Trends in Nonsucrose Constituents of Central California Beets

II. Comparison of Molasses Produced at a Straight House and Steffen House.

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This is the second of two papers dealing with the trends of nonsucrose constituents in beets. The first paper concerned itself exclusively with impurities associated with Steffen-house operations(1)[2].

In this paper the relative levels of nonsucrose constituents found in molasses produced at a straight house will be compared with those of Steffen molasses[3]. An attempt will be made to explain some of the differences noted.

Materials and Methods

Samples of daily molasses-produced composites from straight-house and Steffen-house operations were composited on a weekly basis. The samples were stored at ambient temperature.

The methods used to determine the various nonsucrose constituents in molasses have been given in a previous report(2).

Results and Discussion

Total Nitrogen

The nitrogen data presented are averages of the last four crop years. A plot of the total-N content of molasses produced at a straight house as well as a Steffen house is shown in Figure 1. The data are calculated as percentages on beets. The figure indicates that the same general trend of total-N is found in the two types of molasses produced. The major difference seems to be in the relative level.

The levels are higher in Steffen molasses. This is because the amount of molasses produced at a Steffen house, calculated as a percent on beets, is higher, thereby inflating the total-N level.

It should be noted that the trends in the nitrogen content of beets, as shown in Figure 1, are repeated each year at approximately the same time of year. Only the relative amount differs. At the present time we are not completely certain as to the cause of the trends.

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[2] Numbers in parentheses refer to literature cited.

[3] The straight-house factory is located in Manteca, California. The Steffen-house factory is located in Woodland, California.

There is a highly significant correlation between total-N, calculated as a percent on beets, and the following straight-house statistics: molasses produced [+0.65], cossette apparent purity coefficient (apc) [−0.80], and percent nonsugars in cossettes [+0.89]. A lower but significant correlation was also found between total-N and sugar extraction.

The same correlations of Steffen-house data were generally lower than found for straight-house data. However, they were all significant except for cossette apc.

A significant correlation does not exist between total-N, calculated on a beet basis, and cossette percent sugar. This was due primarily to spring campaign data. As can be seen in Figure 1, total-N content of beets declined quite rapidly in beets harvested after March. In order for a significant correlation to exist, cossette percent sugar would have had to show a similar increase. Representative factory data did not indicate that an appreciable increase occurred.

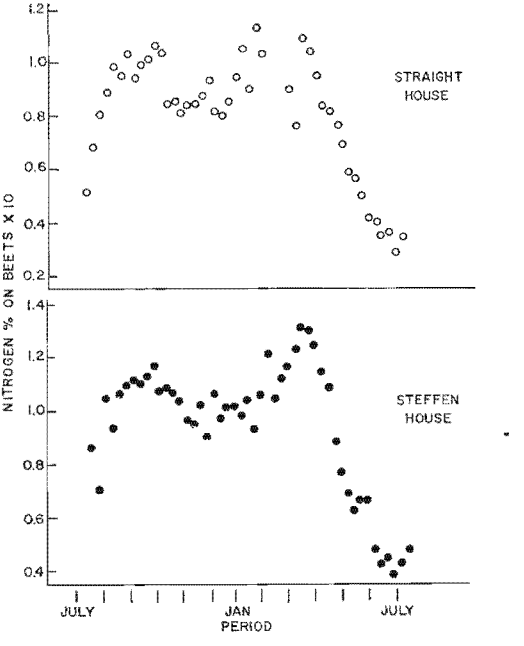

Figure 1.—Total nitrogen in molasses for crop years 1963-1966, straight house and Steffen house.

Amino Nitrogen

Figure 2 contains a plot of the amino-N and PCA-N content of straight-house and Steffen-house molasses produced during the last four crop years. Except for an increase during the February-

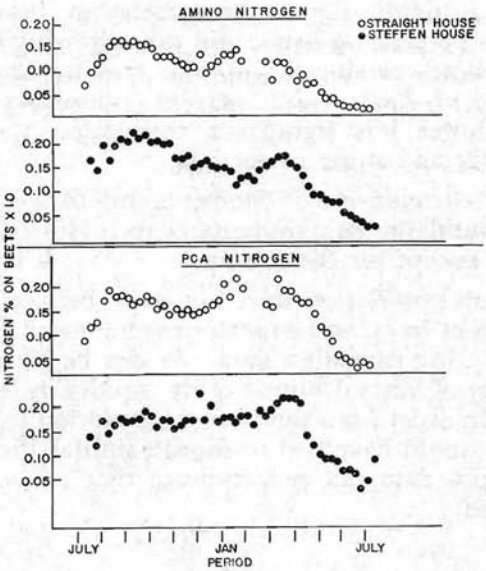

Figure 2.—Amino-N and PCA-N in straight-house and Steffen-house molasses, 1963-1966.

March period for straight house and the December-January period at the Steffen house, amino-N content of beets generally declines throughout the crop year.

Three samples of molasses produced at the Steffen house during the 1966 crop year were analyzed for individual amino acid content using the method of Gehrke (1). The samples represented molasses produced during early fall, late fall and late spring operations. The results are tabulated in Table 1 and are expressed on a nonsugar basis (mM/100 NS).

Of the twelve amino acids, alanine, aspartic acid, glutamic acid and the leucines account for over 70% of the amino acids

Table 1.—Amino acids found in Steffen House molasses, 1966 crop year.

	Early fall		Late fall		Late spring	
Amino acid	mM/ 100NS	rel conc (%)	mM/ 100NS	rel conc (%)	mM/ 100NS	rel conc (%)
Alanine	12.6	24	10.7	21	1.4	31
Valine	4.0	8	2.8	6	0.5	11
Glycine	2.6	5	3.4	7	0.2	6
Isoleucine	4.0	8	3.2	6	0.3	7
Leucine-threonine	3.8	7	2.4	5	0.1	2
Proline	0.5	1	0.3	1	0.3	8
Serine	3.9	8	3.9	8	0.4	9
Aspartic acid	9.9	20	11.1	22	0.5	11
Glutamic acid	7.9	16	9.5	19	0.7	15
Tyrosine	1.7	3	2.3	5	—	—
Total	50.9		49.6		4.4	

found in Steffen molasses. There do not seem to be any big differences in the concentration of amino acids found in early fall and late fall molasses produced. Whereas alanine, valine and proline decline, they are replaced almost quantitatively by an increase in glycine, aspartic acid, glutamic acid and tyrosine. Late spring molasses contain less than 10% of the amino acids which are found in late fall molasses. All of the amino acids decline except proline.

Alanine constitutes approximately 1/3 of the amino acids associated with late spring molasses as compared to 1/4 during the early fall.

The data in Table 1 show that not all of the glutamine or glutamic acid found in the beet was converted to PCA during the factory process. Calculations indicate the conversion to be approximately 85% during the fall campaign, increasing to 95% in the spring.

The amino acids shown in Table 1 account for approximately 70% of the amino-N found using the ninhydrin method of Harris. This is consistent with results reported on the Steffen factory liquors (2).

The average PCA-N content of straight and Steffen-house molasses produced during the last four crop years is plotted in Figure 2. The trends of PCA-N in straight-house molasses follow that of the total-N data. The trends, however, are not quite as prominent.

The PCA-N level in Steffen-house molasses remains quite constant during the crop year until the beginning of March. Here we see a rise through March followed by a decline of almost 80%.

Nitrate and Betaine Nitrogen

A plot of the nitrate-N and betaine-N contents of straight and Steffen-house molasses produced during the last four crop years will be found in Figure 3. The data are calculated as a percent on beets. The straight-house data indicate a general increase in nitrate-N throughout the fall campaign and into the spring. This is followed by a decline.

In contrast, the nitrate-N content of Steffen molasses remains somewhat constant during the fall campaign. Then in the middle of January it increases almost 100%. This is followed by a decline.

The trends and levels of betaine-N, calculated as a percent on beets, are quite similar in the two molasses types. The trends are also similar to those found for total-N.

A summary of the nitrogen data from molasses produced at straight and Steffen-house operations during the last four crop

years will be found in Table 2. The data have been calculated on a nonsucrose basis (mgN/100 NS) to show the relative concentration of the nitrogen components in each molasses.

During the last four crop years straight-house molasses contained an average of approximately 6% more nitrogen com-

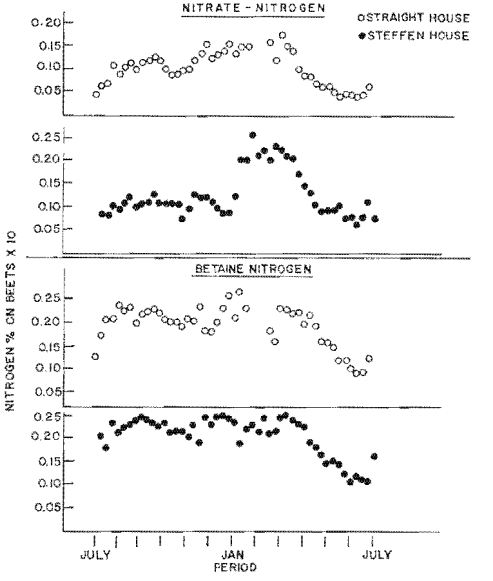

Figure 3.—Nitrate- and betaine-nitrogen in straight- and Steffen-house molasses, 1963-1966.

Table 2.—Summary of nitrogen, Data 1963-1966 crop years, mgN/100 NS.

Straight House						
Nitrogen	1963	1964	1965	1966	Average	Rel . conc %
Total	6107	5794	5950	5099	5738	100
Amino	903	837	767	654	790	14
PCA	1140	1122	1182	886	1083	19
Nitrate	755	648	765	602	693	12
Betaine	1479	1354	1454	1202	1372	24
Other	1830	1832	1776	1757	1800	31

Steffen House						
Nitrogen	1963	1964	1965	1966	Average	Rel conc %
Total	5902	5238	5339	5196	5419	100
Amino	836	852	859	898	861	16
PCA	961	921	878	788	887	16
Nitrate	986	593	776	544	725	13
Betaine	1171	1124	1150	1141	1147	21
Other	1948	1747	1675	1829	1799	34

pounds, calculated on a nonsucrose basis, than was found in Steffen molasses. This difference is due mainly to the betaine-N and PCA-N fractions. Of the nitrogen fractions associated with straight-house molasses, the other-N seems to remain the most constant from year to year, fluctuating approximately 4% during the last 4 years. Nitrate-N fluctuates the most with no consistent trend being evident.

The only nitrogen fraction found in straight-house molasses which shows a consistent trend during the last four crop years is the amino-N. It has declined almost 30% during this period. Of the nitrogen fractions associated with Steffen-house molasses, betaine-N concentration seems to remain quite constant from year to year. Nitrate-N fluctuates the most.

The only consistent trends found in the various nitrogen fractions associated with Steffen molasses produced during the last 4 years are in amino-N and PCA-N. The former has shown a consistent increase from 836 to 898 mgN/100 NS. PCA-N, however, has more than offset this amino-N increase by declining from 961 to 788 mgN/100 NS. The data suggest that either the beets contain less glutamine relative to amino-N or that the conversion of glutamine to PCA in the factory is declining. The latter is probably true.

Approximately 51% of the total amino-N (amino-N plus PCA-N) found in Steffen-house molasses is accounted for as PCA-N. This is much lower than the 58% reported for molasses produced at a straight house. The data suggest that a lower percent of the glutamine and glutamic acid found in beets processed at a Steffen house is converted to PCA.

Inorganic Constituents

The average potassium and sodium content of straight and Steffen-house molasses produced during the 1965 and 1966 crop years have been plotted in Figure 4. The data have been calculated as a percent on beets. The same general trend is prevalent for both molasses types. Only the relative concentration is different.

During the last two crop years a highly significant correlation has been found between potassium, calculated as a percent on beets, and Steffen molasses apc [+0.61]. Correlation of straight-house data indicate a highly significant relationship exists between potassium and molasses apc for the 1965 crop year but not for 1966.

The relative concentrations of potassium and sodium remained quite constant during the last two crop years. The calcium data from straight-house and Steffen-house molasses produced during

the 1965 and 1966 crop years are plotted in Figure 5. The same general trends are evident in both types of molasses. It is interesting to note that the same trends have been found in Steffen-house diffusion juice (2).

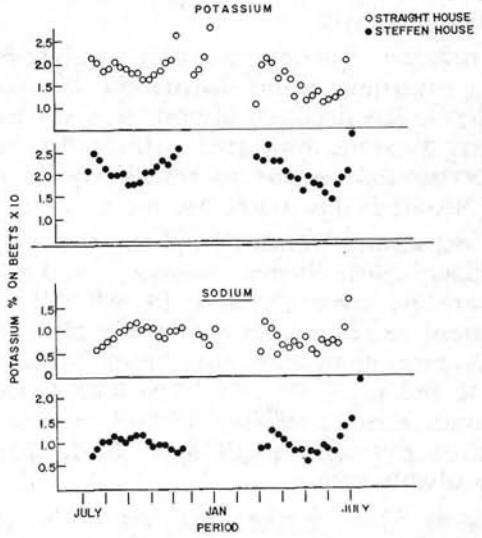

Figure 4.—Average potassium and sodium content of straight- and Steffen-house molasses, 1965-66 crop years.

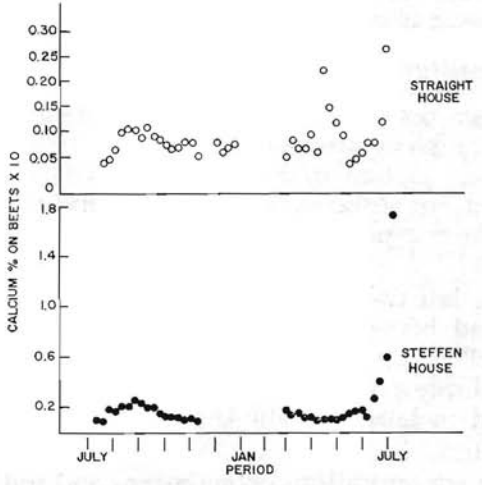

Figure 5.—Calcium data from molasses produced in straight house and Steffen house, 1965-66 crop years.

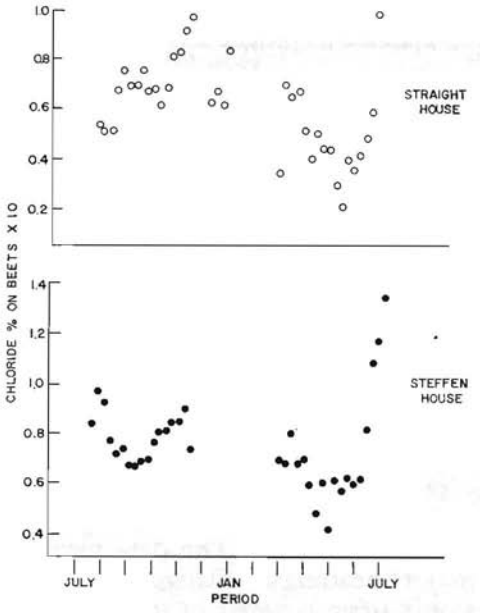

Figure 6.—Chloride data from straight- and Steffen-house molasses, 1965-66 crop years.

Chloride data for the last two crop years are plotted in Figure 6. Of the inorganic constituents studied thus far, chloride seems to fluctuate the most during the crop year and also from year to year. The chloride trends found in the two molasses types vary considerably during the fall campaign. The Steffen data are so widely scattered that it is impossible to find any trend.

A consistently significant correlation between chloride level, calculated as a percent on beets, and molasses apc or true purity data has not been found. This is contrary to data presented by Stark (3).

A summary of the inorganic fractions found in straight and Steffen-house molasses produced during the 1965 and 1966 crop years will be found in Table 3. The results have been calculated on a nonsugar basis (g/100 NS).

Straight-house molasses has approximately 5% more of the inorganic nonsugars studied than Steffen-house molasses. This is due primarily to a higher sodium level.

Calcium levels are much higher in Steffen molasses. This indicates that lime salt production is higher in a Steffen house than a straight house. This would be expected because of the reintroduction of these salts into the factory from the Steffen process.

Table 3.—Summary of inorganic data, 1965-1966 crop years, (g/100 NS).

Inorganic	Straight House	Steffen House
Sodium	6.4	5.6
Potassium	10.8	10.4
Chloride	4.4	4.3
Calcium	0.9	1.1
Magnesium	—	—
Total	22.5	21.4

Table 4.—Nonsucrose content of molasses, 1965-1966 crop years (Relative Concentration)

	Straight House	Steffen House
N-compounds	41	39
Inorganic	23	22
Other NS	36	39

A summary of the nonsucrose constituents found in straight and Steffen-house molasses produced during the 1965 and 1966 crop years is given in Table 4. The data have been categorized under three major headings: nitrogen compounds; inorganic which includes only those covered in this report; and other nonsugars (other NS), presumably carbohydrates and other inorganic. The results are expressed as percentages of the nonsucrose constitutents found in molasses.

The data indicate that the nonsugar fraction of Steffen molasses contains relatively more other NS than straight-house produced molasses. However, it should be noted that at any particular time of the crop year the relative concentration of these fractions will change. This has been explained in an earlier paper on Steffen factory liquors (1).

Summary

The data show that the relative concentration of various nonsugars associated with straight-house and Steffen-house molasses vary considerably during the crop year. In some cases these variations are predictable from year to year. Possibly this information could be used as an aid to predicting optimum harvest time for beets.

The data indicate that straight-house molasses contains relatively more of the nonsugar fraction in the form of nitrogen and inorganic compounds than Steffen produced molasses. This is primarily due to increased amounts of betaine and sodium.

Acknowledgment

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