 percent; for hay plus wood molasses 61.8 percent; and for hay plus cane molasses, 62.6 percent. When calculated by difference, the metabolizable energy values expressed as large calories per gram of dry matter were found to be 2.53 for wood molasses and 2.40 for the cane molasses.

Tests at Montana State College Experiment Station

The tests conducted at Montana State College Experiment Station were under the supervision of Prof. Fred S. Wilson and Dr. William H. Burkett of Montana State College, and they were arranged for by the Forest Utilization Service of the Northern Rocky Mountain Forest and Range Experiment Station. Palatability tests were conducted at the college, and a weight-gain test involving 40 range steers was conducted at a ranch at Helmville, Mont. Wood molasses used for the tests was prepared from western wood waste, including mountain-type Douglas-fir, lodgepole pine, and western larch. A composite sample of the molasses showed the following composition:

Content	Percent
Total solids	64.1
Sugar content	46.8
Fermentable sugar	39.4
Nonsugar organic matter, including solids and volatile matter	10.0
Ash	7.0

The 40 steers were divided into four lots of 10 steers each. Lot I received the control ration, consisting of ground oats, corn, barley, soybean meal, alfalfa meal, salt, and a vitamin supplement; lot II received a ration 10 percent of which was cane molasses; lot III received 10.7 percent of wood molasses as a replacement of other feed; and lot IV received 7 percent of wood molasses as a replacement for other feed. The feed concentrate for each lot was in pellet form, and the average ration was 10 pounds of the pelleted feed per animal per day. The average gain per animal per day for the 84-day period was as follows:

Lot	Weight gain (Pounds)
I (control ration)	1.62
II (10 percent cane molasses)	1.43
III (10.7 percent wood molasses)	1.67
IV (7 percent wood molasses)	1.36

The animals were graded at the end of the test, and all lots were found to be of about the same quality. More information on this feeding test will be found in Montana State College Agricultural Experiment Station Bulletin 498.

Tests at State College of Washington

The Forest Utilization Service, Pacific Northwest Forest and Range Experiment Station, arranged for feeding tests at the State College of Washington. The tests were under the supervision of Dr. Shaw and T. H. Blosser of the Department of Dairy Husbandry. One series of tests was made with 2 groups of 5 heifers each. The heifers were fed a ration containing 5 percent less carbohydrate than that recommended by Morrison,[3] plus 4 pounds of wood molasses a day. The test showed the heifers made standard or better gains in weight.

Another test was made to determine the nutritional value of wood molasses for dairy calves. Two groups of calves, each consisting of 1 Jersey and

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[3] Morrison, F. B. Feeds and Feeding. 21st edition. Ithaca, N. Y., 1949.

4 Holstein heifer calves 3 to 10 months old, were used. Group I was fed a ration 5 percent below the minimum level recommended by Morrison.[2] Group II received the same ration, plus 2 pounds of wood molasses (42 percent sugar) per day for the first 8 weeks and 4 pounds per day for the next 7 weeks. Table 3 shows the results of the feeding.

The gain in weight in the first 8 weeks due to the feeding of 560 pounds of wood molasses was 79 pounds, or 0.141 pound gained for each pound of molasses fed. In the second 7 weeks, 980 pounds of wood molasses were fed, and the gain was 76 pounds or 0.076 pound for each pound of molasses fed. It is generally recognized that, when high levels of readily available simple sugars are fed with cellulosic materials, the amount of cellulosic material digested decreases and the net nutritional value of the total feed is decreased.

Tests at the State College of Washington

Long-yearling grade Hereford steers were also used in feeding trials in which data on daily gain and cost per unit of gain were obtained when feed containing wood molasses was compared with a control feed, as reported in State College of Washington Agricultural Bulletin 543. The results of these trials indicated that 4 pounds per day was the upper limit of wood molasses consumed per steer.

Tests at Oregon Agricultural Experiment Station

Tests were conducted with dairy cattle at Oregon State College by I. R. Jones of the College's Dairy Husbandry Department. The tests were arranged for by the Forest Utilization Service, Pacific Northwest Forest and Range Experiment Station. The molasses used was prepared from partially decayed Douglas-fir, and the yield ranged from 140 to 160 gallons of molasses per ton of wood, calculated on a dry basis.

For the feeding trials, 12 dairy heifers were divided into 3 groups of 4 heifers. Each group consisted of 3 Holsteins and 1 Jersey. Each heifer of group 1 received 2 pounds of ground barley each day, plus oats and vetch hay. Each animal of group 2 received 3 pounds of wood molasses containing about 1.2 pounds of sugar a day plus hay. Each one of group 3 received approximately 3 pounds of blackstrap cane molasses containing about 1.5 pounds of carbohydrate a day, plus oats and vetch hay. Hay consumption was highest for group I, which received 2 pounds of barley per animal daily. Groups II and II had about the same rate of hay consumption. The feeding trial was continued for 84 days.

The total calculated digestible nutrient per pound of weight gain was 10.2 pounds for group I, 13.5 pounds for group II, and 13.2 pounds for group III. These data indicated that the values of digestible nutrient assigned to the two samples of molasses as compared to barley were high, or that appreciable quantities of the molasses remained on the hay not consumed. The solid matter of wood molasses was as readily utilized as the solid matter of blackstrap molasses, and low-quality hay with wood molasses was as palatable as hay with blackstrap molasses.

Cooperative Tests by Milling Companies

Several milling companies, including Moorman Manufacturing Co., Carnation Mills, Arcady Milling Co., Vitality Mills, Quaker Oats Co., Allied Mills, Doughboy Industries, and Misco Mills, tested wood molasses for use as a binder and dust reducer in mixed pelleted feeds. Tests were made to determine the amount that could be mixed with feed and dried to produce a mixture that would not take up water or become sticky. It was found that 10 to 15 percent of molasses could be mixed with feed that was to be pelleted, and as little as 5 percent reduced dust. Mixtures of feed to which 50 percent by weight of wood molasses was added did not take up enough moisture to become sticky when exposed to 80 percent relative humidity.

Wood Sugar as a Preservative for Grass Silage

Tests at Washington State College

The use of wood molasses as a preservative for grass silage was tested at Washington State College. The tests were made with oat hay and alfalfa. The results indicated that the silage had improved keeping qualities and better palatability when wood molasses was added as preservative.

Tests at Oregon State College

Alfalfa was harvested with a field chopper for use as silage. Thirty tons were placed in a silo in mixture with 3 percent of wood molasses, and a similar amount from the same field was mixed with 3 percent of blackstrap molasses in a second silo. Two groups of dairy cows were selected for the test feeding of the two silage mixtures. The cows had been pastured on Ladino clover and grass. The cows in group 1 were fed silage preserved with blackstrap molasses for 3 weeks, then silage preserved with wood molasses for 2 weeks. Group II were fed wood molasses silage for 3 weeks, followed by blackstrap silage for 2 weeks. Records on milk production, body weight, and amounts of silage fed and rejected were kept for each animal. Cows showed a preference for silage preserved with wood molasses.

With respect to milk production and changes in body weight, both types of silage appeared of equal nutritional value.

Silage preserved with both types of molasses was fed to pastured heifers in troughs. That preserved with wood molasses was regularly cleaned up, while that containing blackstrap was frequently left untouched.

Tests at University of Missouri College of Agriculture

A reversal-type experiment was used at the Hatch Dairy Experiment Station Farm, Hannibal, Mo. Two silos were filled with alfalfa-brome silage, with 60 pounds of wood molasses per ton in one silo and 60 pounds of cane molasses per ton in the other. The milking herd was divided into two comparable groups. One group received wood-molasses silage for 4 weeks, after which they received cane molasses. The second group received the cane silage for 4 weeks and then the wood-molasses product. The average daily production and feed consumption indicated that the two silage preparations were quite comparable. This experiment is described in Missouri College of Agriculture Bulletin 605.

Tests at University of Wisconsin Experiment Stations

A study of the use of wood molasses as a preservative for alfalfa grass silage was conducted at University of Wisconsin Experiment Stations under the supervision of Dr. N. N. Allen of the University's Dairy Husbandry Department. Aspen wood molasses containing about 5 percent of sulfuric acid was used. Quantities of molasses ranging from 3 to 10 percent were used to preserve silage in small casks, which were periodically checked and compared. A full silo of alfalfa silage preserved with 5 percent of wood molasses was compared with silage preserved with blackstrap molasses.

All concentrations of wood molasses gave well-preserved silage that was palatable to dairy cattle. The wood-molasses silage in the large silo appeared to have a better odor and to be more palatable than the silage preserved with blackstrap molasses. Over half of the sugar in the silage preserved with wood molasses remained, while the sugar in the silage preserved with blackstrap was utilized to produce the acid necessary for silage preservation.

Wood Molasses as a Feed for Swine

Tests were made at Oregon State College on the use of wood molasses as a feed for swine. The feeding tests were made with a ration containing 15 percent of wood molasses. (Previous tests at Mississippi State

College and at Oregon State College had indicated that 15 percent of wood molasses produced normal gains, but 30 percent was unpalatable.) The molasses was produced from Douglas-fir and contained a high percentage of hexose sugar.

Twenty-four fall-farrowed pigs averaging 62 pounds at 105 days of age were divided into 3 lots of 8 pigs each at Oregon State College. Lot I received a ration consisting of: ground barley, 85.5 percent; tankage, 8.5 percent; ground alfalfa, 4.0 percent; and salt, bonemeal, and ground limestone, 2 percent. Lot II received the same ration with 15 percent of wood molasses replacing an equivalent amount of barley. Lot III received the basic ration with 15 percent of wood molasses replacing the equivalent amount of barley and 5 percent of brewer's yeast replacing an equivalent amount of tankage.

The pigs in all three lots made about the same gains except for one abnormal animal on the basic ration. This pig was eliminated from the test and the remaining ones were kept on the rations until they averaged approximately 203 pounds. Lots I and III required 104 days to do so, and lot II required 111 days. When the feed content of rations was adjusted to account for the moisture in the molasses, it was found that to produce 100 pounds of gain, the hogs in lot I required 399.02 pounds of dry matter; those in lot II, 422.8 pounds; and those in lot III, 421.46 pounds. These tests indicated that, when 15 percent of wood molasses is used to replace other carbohydrates, a satisfactory feet is obtained for swine.

Feeding Tests with Lambs

Tests at Montana State College

Tests at Montana State College showed that wood molasses fed to lambs in amounts as high as 20 percent of the feed mixture had feed value comparable to cane molasses when compared on an equal dry-matter basis. The tests are described fully in Bulletin 498 of the Montana State College Agricultural Experiment Station.

Wood Molasses as a Poultry Feed

Tests at Washington State College

Early work on the feeding of wood molasses to chicks at Washington State College was done by J. McGinnis, H. I. MacGregor, and J. S. Carver. They concluded that wood molasses may be a satisfactory replacement for carbohydrate in chick feeds. Levels of wood molasses up to 20 percent did not have a laxative effect.

In other tests, turkey poults were divided into groups and some groups were fed 5, 10, 15, and 20 percent of wood molasses while others were on a basic ration for comparison. Table 4 shows the results of the feeding tests. It was concluded that turkey poults use wood molasses efficiently as a replacement for carbohydrates of cereal grains.

Tests at Oregon State College

White leghorn pullets at Oregon State College were divided into 4 lots of 24 birds each and placed in individual laying cages. The birds were housed in the same room and managed alike. Lot I received an egg-laying ration with cereal grain as a source of carbohydrate; lot II received a ration of 7.5 percent of Douglas-fir wood molasses replacing an equal amount of cereal grain; lot III a ration with 15 percent of Douglas-fir wood molasses replacing cereal grain; and lot IV a ration with 7.5 percent of wood molasses and 7.5 percent of beet pulp replacing grain. Data collected involved egg production, efficiency of feed utilization as compared to the pounds of feed required to produce 1 dozen eggs, effects of molasses on the health, body weight, and mortality of the birds, and color of egg yolks produced.

Two feeding trials were conducted. Table 5 gives summary information on egg production, feed consumption, and mortality.

Results of the tests indicated egg production increased when 7.5 percent of the grain was replaced with wood molasses. There was some increase in feed consumption, but this was offset by increased egg production. There were no apparent ill effects of wood molasses on the health of the birds or on the color of the egg yolks produced. These two feeding trials are described in a paper by Cooney and Parker.[4]

Wood Molasses as a Feed for Small Animals

The apparent lack of palatability, for swine, of rations with 30 percent of wood molasses indicated to Dr. J. R. Haag of the Agricultural Experiment Station at Oregon State College that palatability tests should be made with white rats in order to observe more closely the individual reactions of animals. Preliminary tests made with wood molasses as compared with sucrose indicated that wood molasses at the 15 and 30 percent levels was not palatable to rats, and that rats fed wood molasses did not make normal gains.

In order to check these findings further, a sample of wood molasses was concentrated to 80 percent solution and allowed to crystallize. About

[4] Wood Sugar Molasses as a Feedstuff for Laying Hens, by W. T. Cooney and J. E. Parker. Poultry Science, Vol. XXXI, No. 2, March 1952.

50 percent of the sugar in solution was obtained as crude crystals. These crystals, after receiving no other purification except removal of the mother liquor, were redissolved in water to make a saturated glucose solution (containing 43 percent of sugar) that was designated as a purified wood-sugar solution. A sample of the same original wood hydrolyzate from which the crystals were obtained was concentrated to 65 percent solids and designated a crude wood-sugar solution. The solution prepared from the crystals was sweet, whereas the crude wood-sugar solution was bitter. Both had a dark color. These solutions, which were prepared at the Forest Products Laboratory, were sent to Dr. Haag to be tested in comparison with wood molasses.

Neither the wood molasses nor the crude wood-sugar solution was eaten in sufficient quantities to maintain body weight by the rats, while the solution of crystals obtained from wood molasses was entirely palatable and good growth resulted. The inclusion of 5 percent of brewer's yeast to the total wood molasses did not improve feed intake or growth. A sample of molasses was tested for its effect on thiamine-destroying power, and it was found that there was no apparent loss of thiamine. It is not known from this experiment if the crystallization of the sugar and removal of noncrystalline material removed harmful material, or if the sweet solution of crystals was more palatable to the rats.

Yeast as a Source of Protein Food and Vitamins for Animals

Fodder yeast (Torula spp.) grown on wood sugar obtained by hydrolysis in sulfite pulping processes has been used as a source of protein and vitamins for the feeding of growing chickens, laying hens, and rats.

In cooperation with Drs. H. T. Scott and C. H. Krieger of the Wisconsin Alumni Research Foundation, studies were made of the protein availability in Torula yeast grown on wood hydrolyzate. For this test, a yeast containing 52 percent of protein was treated by 3 methods and compared with casein as a source of protein. Batch I was autolyzed by heating it 3 hours at 80° C., dried in a drum drier at atmospheric pressure with the drier rolls at a temperature of 120° C., and then ground in a hammer mill. Batch II was autolyzed, dried on the drum drier, and then pulverized in a ball mill. Batch III, consisting of centrifuged yeast cream with about 20 percent of yeast not autolyzed, was frozen, ground to a fine powder, and dried at a low temperature.

Each batch was made part of a ration where the yeast supplied all of the protein. Vitamins and other sources of food were supplied as purified products. These yeast preparations were compared with casein. Each ration was fed to 2 groups of weanling albino rats, male and female, in group cages for 6 weeks.

Yeast as the entire source of protein was found to be inferior to casein. Batch II yeast ground in a ball mill was superior to yeast prepared by other means. The gain in weight, however, averaged only 60 percent of that for casein. Batch I gave gains equivalent to about 50 percent of those obtained with casein, and the frozen and ground yeast gave only 25 percent of the gains obtained with the casein. The fur became thin on the backs of male rats fed yeast of batches I and II. Female rats fed yeast of batch II showed this property to a lesser extent.

Loss of hair was taken to indicate the lack of some amino acid. Yeast was therefore supplemented with various amino acids in further feeding tests, but the only one that produced improvement was methionine. Hair was restored and gain in weight improved when the daily requirement of methionine was added to the ration. This test indicated that failure of rats to gain weight when fed yeast as compared with casein may be due more to the lack of some essential amino acid than to a lack of protein availability.

The use of Torula yeast obtained by wood hydrolysis as a protein supplement and as a source of unidentified vitamins required for egg production, hatchability, and chick growth was studied at Washington State College under the supervision of Dr. J. S. Carver.

White leghorn pullets in 10 groups of 40 birds each were fed 5 different diets in duplicate. Each group was fed a basic diet containing 29 percent of ground wheat, 16 percent of ground barley, 16 percent of ground oats, and 39 percent of mill-run feed. In addition, feeding of whole wheat, dehydrated alfalfa, salt, limestone flour, dicalcium phosphate B-Y feed, fish oil (400D) and manganese sulfate, soybean oil meal, Torula yeast, and herring fish meal was varied. One group on each diet was housed on a wire floor and the other on litter. Groups I and VI received 9.8 percent of soybean meal and 2 percent of fish meal; groups II and VII received 13.5 percent of soybean meal; groups III and VIII received 11.5 percent of soybean meal and 2 percent of Torula yeast; groups IV and IX received 6 percent of soybean meal and 7.5 percent of Torula yeast; and groups V and X received 2.5 percent of soybean meal and 11.0 percent of Torula yeast.

Egg production for 204 days averaged 60 to 69 percent, egg weight 56.3 to 58.4 grams. All groups gained in weight, with groups I and VI on 2 percent of fish meal and groups III and VIII on 2 percent of Torula showing the best gains. Hatchability was 83 to 90 percent for all groups except groups II and VII. These groups, which were fed soybean meal with no fish meal or Torula yeast, averaged only 60 percent. Group II, which was housed on the wire floor, averaged only 50 percent hatchability at the end of 204 days. All groups had low mortality. It appears that Torula yeast in concentrations of 2 to 10 percent in egg production rations contained the unidentified factor necessary for maintaining high hatchability of eggs produced by pullets housed on a wire screen floor. If this is verified by future tests, it is possible that Torula yeast may find a wide market as a replacement for fish meal, which is in short supply.

Dr. A. J. Wiley and collaborators of the Sulfite Pulp Manufacturers' Research League, Inc., Appleton, Wis., have compared yeast produced from the sugar in sulfite waste liquor, from sugar in wood hydrolyzate, and from sugar in blackstrap molasses, in respect to composition and vitamin content. Table 6 shows the results of this analysis.

Torula yeast grown on wood sugar in sulfite waste liquor was supplied by the League for feeding tests at the Agricultural Experiment Station, University of New Hampshire, Durham, N. H. The results of these feeding tests were published by R. C. Ringrose in Poultry Science, Vol. 28(1): 75-83, January 1949. When day-old chicks were fed this Torula yeast as a source of one-half of the needed protein in comparison with brewer's yeast, soybean meal, and fish meal, growth response was about 76 percent of that obtained with soybean meal and 60 percent of that with fish meal. This difference was attributed to the nonprotein nitrogen content of Torula yeast. Torula yeast contains riboflavin and pantothenic acid, which are utilized by the chick to produce good growth. Laying pullets in pens with built-up litter, when fed Torula yeast as a source of protein, produced eggs with high hatchability.

Table 1.--Feed consumption and results of feeding trials with wood molasses and corn at Mississippi State College

Test factors	LOT I ration: cottonseed meal, hay, corn	LOT II ration: cottonseed meal, hay, 3/4 corn, 1/4 molasses	LOT III ration: cottonseed meal, hay, 3/4 corn
Steers in lot	4	4	4
Length of trial....days	120	120	120
Av. initial weight....lb.	474	474	474
Av. final weight....lb.	693	708	655
Av. gain....lb.	219	234	181
Av. daily gain....lb.	1.83	1.95	1.51
Feed per steer....lb.			
Corn	[1]1,287	[1]952	[1]952
Wood molasses		[2]500	
Cottonseed meal	257	257	257
Hay	389	389	389

[1]Dry-matter basis.

[2]Molasses 58 percent dry matter, 45 percent sugar.

Table 2.--Feed consumption and results of feeding tests on reversal trial comparing wood molasses and corn at Mississippi State College

Test factors	LOT I ration: cottonseed meal, hay, and corn	LOT II ration: cottonseed meal, hay, and corn	LOT III ration: cottonseed meal, hay, corn, and wood molasses
Steers in lot	4	4	4
Length of reversal feeding....days	30	30	30
Av. initial weight....lb.	693	708	655
Av. final weight....lb.	749	754	729
Av. gain....lb.	56	46	74
Av. daily gain....lb.	1.87	1.53	2.47
Feed per steer....lb.			
Corn	[1]404	[1]303	[1]303
Wood molasses			[2]150
Cottonseed meal	81	81	81
Hay	90	90	90

[1]Corn is given on dry-matter basis.

[2]Molasses as liquid with 58 percent solids, 45 percent sugar.

Table 3.--Nutritional value of wood molasses fed to dairy calves at Washington State College

Factors considered	Group I	Group II	Difference
First 8 weeks			
Total molasses fed.....lb.	0	560	.....
Total gain in weight.....lb.	262	341	79
Gain in height.....in.	8-1/8	9-7/8	+1-6/8
Following 7 weeks			
Total molasses fed.....lb.	0	980	.....
Total gain in weight.....lb.	259	335	76
Gain in height.....in.	5-4/8	5	-4/8

Table 4.--Weight gains of turkey poults fed wood molasses at Washington State College

Level of wood molasses fed	Number of poults	Mortality	Feed taken per pound of gain in weight
Percent		Percent	Pounds
None	22	9	2.3
5	22	0	2.0
10	22	13.5	2.2
15	22	4.5	2.3
20	22	13.5	2.4

Table 5.--Effects of wood molasses in egg-laying tests with poultry at Oregon State College

Year	Ration	Hens started on test	Egg production	Feed consumption per dozen eggs	Mortality
			Percent	Lb.	Percent
[1]1948-49	Control	24	62.2	5.2	45.8
	7.5 percent wood molasses	24	66.4	5.9	29.2
	15 percent wood molasses	24	57.0	6.6	20.8
	7.5 percent wood molasses; 7.5 percent beet pulp	24	52.8	6.3	37.5
[2]1949-50	Control	36	57.7	5.7	38.9
	7.5 percent wood molasses	36	63.6	5.7	22.2
	15 percent wood molasses	36	53.8	6.9	27.9
	7.5 percent wood molasses; 7.5 percent beet pulp	36	58.4	6.8	19.4

[1] Test period of 304 days.

[2] Test period of 273 days.

Table 6.--Composition of Torula yeast grown on sugar from various sources[1]

Components	Source of sugar		
	Pulp liquor	Wood hydrolysis	Blackstrap molasses
Ash.....percent	9.53	5.56	7.66
Phosphorous.....percent	2.08	1.19	1.81
Calcium.....percent	0.90	0.14	0.13
Crude protein.....percent	50.4	54.2	46.7
Crude fat.....percent	5.14	3.76	5.82
Thiamin.....mcg. per g.[2]	5.6	6.9	9.9
Riboflavin.....mcg. per g.	47.9	80.8	39.8
Biotin.....mcg. per g.	2.4	2.3	3.4
Niacin.....mcg. per g.	443.0	450.0	402.0
Pantothenic.....mcg. per g.	41.7	134.4	50.8
Pyridoxine.....mcg. per g.	35.5	38.3	43.3

[1] Data from Dr. A. J. Wiley, Sulfite Pulp Manufacturers' Research League, Inc.

[2] Micrograms per gram.

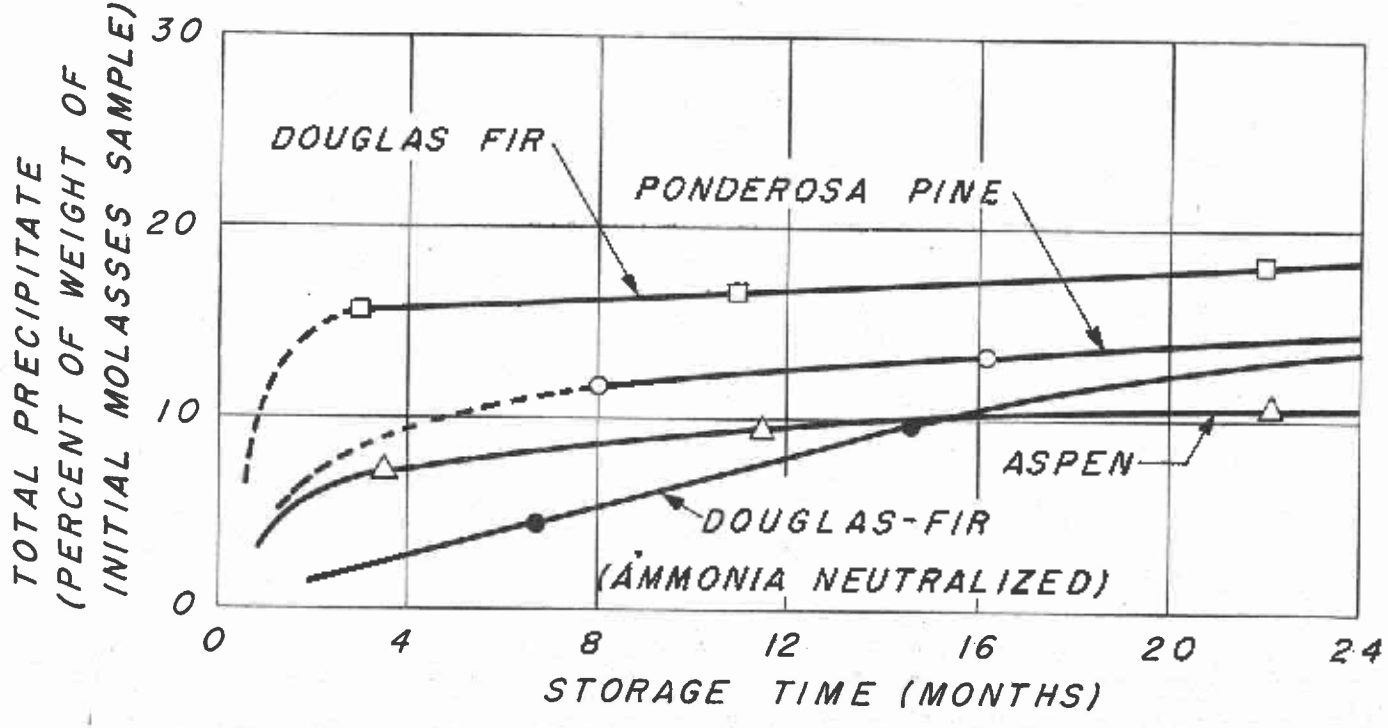

Figure 1.--Rate of precipitation during drum storage of wood molasses from various species.

SUBJECT LISTS OF PUBLICATIONS ISSUED BY THE FOREST PRODUCTS LABORATORY

The following are obtainable free on request from the Director, Forest Products Laboratory, Madison 5, Wisconsin.

List of publications on Box and Crate Construction and Packaging Data

List of publications on Chemistry of Wood and Derived Products

List of publications on Fungus Defects in Forest Products and Decay in Trees

List of publications on Glue, Glued Products, and Veneer

List of publications on Growth, Structure, and Identification of Wood

List of publications on Mechanical Properties and Structural Uses of Wood and Wood Products

Partial list of publications for Architects, Builders, Engineers, and Retail Lumbermen

List of publications on Fire Protection

List of publications on Logging, Milling, and Utilization of Timber Products

List of publications on Pulp and Paper

List of publications on Seasoning of Wood

List of publications on Structural Sandwich, Plastic Laminates, and Wood-Base Aircraft Components

List of publications on Wood Finishing

List of publications on Wood Preservation

Partial list of publications for Furniture Manufacturers, Woodworkers and Teachers of Woodshop Practice

Note: Since Forest Products Laboratory publications are so varied in subject, no single list is issued. Instead a list is made up for each Laboratory division. Twice a year, December 31 and June 30, a list is made up showing new reports for the previous 6 months. This is the only item sent regularly to the Laboratory's mailing list. Anyone who has asked for and received the proper subject lists and who has had his name placed on the mailing list can keep up to date on Forest Products Laboratory publications. Each subject list carries descriptions of all other subject lists.