MOLASSES - GENERAL CONSIDERATIONS

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INTRODUCTION

Initially the term molasses referred specifically to the final effluent obtained in the preparation of sucrose by repeated evaporation, crystallization and centrifugation of juices from sugar cane and from sugar beets. Today, several types of molasses are recognized and in general, any liquid feed ingredient that contains in excess of 43% sugars is termed molasses. Literature relating to the early history, production and processing of molasses is presented by Madsen (1953) and Anonymous (1959) for sugar beets; by Meade and Chem (1977) and Anonymous (1970) for sugar cane and by Hendrickson and Kesterson (1965) for citrus molasses.

The use of molasses in livestock and poultry feeds dates back into the nineteenth century and has been the subject of several excellent review articles (Scott, 1953; Cleasby, 1963; Van Niekerk, 1980; Waldroup, 1981). In North America, one of the earliest documented reports showing the value of cane molasses in cattle feeding was published by Gulley and Carson (1890), for swine by Lindsey et al., (1907) and for poultry by Graham (1906). The extent to which molasses has been used in animal feeds varies from a small amount used to eliminate dust and feed wastage to serving as the major source of dietary energy.

TYPES OF MOLASSES

The Association of American Feed Control officials (AAFCO, 1982) describes the following types of molasses.

Cane Molasses is a by-product of the manufacture or refining of sucrose from sugar cane. It must not contain less than 46% total sugars expressed as invert. If its moisture content exceeds 27%, its density determined by double dilution must not be less than 79.5^0 Brix. IFN 4-13-251 Sugar cane molasses.

Beet Molasses is a by-product of the manufacture of sucrose from sugar beets. It must contain not less than 48% total sugars expressed as invert and its density determined by double dilution must not be less than 79.5^0 Brix. IFN 4-30-289 Beet sugar molasses.

Citrus Molasses is the partially dehydrated juices obtained from the manufacture of dried citrus pulp. It must contain not less than 45% total sugars expressed as invert and its density determined by double dilution must not be less than 71.0^0 Brix. IFN 4-01-241 Citrus syrup.

Hemicellulose Extract is a by-product of the manufacture of pressed wood. It is the concentrated soluble material obtained from the treatment of wood at elevated temperature and pressure without use of acids, alkalis, or salts. It contains pentose and hexose sugars, and has a total carbohydrate content of not less than 55%. IFN 4-08-030 Hemicellulose extract.

Starch Molasses is a by-product of dextrose manufacture from starch derived from corn or grain sorghums where the starch is hydrolyzed by enzymes and/or acid. It must contain not less than 43% reducing sugars expressed as dextrose and not less than 50% total sugars expressed as dextrose. It shall contain not less than 73% total solids. IFN 4-08-037 Maize sorghum grain starch molasses.

Recent production estimates for the various types of molasses show that of the total United States supply, 60% was cane molasses, 32% was beet molasses, 7% was starch molasses and 1% citrus molasses (Anonymous 1981). As is indicated by these percentages, the production of citrus molasses, starch molasses and hemicellulose extract is quite limited and normally usage is localized near the areas of production.

PRODUCTION AND TRADE STATISTICS

The total production of molasses for 1981-82 is approximately 35 million metric tons (Anonymous 1982b). The U.S. production of all types of molasses as compared to world production is shown in Table 1 (Anonymous 1982a, 1982b)

Table 1. Molasses Production in the U.S. As Compared to World Production

Year	U.S.	World
	---------------Million metric tons---------------	
1978-79	2.02	32.3
1979-80	1.93	29.7
1980-81	2.06	30.9
1981-81	2.12	34.8
1982-83 (est.)	2.08	34.4

The U.S. production of cane molasses comes from Florida, Louisiana, Texas, Hawaii and Puerto Rico. The major consuming areas of the world for molasses are the United States, Canada, Europe and the Far East. The size of this market is about 10-11 million tons, of which 4-5 million tons are produced within the market.

The production of molasses by region is shown in Table 2. Several changes have occurred in recent years causing increases or decreases in several of the regions (Anonymous 1982a, 1982b).

In 1981, total market supplies of molasses available in the United States were approximately 2.8 million metric tons. The percentages of the total United States molasses supply used by various groups were as follows: mixed feeds and direct feeding, 81%; yeast and citric acid, 14%; pharmaceutics, 4%; distilled spirits, 1%; (Anonymous 1982a and 1982b). A further breakdown of the feed utilization percentage shows that of the total used for feed, approximately 65% goes to liquid and feedlot use and 35% is used for dry feed. Baker (1979) reporting on world usage indicated that the animal feed industry was also the principal marketing area in the United Kingdom (75%) and Denmark (95%), whereas in the European Economic Community in general, usage of molasses fell to 58%. Although these utilization percentages have remained relatively constant over the past decade, future use patterns are dependent upon many factors. These include the world supply of sugar, cost of molasses relative to cost of grain, technological advancements in utilization of alcohol

Table 2. Molasses Production in Specific Regions

Country	1978-79	1980-81	1982-83
	------------------Million metric tons	---------------------	
North America	3.40	3.21	3.38
Caribbean	2.14	1.79	1.84
Central America	0.60	0.72	0.82
South America	7.13	7.26	7.86
European Community	2.99	3.19	3.59
Other Western Europe	0.68	0.62	0.72
Eastern Europe	2.13	1.83	2.02
U.S.S.R.	3.31	2.67	2.67
Africa	1.82	1.88	2.11
Middle East	0.69	0.38	0.60
Other Asia	6.68	6.44	7.93
Oceanic	0.66	0.82	0.86

as power and changes in processing techniques. An added usage of molasses in recent years is the production of alcohol. The most successful program is in Brazil where, by 1985, alcohol production from molasses is expected to contribute about 2% of their total energy needs (Baker, 1981).

As a result, Brazil has reduced its molasses exports from about a million tons to the present figure of 635,000 tons. This trend may continue in areas where it is difficult or very expensive to move molasses to ports. In the major consuming areas it appears unlikely that molasses will be used in large quantities as a substrate for the production of power alcohol.

The greatest increase in imported cane molasses (Table 3) in recent years has occurred in Western Europe (Baker, 1981). The grain farmer in this region is protected with very high supports, and molasses always has a favorable relationship to grain prices at almost any level (Kosseff, 1980).

Table 3. Imported Cane Molasses Usage

Location	1973	1978	1981
	------------------Million metric tons	---------------------	
North America	2.55	2.10	1.38
Western Europe	1.50	2.60	2.68
Far East	1.33	1.35	1.05

COMPOSITION

The average composition and selected nutrient content of the various types of molasses is presented in Tables 4, 5 and 6. As is often found with many industrial by-products, the chemical composition of molasses shows wide variation. Its composition is influenced by factors such as soil type, ambient temperature, moisture, season of production, variety, production practices at a particular processing plant, and by storage variables. Consequently, considerable variation may be found in nutrient content, flavor, color, viscosity and total sugar content. The composition data presented in Tables 4, 5 and 6 reflect these differences since these figures were compiled from analysis presented in several publications (Wornick, 1969; Anonymous, 1970; Hendrickson and Kesterson, 1971; NRC, 1971; Curtin, 1973 and NRC, 1979).

Brix

The molasses trade commonly use the term Brix as an indicator of specific gravity and as illustrated in Table 4, represents an approximation of total solids content. Brix is a term originally initiated for pure sucrose solutions to indicate the percentage of sucrose in solution on a weight basis. However, in addition to sucrose, molasses contains glucose, fructose, raffinose and numerous non-sugar organic materials. Consequently, a Brix value for molasses will often differ dramatically

Table 4. Composition and Nutrient Content of Molasses Products Hemicellulose

Item	Cane	Beet	Citrus	Extract	Starch
Brix	79.5	79.5	71.0	65.0	78.0
Total Solids (%)	75.0	77.0	65.0	65.0	73.0
Specific Gravity	1.41	0.41	1.36	1.32	1.40
Total Sugars (%)	46.0	48.0	45.0	55.0	50.0
Crude Protein (%)	3.0	6.0	4.0	0.5	0.4
Nitrogen Free Extract (%)	63.0	62.0	55.0	55.0	65.0
Total Fat (%)	0.0	0.0	0.2	0.5	0.0
Total Fiber (%)	0.0	0.0	0.0	0.5	0.0
Ash (%)	8.1	8.7	6.0	5.0	6.0
Calcium, (%)	0.8	0.2	1.3	0.8	0.1
Phosphorus, (%)	0.08	0.03	0.15	0.05	0.2
Potassium, (%)	2.4	4.7	0.1	0.04	0.02
Sodium, (%)	0.2	1.0	0.3	---	2.5
Chlorine, (%)	1.4	0.9	0.07	---	3.0
Sulfur, (%)	0.5	0.5	0.17	---	0.05
Energy (kcal/kg)					
Swine (ME)	2343	2320	2264	2231	---
Poultry (ME_N)	1962	1962	---	---	---

from actual sugar or total solid content. In fact, Baker (1979) stated that, "With an impure sucrose solution such as molasses, Brix does not represent anything except a number denoting specific gravity and this cannot be related to either sucrose or dry matter content." Regardless, in the United States, Brix is used in the official definition of beet, citrus, starch and cane molasses (AAFCO, 1982).

Sugars

All types of molasses contain relatively large amounts of total sugars or carbohydrates and these compounds constitute the majority of the feeding value of molasses. Sugar mills can control the amount of sucrose extracted and because of this, the sugar content of molasses produced in different countries will vary according to the production technology employed. According to Baker (1981), changes in the design of centrifuges used to separate sugar and syrup constitute one of the major advancements in the cane sugar industry. Continuous centrifugation now results in more sugar extracted with a corresponding decrease in the amount of sugar left in molasses. In the beet processing industry, the Steffen process has been the most efficient and widely used method of reducing the sugar content of beet molasses. More recently, the use of ion exchange resins (Quetin process) extracts more sugar from the beet which decreases the sugar content of molasses about 4%. Another recent development in the separation of sugar from beet and cane molasses is the Finnsugar-Pfeifer and Langen process. The use of this process to date has been mainly restricted to Europe.

Protein

As is presented in Table 4, none of the molasses types contain significant levels of crude protein (N x 6.25). Also, the nitrogenous materials which are present consist mainly of non-protein nitrogen compounds which include amides, albuminoids, amino acids and other simple nitrogenous compounds. These two factors, minimal quantity and quality of protein, would indicate the molasses protein is of limited nutritional value for non-ruminants. The effect of soil type on nutrient content is well illustrated by a Florida report showing that molasses produced from cane grown on organic soils contained 7-10% protein as compared to 3% for molasses from mineral soils (Chapman et al., 1965). However, Combs and Wallace (1973) reported that substituting this molasses protein for corn protein in swine diets resulted in significant decreases in rate and efficiency of gain.

Minerals

In general, the mineral content of molasses has not been considered when formulating diets for swine and poultry. Factors contributing to this situation include: the lack of bioavailability data for the various mineral elements and the wide range of values reported to exist within the various molasses types. However, in comparison to the commonly used sources of dietary energy, mainly cereal grains, the calcium content of cane and citrus molasses is high, whereas the phosphorus content is low. Cane and beet molasses are comparatively high in potassium, magnesium, sodium, chlorine and sulfur. Additional comparisons between types of molasses show that in general, cane molasses is higher than beet molasses in calcium, phosphorus and chlorine, whereas beet molasses is higher in potassium and sodium.

The trace mineral content of cane, beet and citrus molasses is presented in Table 5. Cane and citrus molasses contain higher amounts of copper, iron and manganese than beet molasses. Within a molasses type, the trace mineral variability can be quite high. Curtin (1973) reported that cane molasses contained an average of 297 mg/kg iron with a range of 145-640 mg/kg and that beet molasses contained an average of 65 mg/kg zinc with a range of 4 to 264 mg/kg. Similar ranges also were presented for copper and manganese.

Table 5. Trace Minerals in Molasses

Mineral	Cane	Beet	Citrus
Copper, mg/kg	36	13	30
Iron, mg/kg	249	117	400
Manganese, mg/kg	35	10	20
Zinc, mg/kg	13	40	---

Vitamins

The approximate B-vitamin content of cane, beet and citrus molasses is shown in Table 6. Curtin (1973) reported that processing procedures concentrated the heat and alkali-stable vitamins in the final molasses and that pantothenic acid appeared to be sensitive to some of the processes used in sugar production. In addition to the vitamins presented in Table 6, Baker (1979) reported that cane molasses contained approximately 6,000 mg/kg inositol, 800 mg/kg niacin and 5 mg/kg pyridoxine. In comparison to commonly used grains, the biotin content is quite high in both cane and beet molasses. However, data presented by Curtin (1973) and Olbrich (1963) indicated that the vitamin content of molasses was subject to wide variations. These variations coupled with their relatively low content in molasses tends to diminish their nutritional significance.

Table 6. Vitamins in Molasses

Vitamin	Cane	Beet	Citrus
Biotin, mg/kg	0.36	0.46	---
Choline, mg/kg	745.0	716.0	---
Pantothenic Acid, mg/kg	21.0	7.0	10.0
Riboflavin, mg/kg	1.8	1.4	11.0
Thiamine, mg/kg	0.9	---	---

Energy

As mentioned previously, sugars and soluble carbohydrates account for the major portion of the feeding value of molasses. The metabolizable energy content of the various types of molasses is presented in Table 4. A comparison of these values with commonly used energy feeds in swine and poultry diets is shown in Table 7. Averaging the energy values for barley, corn, oats and wheat shows that for swine, molasses contains only 77% of the energy found in these grains and that with poultry, the figure decreases to 68%. However, in certain countries of the world, molasses is the only inexpensive and available energy source that can be used in livestock and poultry production.

In addition to energy, molasses products also provide other advantages in rations, particularly for ruminants, which are difficult to evaluate on a numerical basis. These advantages include:

1. Increases the palatability of many types of rations.
2. Energy in form of simple sugars is easily digestible.
3. Molasses at times appears to exert a tonic effect.
4. In many feeds it eliminates dust.

Table 7. Comparison of the Metabolizable Energy Content of Molasses with Other Energy Feeds

Feedstuff	IFN	Swine ME (kcal/kg)	Poultry ME (kcal/kg)
Cane Molasses	4-04-696	2343	1962
Beet Molasses	4-00-669	2320	1962
Barley	4-00-549	2870	2640
Corn	4-02-935	3325	3430
Oats	4-03-309	2668	2550
Wheat	4-05-268	3220	2800

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