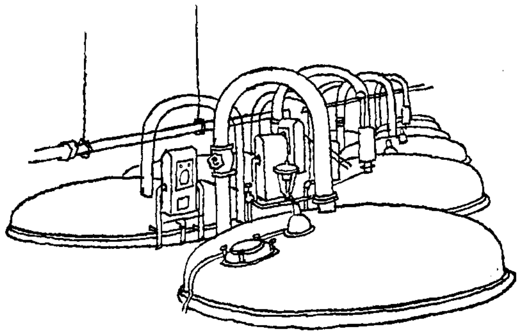
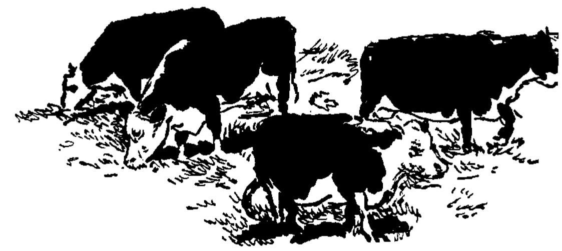


VERNON W. RUTTAN and T. N. HUBBUCH[1]
Tennessee Valley Authority

The Changing Industrial Molasses Market

As long as the industrial alcohol demand continues a minor element in the molasses market it seems likely that ever larger quantities of molasses will be used for livestock feeding purposes



THE USE OF PETROLEUM raw materials in place of blackstrap molasses in the manufacture of industrial alcohol has been a major factor in unsettling the blackstrap molasses market for over a decade. At the same time that use of blackstrap in the alcohol industry has been declining, however, its use as a livestock feed material has been expanding.

Superimposed on these opposite molasses-use trends were the heavy alcohol demands created by World War II and the Korean conflict. The sudden and sizable nature of these demands resulted in a temporary reversal in the trend of declining use of molasses in alcohol manufacture, because alcohol production from molasses could be expanded more rapidly than from petroleum synthesis. However, as expansion of petroleum synthesis of alcohol increases, molasses producers are placing increased reliance on the feed market as an outlet for abundant and growing amounts of molasses flowing from sugar production centers of the southern states and the Caribbean.

The Supply of Industrial Molasses

Consumption of molasses by American industry has averaged more than 400 million gallons a year, during the past 10 years, but supplies have fluctuated between a high of 640 million gallons and a low of 268 million gallons (Table I).

Almost the entire supply of industrial molasses is produced as a by-product of the cane, beet, and corn sugar industries. Blackstrap molasses, a by-product of the cane sugar refining industry, normally accounts for between 80 and 90% of total supplies.

Imports of blackstrap, principally from the Caribbean area, have in most years accounted for between 70 and 80% of total industrial molasses supplies. During the five-year period, July 1, 1947, to June 30, 1952, (fiscal years 1948-52) imports of molasses (almost entirely blackstrap) averaged 353 million gallons annually, while domestic production of all molasses products averaged 133 million gallons.

Cane Molasses Products. Blackstrap is the major form of cane molasses (*7*, *20*). It is a by-product of the manufacture of sugar from cane and contains 50 to 60% of sugar. About 45 gallons of blackstrap molasses are produced for each ton of raw sugar plus 5 to 6 gallons for each ton of refined sugar. A small variable amount of cane molasses is also derived directly from sugar cane, without the extraction of sugar. This "high test" product contains at least 75% sugar. Production and supply data are not available separately for blackstrap and high test molasses, but high test has been relatively unimportant as a source of industrial molasses in recent years (*20*).

While imports of blackstrap normally account for between 70 and 80% of total supplies, they accounted for considerably less than this amount in 1943 and in 1946 and 1947. Imports dropped from 389 million gallons in 1942 to 191 million gallons in 1943, principally because of failure by the U. S. Government to allocate shipping for transport of molasses. Imports fell to 150 and 166 million gallons in 1946 and 1947 as a result of diversion of molasses to alcohol production by the Cuban government.

Prior to 1952, imports of molasses from Cuba remained somewhat below prewar levels, while imports from other countries rose slightly. In spite of smaller than normal imports from Cuba during most of the period since World War II, an average of 189 million gallons or 39% of total industrial molasses supplies was imported from Cuba during the period 1948-52. Imports from other areas, principally Puerto Rico, the Dominican Republic, and Hawaii, averaged 164

[1] *Present address: Army Chemical Corps, Muscle Shoals, Ala.*

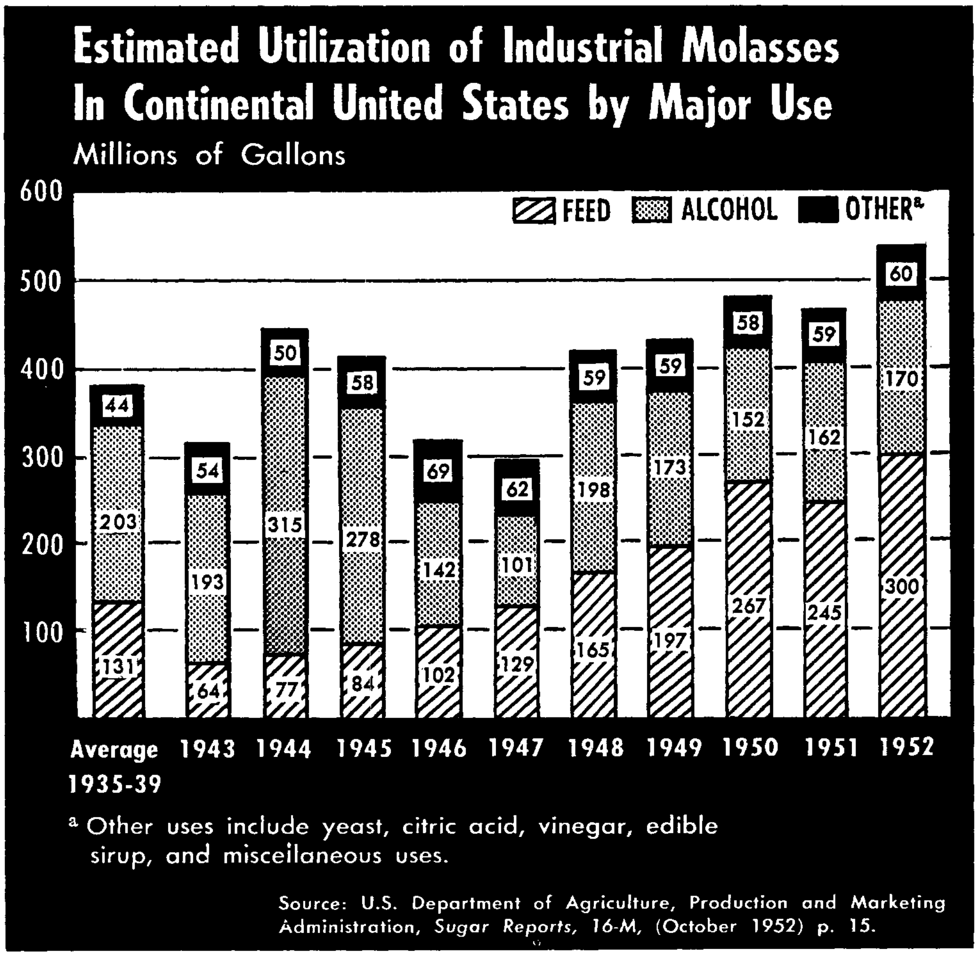
Table I. Market Supplies of Industrial Molasses Available in Continental United States by Source and Type—1935–51

(Millions of Gallons; Percentages Represent Share of Total Market Supplies)

	Total Market Supplies		Blackstrap[a] Molasses		Imports[b]						Domestic									
					Total		Major Source: Cuba		Major Source: Other[c]		Total		Major Type: Blackstrap[d]		Major Type: Beet		Major Type: Citrus		Hydrol	
Year	Amt.	%	Amt.	%	Amt.	%	Amt.	%	Amt.	%	Amt.	%	Amt.	%	Amt.	%	Amt.	%	Amt.	%
1935	393	100	358	91	312	80	[e]	..	[e]	..	80	20	45	12	25	6	..	..	10	2
1936	337	100	304	90	251	74	[e]	..	[e]	..	86	26	52	15	26	8	..	..	8	3
1937	453	100	420	93	359	79	247	54	112	25	94	21	60	13	25	6	..	..	9	2
1938	375	100	341	91	281	75	163	43	118	32	94	25	59	16	27	7	..	..	8	2
1939	332	100	296	89	226	68	134	40	92	28	106	32	70	21	27	8	..	..	9	3
1940	383	100	349	91	289	75	211	55	78	20	94	25	59	16	25	6	..	..	10	3
1941	483	100	444	92	390	80	280	57	110	23	93	20	54	11	27	6	..	..	12	3
1942	480	100	443	92	389	80	297	61	92	19	91	20	54	11	22	5	..	..	15	4
1943	282	100	241	85	191	67	135	47	56	20	91	33	49	18	26	9	..	..	16	6
1944	455	100	415	91	349	76	251	55	98	21	106	24	66	14	23	5	3	1	14	4
1945	380	100	325	86	256	67	170	45	86	22	124	33	69	18	36	10	3	1	16	4
1946	268	100	207	77	150	55	67	25	83	30	118	45	57	21	41	15	8	3	12	6
1947	292	100	220	75	166	57	65	22	101	35	126	43	54	18	45	15	10	4	17	6
1948	422	100	361	86	300	71	159	38	141	33	122	29	61	14	36	8	11	3	14	4
1949	429	100	375	87	301	70	160	37	141	38	128	30	74	17	32	7	7	2	15	4
1950	476	100	410	86	339	72	196	42	143	30	137	28	71	15	43	7	7	2	16	4
1951	464	100	402	87	326	70	130	28	196	42	139	30	76	16	36	8	9	2	18	4
1952	640	100	577	90	499	78	300	47	199	31	140	22	78	13	38	6	9	1	15	2

[a] Includes all imports plus domestic blackstrap.
[b] Almost entirely blackstrap. Some high test (invert) was imported from Cuba in the years 1935–43 due to U. S. quota system which restricted sugar imports. Small amounts of beet molasses have occasionally been imported from Canada, Poland, and Denmark.
[c] Includes Dominican Republic, Dutch Indies, Mexico, Hawaii, Puerto Rico, Haiti, British West Indies, Canada, Poland, Peru, Java, Italy, and Denmark.
[d] Includes in some years a small amount of domestic high test (invert) molasses.
[e] Not available on revised basis.
Source: U. S. Department of Agriculture, Production and Marketing Administration, *Sugar Reports*, pp. 16–7, October 1952.

Figure 1



million gallons, or 34% of total supplies during this same period. Present imports from such areas as Java, British West Indies, Trinidad, Haiti, and other areas are rather small. Imports from these areas could probably be expanded, however, if United States' demand were to exceed available supplies from other areas.

Although domestic production of blackstrap rose from 45 million gallons in 1935 to 78 million gallons in 1952, it still accounts for less than 15% of total supplies. United States production is concentrated mainly in the cane sugar areas of Florida and Louisiana, and in the larger east and west coast port cities where the sugar refineries utilizing imported raw sugar are located.

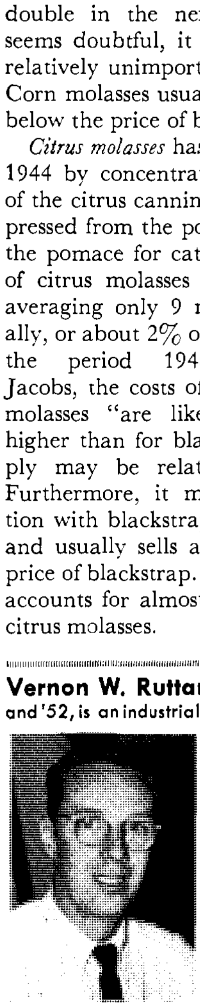
Other Molasses Products. The beet sugar, corn sugar, and citrus canning industries provide three minor sources of molasses. Wood molasses has been produced experimentally (*8*).

Beet molasses is a by-product of beet sugar manufacturing. The sugar content is 50 to 60%, or the same as blackstrap. Beet molasses provide between 5 and 10% of the total molasses supply in the United States. Average annual production during 1948-52 amounted to 37 million gallons, slightly less than 8% of total supplies. Being a by-product of the beet sugar industry, the volume of beet molasses depends on beet production. As there seems to be little reason to expect a rapid expansion in the production of domestic beet sugar, beet molasses production will probably not rise significantly in the foreseeable future. Indeed, technical advances in the industry may reduce the amount of by-product molasses.

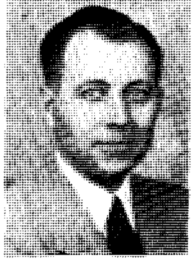
Corn molasses (*hydrol*) is a by-product in the manufacture of corn sugar. It has a total sugar content about the same as that of blackstrap and beet molasses. Corn molasses provide 3 to 6% of total available supplies of molasses. It is produced largely in the Midwest. Production of corn molasses, which has remained at about the same level since 1942, averaged 16 million gallons or about 3% of total supplies during the period 1948-52. If output were to double in the next few years, which seems doubtful, it would still remain a relatively unimportant source of supply. Corn molasses usually sells at 30 to 40% below the price of blackstrap.

Citrus molasses has been produced since 1944 by concentrating the waste liquids of the citrus canning industry, which are pressed from the pomace prior to drying the pomace for cattle feed. Production of citrus molasses has remained small, averaging only 9 million gallons annually, or about 2% of total supplies during the period 1948–52. According to Jacobs, the costs of production of citrus molasses "are likely to be relatively higher than for blackstrap and the supply may be relatively limited" (*11*). Furthermore, it meets strong competition with blackstrap in the feed market, and usually sells about 20% below the price of blackstrap. The state of Florida accounts for almost the entire supply of citrus molasses.

Vernon W. Ruttan, Yale '48, Chicago '50 and '52, is an industrial economist in the Tennessee Valley Authority, where he does economic research on problems relating to TVA's agricultural and industrial development programs. While doing graduate work at the University of Chicago he was a research associate in the department of economics, assigned to study the technological progress in the meat packing industry.



Theodore N. Hubbuch, resident chemical engineer for the Army Chemical Corps at Sheffield, Ala., is an alumnus of TVA, with which he spent about 15 years, first as a project leader in chemical engineering and later as industrial engineer in industrial development. He was educated at the University of Louisville and at Harvard, and then worked in the research laboratory of applied chemistry at MIT.



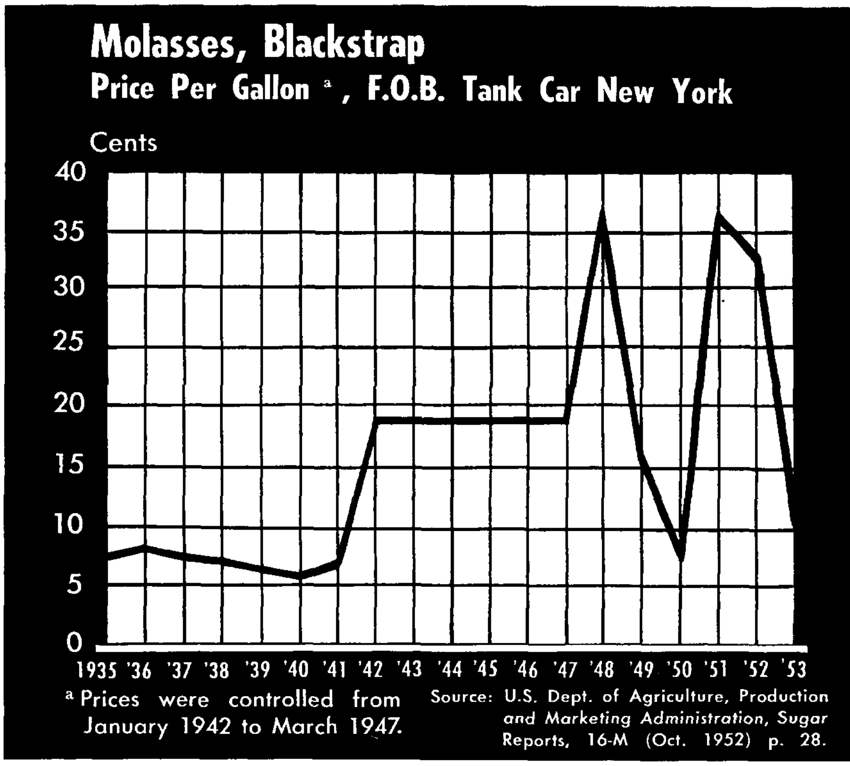


Figure 2

Markets for Molasses

In recent years the molasses market has been characterized by wide fluctuations in consumption and price and by a substantial shift in utilization. The consumption of molasses has varied quite widely during recent years because of fluctuations in imports. In 1947, for example, consumption was below 300 million gallons, while in 1948 it rose to 422 million gallons. The most marked change in consumption, however, was a shift in use. There has been an actual and relative decline in consumption of molasses by the alcohol industry and an increase in consumption by the livestock industry in recent years until, at the present time, the livestock industry has supplanted the alcohol industry as the major consumer of molasses (Figure 1). Meanwhile, prices have fluctuated from less than 6 cents per gallon in 1940 to over 36 cents per gallon in 1951 (Figure 2).

The alcohol and feed industries consume 80 to 90% of all molasses products and practically all of the blackstrap on the American market.

The Alcohol Market. In the past, the ethyl alcohol industry was the most important market for industrial molasses, and molasses was the most important source of raw material for the production of ethyl alcohol.

Since the end of World War II, however, production of ethyl alcohol from molasses has declined below prewar levels of 70 to 90 million gallons per year, and synthetic alcohol, produced from petroleum by-products, has become the major source of ethyl alcohol. For example, in 1952, of the 246 million gallons of ethyl alcohol produced, 125 million gallons, or 51%, was produced from synthetic sources, while only 69 million gallons, or 28% was produced from molasses (Table II).

Small quantities of ethyl alcohol normally are produced from low quality or water-damaged grains, such as corn, wheat, and sorghum. During World War II, when it was necessary to expand the production of alcohol butadiene, a basic material in the production of synthetic rubber, large quantities of high quality grain were used for alcohol production. Production of alcohol from grain rose from 6% of total production in 1941 to 43% of total production in 1945. In fiscal 1951 production of alcohol from grain rose to 60 million because of the large quantities of low quality grain available at considerable discount.

Ethyl alcohol has also been produced from sulfite liquors, cellulose pulp, whey, pineapple juice, and potatoes and potato products. During the war, production from sulfite liquors was quite important while potatoes were an important source during the years 1948-49. This was during the period of high level support prices for potatoes when the Department of Agriculture purchased large quantities to maintain parity prices.

Although published data on the cost of producing synthetic alcohol is lacking, synthetic alcohol is generally considered to be the cheapest source of ethyl alcohol except when molasses or grain can be purchased at extremely low prices (*4*, *13*, *18*).

The ability of synthetic alcohol to compete with fermentation alcohol on a cost basis, regardless of the economic climate, is demonstrated by the steady growth of synthetic capacity during the depressed 1930's, the period of high alcohol prices during World War II, and the period of depressed alcohol prices which followed World War II. Since the outbreak of the Korean hostilities, synthetic capacity has expanded even more rapidly. According to Reconstruction Finance Corporation estimates, synthetic alcohol capacity had reached 140 million gallons annually by Jan. 1, 1952. NPA authorizations have been granted that would add over 90 million gallons of additional capacity by the end of 1953, at which time synthetic capacity will amount to 230 million gallons (*4*, *19*). Even in 1952, when more industrial alcohol was produced than in any other year since the end of World War II, total output of industrial ethyl alcohol from all sources amounted to only 246 million gallons. Competition from synthetic alcohol has already forced several producers of fermentation alcohol to discontinue sales of the latter product (*4*).

There is little doubt, however, that a major military emergency would create a greater demand for alcohol than could be supplied by the synthetic industry. Although present indications are that the synthetic rubber industry will place smaller reliance on the alcohol industry for raw materials than in the past, other potential military uses are great (*18*, *19*).

In the past, the price of industrial molasses has varied directly with the price of ethyl alcohol because of the importance of molasses in the alcohol industry (*16*, *18*). It seems almost certain that as the importance of industrial molasses as a source of raw material in the ethyl alcohol industry continues to decline, the price of molasses will come to reflect its value as a livestock feed to a much greater extent than at present.

The Feed Market. Utilization of molasses by livestock feeders and feed mixers has continued to rise as utilization by the alcohol industry has declined. In the 1945 fiscal year only 84 million gallons, amounting to 20% of the total molasses consumed, was used for livestock feeding purposes. In fiscal 1952, when total utilization amounted to 530 million gallons, 300 million gallons or 57% was used for feeding purposes (Figure 1).

Several reasons have been given for the increase in molasses utilization by the livestock industry since the end of World War II. Among these reasons have been: an increase in the molasses content of feeds which customarily included molasses as an ingredient; the use of molasses in types of feed which formerly did not generally use it; the large increase in the volume of manufacture of mixed feeds as compared to the prewar period; and increased direct feeding on farms (*12*).

Table II. Total Production of Ethyl Alcohol by Major Source of Raw Materials—1935–51

(Millions of Wine Gallons; Percentages Represent Share of Total Net Ethyl Alcohol Production)

Year Ended June 30	Total Net Ethyl Alcohol Production Amt.	%	Molasses Amt.	%	Synthetic Amt.	%	Grain Amt.	%	All Other Materials[a] Amt.	%
1935	95	100	81	85	9	10	3	3	2	2
1936	103	100	79	76	16	16	7	7	1	1
1937	118	100	89	76	18	15	10	8	1	1
1938	106	100	77	73	19	18	10	9	..[b]	..[c]
1939	106	100	72	67	25	24	8	8	1	1
1940	128	100	88	68	32	25	7	6	1	1
1941	157	100	111	71	36	23	9	6	1	..[c]
1942	221	100	152	69	48	22	20	9	1	..[c]
1943	192	100	84	44	51	26	57	30	..[b]	..[c]
1944	311	100	109	35	60	19	109	35	33	11
1945	342	100	100	30	59	17	148	43	35	10
1946	173	100	46	26	67	39	55	32	5	3
1947	131	100	29	22	70	53	21	16	11	9
1948	175	100	75	43	74	42	18	10	8	5
1949	185	100	67	36	87	47	6	3	25	14
1950	165	100	57	35	90	54	1	1	17	10
1951	234	100	56	24	99	42	60	26	19	8
1952	246	100	69	28	125	51	48	20	4	1

[a] Chiefly sulfite liquors, cellulose pulp, chemical and crude alcohol mixtures, whey, pineapple juice, grain and molasses mixtures, and potato and potato products.
[b] Less than 1 million.
[c] Less than 1%.
Source: U. S. Department of Agriculture, Production and Marketing Administration, *Sugar Reports*, 16-M, p. 23, (October 1952).

Basic to the trend toward increased utilization in each of these uses has been the rise in the price of corn relative to the price of molasses during recent years (*5*). Feeding tests indicate that 6.5 gallons of molasses is equivalent in feed value to one bushel of corn (*12*). Thus when the price of 6.5 gallons of molasses is below the price of one bushel of corn at point of utilization, it pays livestock feeders to substitute molasses in feeding rations. In general, as can be seen from Figure 2, the greater this differential between the price of one bushel of corn and 6.5 gallons of molasses, the greater has been the consumption of molasses. The fact that the 1951 decline in the corn-molasses price differential was accompanied by a rather small decline in feed utilization is a reflection of both the short-run stability of feeding practices and greater realization by livestock feeders and feed mixers of the feed value of molasses.

Regional price and consumption differentials also emphasize the importance of price considerations in molasses feed consumption. Corn prices are generally lowest in the Midwest and highest on the east and west coasts. Differentials in the price of molasses largely reflect the cost of shipment from point of production and are highest in the Midwest and lowest along the east and west coasts and in the South. In 1947, the estimated use, per cow, of molasses by the prepared feed industry was considerably lower in the North Central, South Central, and South Atlantic regions where the corn-molasses differential is smaller than in the North Atlantic and Pacific Coast regions where this differential is greatest (Table III).

Use in Mixed Feeds. Utilization of molasses in mixed feeds seems to be determined by technical limitations on the quantity of molasses which can be efficiently incorporated into mixed feeds, the rate of expansion of the mixed feed industry, and the price of molasses. Even under the most favorable price conditions, feed mixers rarely incorporate more than 25% molasses into their feed because of technical difficulties. Under adverse molasses-grain price relationships, the quantity of molasses incorporated into feed mixtures rarely falls below 6 to 10% in dairy and beef cattle feeds and 2 to 4% in hog feeds because of the importance of molasses as a palatability factor and a binding agent (*5*).

During recent years, the larger commercial feed mixers probably have been utilizing almost as much molasses in their mixed feeds as is economically and technically feasible (*5*, *17*). Therefore, even under favorable molasses-corn price relationships, it seems likely that increased utilization of molasses by the feed industry will depend on: the rate of expansion of the feed industry and the development of techniques whereby greater quantities of molasses can be economically incorporated into livestock feed mixtures.

During the period 1947–51, growth in the output of the prepared feed industry accounted for perhaps as much as 80% of the increased utilization of industrial molasses. Utilization of molasses in the feed industry during 1947–51 expanded by 56%—from 128.5 million gallons to 200.5 million gallons—while the output of the feed industry expanded by 44% from 22.3 million tons to 32.7 million tons. Assuming favorable cost-price relationships, and no reduction of the molasses content of mixed feeds, a similar rate of expansion in the mixed feed industry during 1952–60 would result in production of 60 million tons of mixed feed and utilization of 400 million gallons of molasses in 1960, an increase of approximately 100% over 1951. This approximates total available supplies in 1951.

Use for Direct Feeding. It should be emphasized that the expansion projected above depends on the maintenance of favorable cost-price relationships between corn and molasses. The potential utilization of molasses in direct feeding can be even greater than in the mixed feed industry if favorable relationships between the price of corn and molasses are maintained (*6*).

H. E. Bode of the Sugar Research Foundation estimates a market potential for feed molasses of over 10 billion gallons annually if molasses prices are stabilized at 10% below its equivalent feed value and the feed industry takes positive action to increase molasses marketing efficiency (*2*).

In the past, utilization in direct feeding has been limited by the high cost of distribution in liquid form. In mid-1950, marketing costs of distributing molasses in barrels, the traditional method, totalled approximately 14.6 cents per gallon (*6*). These costs included barreling transportation from port to country distribution point, handling charge at distribution point, and transportation to farm.

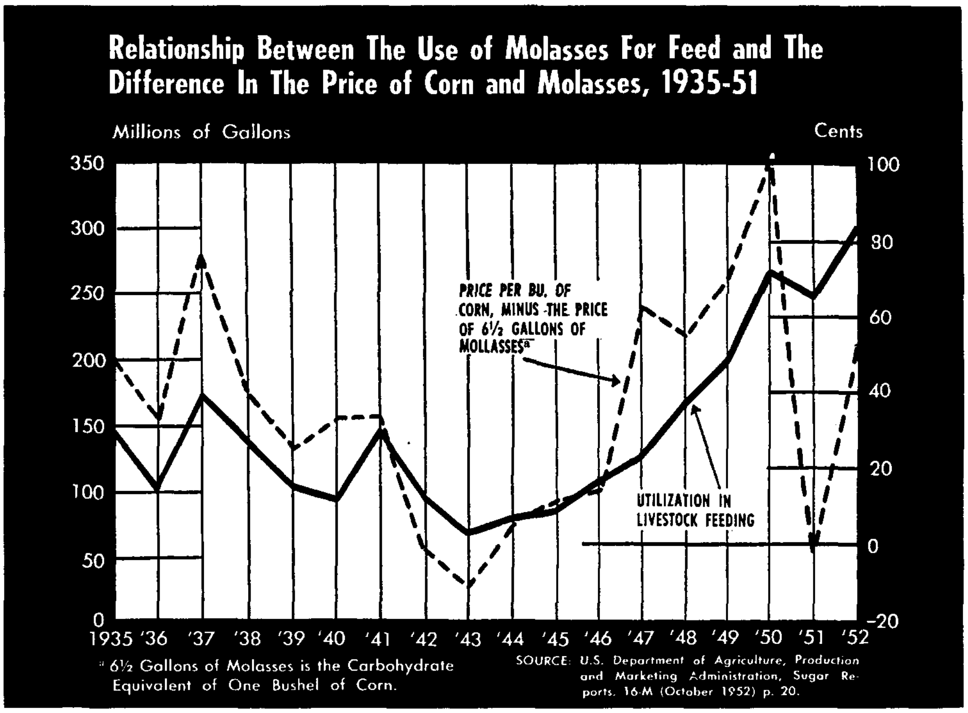


Figure 3

Cost estimates obtained by Doyle indicate that this cost can be reduced to approximately 7 cents per gallon by tank truck delivery to farmers located from 100 to 250 miles from port terminals. When the molasses can be shipped directly from processing plants to farmers located within a 100-mile radius, as is done in the case of Florida citrus and blackstrap molasses, marketing charges have been reduced to approximately 3 cents per gallon.

If corn sells at $1.70 per bushel, the present (July 1, 1953) price in Memphis, the equivalent feed value of molasses on the farm is 26.2 cents per gallon. Under these conditions, delivery costs reduce the f.o.b. price to between 11.6 and 23.0 cents per gallon, depending on method of delivery, if farmers used molasses up to the equivalent feed value (Table IV).

It should be pointed out that hydrol and citrus molasses normally sell at prices ranging from 20 to 40% below the price of blackstrap molasses, even though there is no difference in feeding value. For example, July 1, 1953, price quotations show that blackstrap sold for 10.5 cents per gallon and citrus molasses for 8.7 cents per gallon in Florida. In the Midwest, blackstrap sold slightly above 15 cents per gallon while hydrol sold for 11.1 cents per gallon. These prices represent discounts of approximately 25%.

Minor Markets. Between 10 and 15% of total annual utilization of industrial molasses is used in the production of yeast, citric acid, vinegar, and molasses and sirups for human consumption. In the 1951 fiscal year, 60 million gallons, or 11% of total utilization, was accounted for by these uses (Figure 1). This quantity of molasses utilized in the production of these products is only slightly higher at present than prior to World War II.

Because of the relatively stable market and small amount of molasses utilized in making these products, they exert almost no influence on the price of molasses.

Molasses Price Fluctuations. The price and demand picture in the industrial molasses market during the last decade can be summarized about as follows: Molasses prices rose during 1941 from 7 to 16 cents per gallon as the

Table III. Relationship Between the Use of Molasses by the Feed Industry and the Difference in the Price of Corn and Molasses for Selected Regions—1947

	Price of Corn per Bushel[a]	*Price of Molasses per 6.5 Gallons*[b]	*Difference*	*Gallons of Molasses Utilized per 100 Cattle*[c]
North Central	$2.27	$1.75	$0.52	0.74
South Central	2.25	1.69	0.56	1.03
South Atlantic	2.15	1.43	0.72	1.34
North Atlantic	2.44	1.56	0.88	4.98
West	2.36	1.30	1.06	2.50

[a] Refers to prices received by farmers. In general the prices received by farmers are lower than central market prices in regions where central market prices are quoted.
[b] At representative port or distribution point in the region.
[c] A total of 8,037,000 gallons was used by this industry in the states of New Hampshire, Massachusetts, Delaware, Montana, Idaho, Utah, and Washington. The distribution of the total among these states was withheld to avoid disclosing figures for individual companies. This amount has been allocated among the above states on the basis of cattle population.
Source: Prices of corn received by farmers from "Agricultural Statistics," 1949, p. 43. Price of molasses calculated by applying OPS regional price differentials to price of blackstrap molasses at New York; molasses consumed by prepared feed industry from "Census of Manufactures: 1947," "Grain-Mill Products," p. 9, and number of cattle from "Agricultural Statistics: 1948," p. 333.

Table IV. Estimated Molasses Prices Under Alternative Delivery Systems—Memphis, Tenn., July 1, 1953

	Tank Truck Delivery		Barrelled Delivery	
Molasses delivery cost:	7.0[a]–3.2[b]		14.6[c]	
	Delivered	f.o.b.	Delivered	f.o.b.
Molasses price based on corn equivalent value:[d]				
Maximum	26.2	19.2–23.0	26.2	11.6
10% Discount[e]	23.6	16.6–20.4	23.6	9.8
25% Discount[f]	19.6	12.6–16.4	19.6	5.0
Blackstrap price at Memphis (July 1, 1953)	17.6–21.3	14.3	28.9	14.3
Estimated cost of producing wood molasses (f.o.b.):				
50-ton Plant		20.4–23.8		
100-ton Plant		17.6–21.0		

[a] Based on 1950 northeastern cost data on tank-truck delivery of blackstrap for an average of 100 miles from distribution point.
[b] Based on 1950 Florida cost data on tank-truck delivery of blackstrap for an average of 70 miles from distribution point.
[c] Based on 1950 northeastern cost data on delivering barrelled blackstrap for an average of 100 miles.
[d] Average price paid to farmers per bushel of corn at Memphis and nearby markets in June 1953 was $1.70.
[e] Bode, *op. cit.*, suggests that a price 10% below the feed equivalent value will be required to achieve rapid increase in feed utilization.
[f] Approximate discount presently (July 1, 1953) offered by citrus and hydrol producers.

demand for alcohol rose in response to initiation of the synthetic rubber program. Between January 1942 and March 1947 molasses prices were controlled at 18.5 cents per gallon.

During the year following decontrol, prices rose for a short time to a high of 37 cents under presure of heavy postwar demand by the alcohol industry and high corn prices.

From July 1948 through June 1950, the alcohol demand fell off steadily, throwing additional supplies of molasses into the feed market. Corn prices also fell back to below $1.50 per bushel from postwar highs of above $2.00. Under this pressure, the price of blackstrap fell to 8 cents per gallon at ports of entry before the feed market absorbed the additional supplies. At this low price, 6.5 gallons of molasses were selling at from 70 cents to $1.00 below the price of a bushel of corn.

Following the outbreak of the Korean hostilities and reactivation of the synthetic rubber program, the price of blackstrap molasses rose from 11 cents per gallon in New York in June to 36.5 cents per gallon in December 1950 and January 1951. This became the OPS control level and prices remained at this level until Oct. 26, 1951, when OPS issued an order stabilizing the price of blackstrap at 32 cents a gallon in New York.

Between Oct. 26, 1951, and Dec. 31, 1952, the price of blackstrap fell from 32 cents per gallon to 10.5 cents per gallon. Several factors contributed to this decline. The most important was the purchase of foreign alcohol supplies by the Reconstruction Finance Corporation for use in the synthetic rubber program and subsequent elimination of high-cost alcohol butadiene production in favor of direct production from petroleum by-products. A record output of molasses by Cuba in fiscal 1952 intensified the decline in the price structure. The Cuban Sugar Stabilization Institute found it impossible to hold the price at the announced level of 20 cents a gallon (*21*). Blackstrap prices have not, however, returned to the pre-Korean and pre-World War II levels of below 10 cents per gallon but have remained in the neighborhood of 11 cents per gallon for the past six months.

The sharp rise in molasses prices which occurred in late 1950 and 1951 resulted in a relatively small decline in feed consumption. This small decline is a reflection of the short-run stability of feeding practices and of greater realization by feed mixers and livestock feeders of the feed value of molasses (*5*). A sharp rise in feed utilization accompanied the decline in molasses prices which began in late 1951 (*18*).

The Outlook for Wood Molasses

History of Wood Molasses Development. Wood molasses has been produced on an experimental basis at Madison, Wis. (*8*), Springfield, Ore. (*15*), and Wilson Dam, Ala. (*8*).

The Springfield plant was never operated except on an experimental basis by the Williamette Valley Wood Chemical Co. More recently, a company which holds a lease from the General Services Administration has operated two of the five percolators to produce industrial alcohol (*15*).

In 1950, the Forest Products Laboratory estimated that with the addition of suitable equipment molasses could be produced for slightly under 10 cents per gallon in the Springfield plant (*9*, *15*).

TVA has operated a pilot plant in cooperation with Forest Products Laboratory, which represents an intermediate scale between that of the Forest Products Laboratory and the Springfield plant. Modifications of the FPL wood sugar process permit utilization of somewhat simpler equipment and production of solutions of higher concentration (*8*).

Estimates of 1951 production costs, developed by the TVA Division of Chemical Engineering for plants processing 25, 50, and 100 tons of dry hardwood per day are shown in Table V.

Indications are that it may be possible to reduce the costs allocated to molasses production by as much as 6.5 cents per gallon through recovery of by-product furfural and acetic acid. Until this possibility is fully explored, it will not be possible to evaluate definitely the commercial feasibility of wood molasses.

The Market for Wood Molasses. At the present time, the following factors seem favorable to commercial production of wood molasses:

1. Wood molasses now can be produced, from wood waste or cordwood, in plants utilizing 50 tons per day or more, at prices slightly below the equivalent corn feed value.
2. At that price, the estimated potential feed demand for molasses exceeds the present total U. S. utilization of molasses for all purposes.
3. In an all-out war effort, industrial alcohol demand probably would force the price of molasses products above the present cost of producing wood molasses.

Table V. Effect of Plant Capacity on Production Cost of Wood Molasses

	Plant Capacity, Tons Dry-Wood Substance per Day		
	25	50	100
Annual Production Capacity[a] (Gallons)	1,025,833	2,041,666	4,083,332
Estimated Investment (Dollars)	414,000	627,000	950,000
Production Cost of 50% Molasses (Cents per Gal.)			
From wood waste[b]	26.5	20.4	17.6
From cordwood[c]	29.9	23.8	21.0

[a] 325 operating days per year.
[b] Based on cost of wood waste at $4.47 per cord.
[c] Based on cost of cordwood at $12 per cord.
Source: Gilbert, Nathan, Hobbs, I. A., and Sandberg, W. D. "Utilization of Wood by Hydrolysis with Dilute Sulfuric Acid," *Forest Products Research Society*, p. 5, 1952, Preprint 192.

4. Several recent developments indicate that additional markets for wood molasses may evolve.

a. Substitution of urea as the protein source may enable livestock feeders to incorporate greater quantities of molasses and low-grade roughage in feed rations. Other research, however, points to possible toxic effects of urea utilization (*14*).

b. New chemical metallurgical processes announced recently may require a soluble ash-free reducing agent—wood molasses has such properties (*1*, *3*).

c. A glucose molasses solution, used in the past as a developing media for certain mold organisms in the production of antibiotics, may be the basis for increased demand for molasses products, depending on the availability of other developing media.

d. Wood molasses may be especially useful for sand molds for metallurgical casting.

5. Among possible economic byproducts from the process, furfural appears to be the most promising in terms of cost reduction.

Some factors seem unfavorable to commercial production of wood molasses:

1. A shift away from the use of fermentation alcohol in synthetic rubber production.

2. Price instability in the molasses market could cause a wood molasses producer to operate only sporadically, reducing the average return on investment.

3. In the past, the price of molasses products has approached or exceeded the corn equivalent feed value only during emergency periods. The feed industry in the past has not been willing to absorb large quantities of molasses except at prices considerably below the equivalent feed value (Table IV).

4. The f.o.b. price of molasses must allow for delivery costs and the fact that in corn-producing areas, corn sells below central market prices.

5. In the past, farmers and feed mixers have discriminated against molasses products other than blackstrap even though the feed value of these other products is equivalent to that of blackstrap. Feed mixers and market experts generally agree that wood molasses would initially have to be offered at a discount to find outlets in the feed market.

The Molasses Market Outlook. It appears that, in spite of the great hypothetical demand for molasses as a livestock feed, livestock feeders and feed mixers have, in the past, been unwilling to absorb this increased supply of molasses except at prices considerably below its equivalent feed value. This reaction is in part due to the instability of molasses prices. Because of the fluctuating demand for molasses in alcohol production, the price of molasses has at times exceeded the value of molasses as a substitute for corn in livestock feeding.

If the alcohol demand, as is expected, becomes only a minor element in the molasses market, it seems likely that substantially larger quantities of molasses will be utilized for feeding purposes. A closer relationship between the price of feed grains and molasses in the future should result in greater stability in the price of molasses since the price of corn fluctuates less widely than the price of alcohol.

In the past, stable molasses prices at levels considerably below the equivalent feed value of molasses have resulted in increased utilization of molasses as feed. During the four-year period from 1947 to 1950, inclusive, the only sustained period of increased utilization of molasses for feed in the past 15 years, the price of molasses was from 8.6 and 16.0 cents (30 to 50%) below its corn equivalent value.

With greater stability in molasses prices in prospect, it seems entirely possible, as Bode points out, that the price of molasses could be stabilized at a price approximately 10% below the corn equivalent feed value of molasses (*2*). This would require certain positive steps by the molasses industry.

Any attempt to predict the level of corn prices over a 5- to 10-year period would be extremely hazardous; even the USDA outlook forcasts for one-year periods are subject to substantial error. Except for a general inflation or deflation, which would affect all prices, there does not appear, however, to be any reason to believe that corn prices will differ a great deal from present levels for long periods if present support policies continue.

The experience of producers of citrus and hydrol (corn) molasses products indicates that a new molasses product would sell at a discount of 20 to 40% below the price of blackstrap. If the 25% discount prevailing at the present time (July 1, 1953) were required to encourage consumption of wood molasses by the livestock industry, it would be necessary to sell wood molasses for between 5 and 16 cents per gallon f.o.b. Memphis, depending on the method of delivery. Estimates of the cost of producing wood molasses at Memphis in 1951 ranged from 17.6 to 29.9 cents per gallon. New developments outside the feed market or new technical developments in the production of wood molasses would be needed to make its manufacture commercially feasible.

Acknowledgments

The authors are especially grateful to Stefan H. Robock of the Tennessee Valley Authority, Industrial Economics Branch; Nathan Gilbert of the Tennessee Valley Authority, Division of Chemical Engineering; and Philip Jones and his staff in the USDA Production and Marketing Administration, Sugar Branch, for their helpful comment and criticism on earlier drafts of the manuscript.

Literature Cited

(1) *Barron's*, p. 15, June 9, 1952.
(2) Bode, H. E., *The Chemical Economics of Feed Molasses*, Sugar Research Foundation, pp. 6, 25–28. New York: 1951.
(3) *Business Week*, p. 52, May 17, 1952.
(4) *Business Week*, p. 78, Nov. 8, 1952.
(5) Doyle, B. K., *Marketing Industrial Molasses*, U. S. Department of Agriculture, Production and Marketing Administration, Sugar Branch, pp. iv, 33–53 (Dec. 1951)
(6) Doyle, B. K., *Ibid.*, p. 57–67.
(7) *Federal Register*, "CPR 89—Industrial Molasses" (Dec. 5, 1951).
(8) Gilbert, Nathan, Hobbs, I. A., and Levine, J. D., "Hydrolysis of Wood Using Dilute Sulfuric Acid," *Ind. Eng. Chem.*, **44**, pp. 1712–20 (July 1952).
(9) Harper, James E., *Wood*, **39**, pp. 20–22 (Aug. 1947).
(10) Jacobs, P. Burke, U. S. Department of Agriculture, *Misc. Pub.* No. 695, p. 21 (1950).
(11) Jacobs, P. Burke, *Ibid.*, pp. 53–73.
(12) Kutish, L. John, "The Marketing of Feed Molasses," U. S. Department of Agriculture, Production and Marketing Administration, Sugar Branch, pp. 3, 14–15 (Feb. 1950).
(13) Tousley, Rayburn D., "The Economics of Industrial Alcohol," State College of Washington, Bureau of Economics and Business Research, *Bull.* No. 3, p. 37 (1945).
(14) U. S. Department of Agriculture, Bureau of Agricultural Economics, "Economic Considerations in the Use of Urea for Feeding Beef and Dairy Cattle," pp. 1–14 (Sept. 1952).
(15) U. S. Department of Agriculture, Forest Products Laboratory, Madison, Wis. Private communication.
(16) U. S. Department of Agriculture, Production and Marketing Administration, *Sugar Reports*, 9-M, pp. 1–6 (Oct. 1950).
(17) U. S. Department of Agriculture, *Ibid.*, 12-M, pp. 1–4 (Oct. 1951).
(18) U. S. Department of Agriculture, *Ibid.*, 16-M, pp. 3–13 (Oct. 1952).
(19) U. S. Reconstruction Finance Corporation, Private communication.
(20) U. S. Tariff Commission, "Sugar, Molasses, and Manufactures," *Summaries of Tariff Information*, **5**, pp. 24–27, 30–33 (1948).
(21) *Wall Street Journal*, p. 11, July 10, 1952.