FACTORS CAUSING DECLINES IN THE SUGAR CONTENT OF BEETS IN IRAN

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It was about 130 years ago that the sugar extraction industry became common in Europe, particularly in Germany and France. At that time the annual production of all sugar producing companies hardly exceeded 50,000 tons the sugar content barley averaged 13 per cent, and the yield of sugar beets per hectare was somewhere between 15 and 20 tons. Since then the efforts of scientists and engineers have resulted in the level of sugar extracted from beets reaching 25 million tons, the sugar content rising to 17 per cent, and the average yield per hectare of land under beet cultivation being tripled. The factors that have contributed to this fast growth are:

1. The rise of yield per hectare through seed improvement and better methods of cultivation.
2. The use of new techniques in the sugar producing industry.
3. The selection of richer seeds which produce beets with a higher sugar content.

The object of this article is to review the progress of the sugar industry in Iran during its thirty-five year life span. (The operations of the Kahrizak factory in 1895 and 1896 are ignored.) A brief review of the history of the industry will constitute an informative preliminary to such a survey.

1. In the year 1931 Kahrizak sugar factory resumed operations after a 35-year stoppage. From the year 1932 onwards, the sugar factories of Karaj, Varamin, Shahi (presently Shahzand), Marvdasht, Shahabad, Abkou and Miandoab were set up with Government capital and started production. Practically speaking, in 1931 the capacity of these factories totalled 3,200 tons of sugar beets per day.
2. The seeds needed to produce sugar beets were purchased entirely from abroad and given to farmers free of charge. Then the Agricultural Department, and later the Ministry of Agriculture, were responsible for the purchase of seeds. At first Germany was the biggest supplier but in subsequent phases

Denmark, Czechoslovakia, Poland, Netherlands and the U.S.S.R. began to export seeds to Iran.

3. In 1936, the Department of Agriculture produced a plant to establish a centre which would concentrate on the improvement and the production of seeds for sugar beets. This centre established in Karaj, started operations in 1939. A foreign expert specializing in the field of seed improvement was employed by the government. In 1953 the centre, according to a seven-article law, was changed into the Seeds Development and Supply Centre and was vested with powers to tackle exclusively the task of seed improvement and supply all over the country.

4. Parallel efforts to produce seeds state-owned sugar factories reached a stage of their industrial development in which they could produce a total of 35,000 tons of sugar in 1940.

5. The outbreak of World War II, and particularly the invasion of Iran by the Allies, eliminated the possibility of obtaining supplies from abroad, and resulted in the consumption of domestic stocks. To prevent the shut-down of factories due to shortages of supplies, the only alternative was to use relatively improved seeds. Everything went well. From 1944 through 1947,more or less improved seeds, and from 1948 up to the present time, improved seeds, have been given to estate and privately-owned sugar factories for use by beet growers.

6. World War II not only affected the supplies but also brought plans for the establishment of new sugar factories - especially plans for the extension of existing factories which were at a standstill.

7. Since 1950, seven public-owned sugar factories have gradually been established in the country. Also, the capacity of a number of the existing factories has been expanded. The assistance and encouragement offered by the government has led to remarkable investments in this line by the private sector. As a result, in 1966 the total production of the government-owned factories reached 10,000 tons, and that of privately owned factories 15,000 tons. The construction of another factory with a capacity of 6,000 tons is now under way. Thus, in three years time, the total daily production is expected to amount to 31,000 tons. This is three times the 1941 figure.

Efforts made during the past 35 years have yielded the following results:

1. *Domestic production of seeds:* All the existing sugar factories of Iran

need an annual supply of about 2,500 tons of seeds. If we were to import this quantity from abrosd (as was the case before September 1941 at 5 rials per kilogram, it would entail a loss of around 125 million rials in foreign exchange.

2. *Yield per hectare:* There has been a marked increase in yield per hectare. By means of seed improvement, use of effective insecticides and fertilizers, intensive farming and the application of modern techniques in agriculture, the yield rose from 10 tons (the normal production before September 1941) to an average of 20 tons per hectare. As a result, the total production jumped from 240,000 in 1940 to the region of 2,000,000 tons in 1966.

3. *Domestic production of sugar from beets:* Parallel with the increase in the area under cultivation and yield per hectare, the production of sugar factories has also increased from 41 tons in 1931, and 35,000 tons in 1940, to over 240,000 tons in 1966.

4. *Sugar content of beets:* Although there has been an accelerated rate of growth in the sugar industry, regretfully, the sugar content of beets has declined considerably. The main object of what follows is to make an attempt to discover the reasons for this decline.

Decline in the sugar content of beets. Table I, which shows the figures relating to consumption and sugar content for every state-owned factory from the date of its establishment till the end of 1966, reveals a continuous decline in the sugar content of the beets used in all factories. We concentrated on state-owned factories for two main reasons:

(i) A number of these factories provide an opportunity to compare the sugar content of crops produced by domestic seeds since 1942 and those produced by foreign seeds before that date.

(ii) Since the period of operation of state-owned factories varies between a minimum of ten years and a maximum of thirty-five years, a study of the fluctuation of sugar content of beets used in these factories will give us a better result.

In addition to Table I we have, in order to give more exact picture of changes in the sugar content of beets, selected one factory as an index and drawn the variation curve for the content of beets consumed by the factory in Figure I. Figure 2 gives the variation curve for the numerical average sugar content for all the factories under study. The Karaj Sugar Factory has been selected as an index for the following reasons:

Table 1

Year	Kahrizak (1)	(2)	Karaj (1)	(2)	Marvdasht (1)	(2)	Shahabad (1)	(2)	Shahsand (1)	(2)	Abkuh (1)	(2)	Miandoab (1)	(2)	T.Haydarieh (1)	(2)	Rezaiyeh (1)	(2)	Fasa (1)	(2)	Chenaran (1)	(2)	Karman (1)	(2)
1932	13645	17.2	3972	18.9																				
1933	4431	18.8	2053	20.5																				
1934	16036	18.7	14079	19.5																				
1935	10723	18.9	21572	19.2	11679	17.6	6405	17.2																
1936	8714	18.7	12680	19.7	28754	18.0	13483	18.8			11945	16.4	5920	-										
1937	4358	17.2	9169	19.2	38141	17.8	15230	17.8			21450	17.2	22659	-										
1938	6614	18.2	13337	18.2	53965	18.5	12373	18.2	11340	20.0	18805	16.6	15962	18.6										
1939	3723	17.7	5871	19.1	54600	18.4	10321	17.0	11030	19.8	54415	17.9	30000	18.6										
1940	8644	17.3	19429	18.8	55698	18.4	27357	17.3	19374	20.8	61358	18.4	35608	19.2										
1941	7760	17.7	16680	19.1	48010	18.2	5536	16.0	12253	20.1	54527	18.3	6660	20.0										
1942	6359	17.0	11064	17.4	18375	18.4	3815	16.0	13308	18.8	26801	17.9	13698	17.9										
1943	6147	18.3	16227	18.5	46198	18.2	4769	16.5	10350	18.2	46399	18.5	21970	17.9										
1944	6061	16.7	25057	17.9	46330	17.6	5405	15.2	13877	17.8	42270	17.8	38598	18.0										
1945	6598	16.4	23029	16.4	34996	17.7	5032	15.3	15152	17.6	65034	18.2	26870	17.9										
1946	10659	17.3	29624	16.7	50901	18.1	15044	17.3	32839	17.5	62389	14.8	33766	18.3										
1947	11264	17.3	38182	17.8	87179	17.6	41919	17.7	45236	18.4	79220	17.3	49930	18.7										
1948	8132	17.5	29707	17.4	62080	17.7	19382	17.2	20847	16.7	70702	17.7	30971	17.6										
1949	6937	17.3	13272	18.0	57107	18.0	16345	17.5	13332	17.8	74955	17.9	13919	18.5										
1950	12306	17.4	41573	17.8	93558	17.5	52885	17.8	35100	17.9	106502	17.0	36764	19.5			5173	18.4						
1951	14268	16.2	39230	17.5	132716	17.0	53076	17.3	44863	17.5	127001	16.7	38183	18.2	23670	17.6	33314	18.5						
1952	16584	16.2	45373	18.1	88790	17.5	46020	17.2	42898	18.0	109482	17.3	59003	18.8	43301	17.8	32682	18.8						
1953	16936	15.7	47987	16.2	126466	17.6	21560	16.6	40507	14.7	144573	15.6	57267	17.8	42479	16.7	38448	17.5						
1954			31321	16.8	100514	17.5	42263	17.0	40004	16.5	102267	17.1	46268	17.3	47932	17.6	31121	17.3	2199	16.6				
1955	5674	16.7	31141	17.8	105202	17.2	56631	17.7	36032	17.7	109475	17.7	68479	17.1	57480	17.2	37802	17.4	13800	16.7				
1956	7129	16.7	24250	18.1	138491	16.1	48496	18.2	37841	16.0	125385	17.5	57496	18.4	75357	17.9	38050	17.6	28297	16.7	2340	15.4	5408	17.5
1957			35580	15.4	151181	17.0	53801	16.4	31940	16.3	108571	16.9	48539	17.4	112736	16.6	29381	16.2	53801	16.4	42492	17.6	25175	18.1
1958			40015	17.4	160252	16.7	62550	16.8	44476	16.7	132358	16.4	49125	18.9	107430	16.4	48757	17.1	62550	16.8	55294	17.9	24629	17.9
1959			33269	18.2	121526	16.6	54010	16.8	46012	17.2	95777	16.5	60038	18.2	80502	17.0	42733	17.5	54010	16.8	48369	17.9	35610	16.2
1960			19791	17.4	158898	17.0	37165	17.5	24808	16.9	88131	17.5	48370	17.9	70854	17.8	32256	17.0	37665	17.5	52381	18.5	38029	17.6
1961			15250	17.8	108102	17.0	39517	17.0	32370	17.6	100146	17.4	48065	18.0	83851	17.1	30517	17.3	39517	17.0	54664	18.7	39516	16.8
1962			44099	16.7	89654	17.1	37956	16.7	43498	17.0	104138	16.9	50402	17.8	75882	16.2	40925	16.8	37956	16.8	55155	17.9	45727	17.4
1963			42028	16.7	71328	15.6	18518	16.7	36347	16.9	116498	15.8	32966	18.0	98610	15.9	44102	16.2	18518	16.7	76628	17.3	39221	17.1
1964			33940	16.7	57182	15.6	39911	16.0	30333	16.4	100702	16.2	40813	18.0	84038	16.4	40621	17.3	37911	16.0	54607	17.1	32505	16.3
1965			62231	15.7	105170	17.4	58000	16.0	34402	16.7	107589	16.1	53271	16.4	74995	16.4	46028	15.8	58000	16.0	69660	17.7	38607	17.8
1967			74510	15.6	89216	17.3	62995	16.4	54690	17.2	142506	16.4	58930	16.0	108467	15.8	54135	15.2	54135	16.0	130926	17.5	42669	17.8

(1)Consumption in tons. (2)Content (per cent).

Figure 1

Changes in the sugar content of beets used at the Karaj Sugar Factory
From 1932-1966

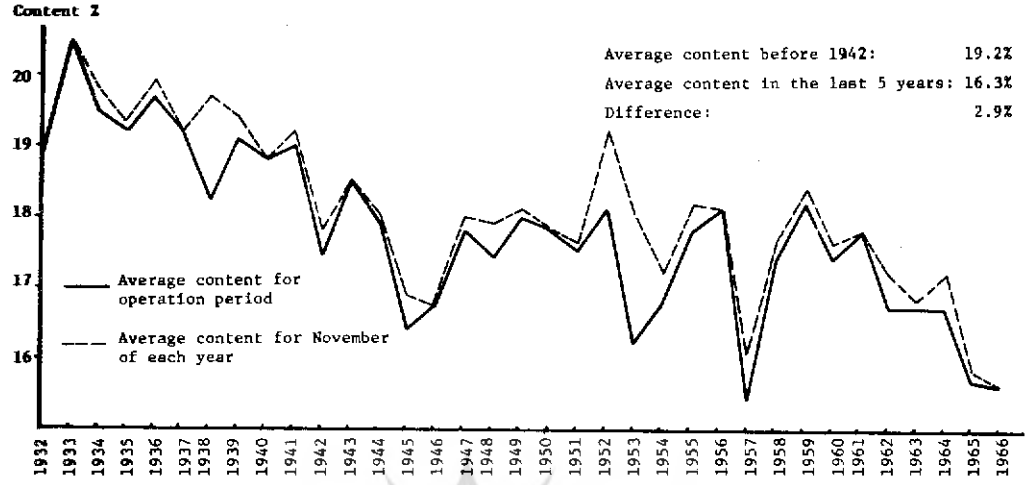
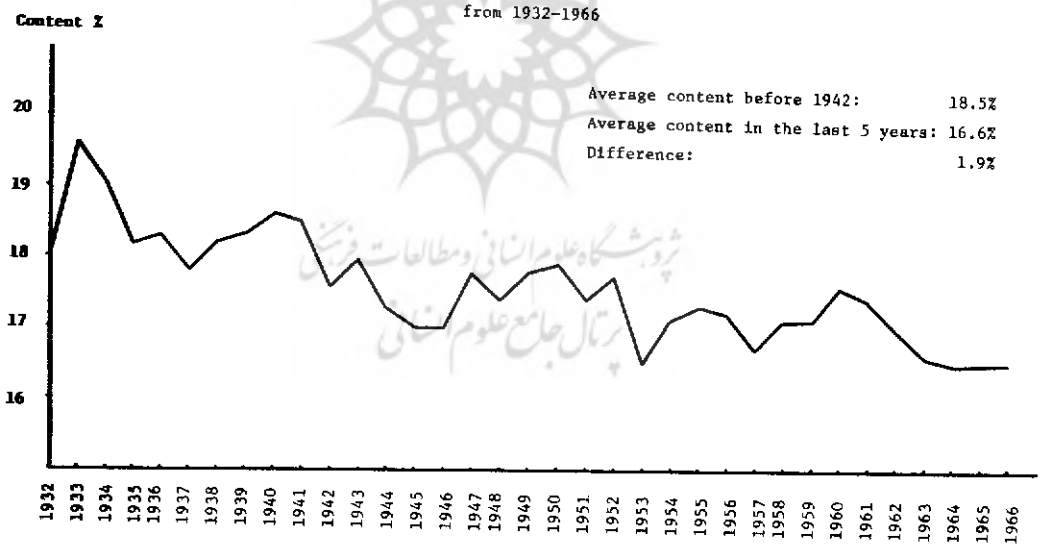


Figure 2

Changes in the sugar content of beets in State-Owned Factories
from 1932-1966



(i) It is the oldest of the sugar factories now operating in Iran, having been established some 35 years ago.

(ii) This factory, together with the agricultural area from which it obtains its beets, is close to the Seeds Improvement Centre. Thus it has always been possible for specialized experts to observe fluctuations in sugar content at close range both in the farms and in the factory.

Figure 2 has been drawn on the basis of the numercial average sugar content of beets. The average sugar content over the amount consumed has been calculated and analysed and found to be approximately similar to the results obtained from Figure 2. The following summarizes the conclusions reached from Table 1 and Figure 2.

1. The sugar content of beets from all factories had been in continuous decline during the period under survey.
2. Diminishing productivity was more pronounced in the years 1942-47 than in the years preceding 1942. This can be explained by the fact that during this period domestic seeds were little improved.
3. The relative decline for the years 1947-52 is not so pronounced as the decline in the previous period. The factor which braked the rate of decline was the use of fully improved domestic seeds.
4. Fluctuations in the average sugar content have been even less in the period 1952-1960.
5. The systematic decline that has taken place in the years 1961-1966 is alarming, the only comfort being that the curve is steady for the last three years.

An analysis of the graph representing the sugar content of beets for our model factory (Karaj) leads to similar conclusions.

Since there is ample statistical evidence to prove the continuous decline in the sugar content of beets in this country, an effort must be made to find the reasons for it. For some time there have been disputes between the producer of seeds (the Ministry of Agriculture) and the consumers (the owners of sugar factories) about this downward trend. The consumers say that the process of seed improvement exerts a downward pressure on the sugar content of domestic seeds, whilst the producers and the experts from the Institute for the Improvement of Seeds and Saplings either disagree or hold that the apparent decline in sugar content is due to factors which do not concern the quality of the seed itself.They cite sowing, harvesting and storing me-

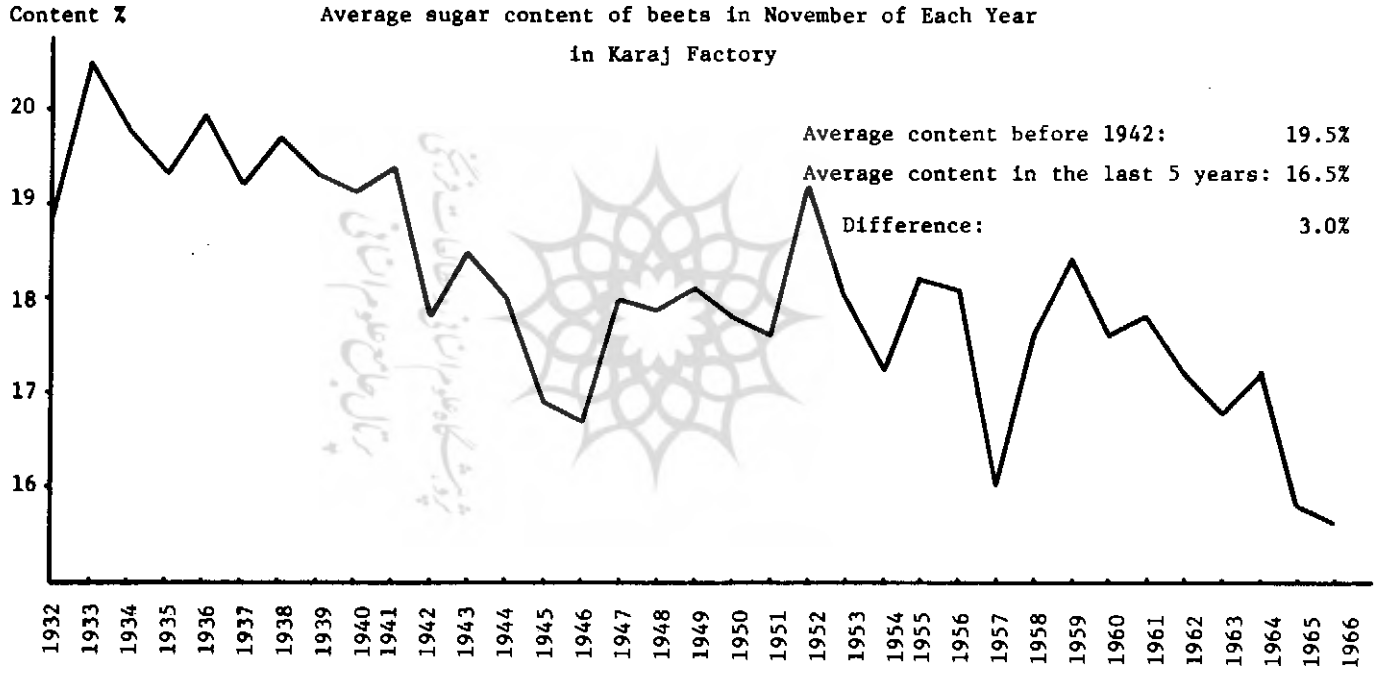
thods as possible culprits. However, this clash of view is really a result of the fact that, in Iran, sugar beet is traded according to its weight so that, on the one hand it is the farmer's interest to produce larger and heavier beets regardless of sugar content, and on the other hand it is the sugar manufacturer's interest to buy smaller, lighter beets with a higher sugar content.

From the point of view of the national economy, a higher sugar content for beets is essential. If the joint efforts of the factory owners and the specialists in seed improvement bring about only a 5 per cent boost in sugar content, as well as an increase in the output of beet seeds per land unit, then, by 1971, we should expect an increase of 18,600 tons in sugar production. By that year as well, the capacity of the sugar factories of Iran should reach 31,000 tons of sugar beets per day (over 120 days of operation). Thus, from the point of view of increasing sugar production, an increase in the sugar content of beets is crucial. However, there are other factors which exacerbate the decline in sugar content besides the seeds and these will be studied by comparing the present situation with the pre-1941 situation.

Possibly the extractable sugar content is lowered through the production of beets in excess of the normal capacities of the sugar factories. The average length of the production period in the factory under review, especially during those years in which there has been a drop in production, is normally over 100 days. The extractable sugar content at the beginning and towards the end of the production period is definitely less than in the midway period. This we can safely say that, the longer the time span of production, the greater the decline in the sugar content of beets will be. This argument is justified because (a) the utilization of unripe beets at the beginning of Mehr (late September) reduces their sugar content and; (b)storing the beets in unsuitable places such as wrongly constructed silos and factory compounds, or keeping them rooted in the soil, means that a decline in their sugar content is inevitable.

However, it is possible that factors other than the long time-span of production are involved and indeed a survey of the fluctuations in different months, over a period of years, reveals a continuous downward trend as compared with the corresponding month of previous years. Further support for this contention can be gained by refering to Figure 3 denoting the fluctuations in the sugar content of beets in the Karaj factory from the first year

Figure 3


Content %
Average sugar content of beets in November of Each Year
in Karaj Factory
20
19
18
17
16
Average content before 1942: 19.5%
Average content in the last 5 years: 16.5%
Difference: 3.0%
1932
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1966

of its establishment to 1966. The diagram shows a continuous decline in sugar content regardless of the length of the production period. Moreover, a comparison of the sugar content of beets in the production periods prior to 1943 (when imported seeds were used) shows an inevitable decline, other parameters being constant. The following figures confirm this statement.

Example 1: Karaj sugar factory:

Year of operation	Total consumption of beets (in tons)	Average sugar content in production period (per cent)
1934	14,079	19.5
1949	13,272	18.0

Example 2: Kahrizak sugar factory:

1934	16,036	18.7
1952	16,584	16.2
1953	16,936	15.7

Example 3: Kahrizak sugar factory:

1935	10,732	17.9
1945	10,659	17.3

Example 4: Kahrizak sugar factory:

1941	7,060	17.7
1956	7,129	16.7

Example 5: Marvdasht sugar factory:

1940	55,698	18.4
1949	56,107	18.0

Example 6: Shah-zand sugar factory:

1940	19,274	20.8
1948	20,847	16.7

Example 7: Shah-zand sugar factory:

1942	13,308	18.8
1949	13,332	17.8

Example 8: Abkuh sugar factory:

1940	61,358	18.4
1945	65,036	18.2

From the above figures, from Figures 2 and 3, and from a comparison with the pre-1941 situation, we can draw the following conclusions:

a. The average sugar content of beets used by all government factories in the years preceding 1942 was 18.5 per cent of the total weight, whereas it has been 16.6 per cent in the last five years (making an average decline of 1.9 per cent).

b. The average sugar content of beets used by the index (Karaj) factory in the years preceding 1942 was 19.2 per cent of the total weight. Over the last five years this has been 16.3 per cent. The average decline is, therefore, 2.9 per cent.

c. A close study of the diagram showing the fluctuations of sugar content during the month of November for the Karaj factory reveals that prior to 1942, the average sugar content was 19.5 per cent of the total weight and that the same figure for the last five years is 16.5 per cent. The decline is, therefore, 3 per cent of the total weight of the beets.

Before we go on to ask what other factors, besides the length of the production period, can be found, we will assume that the average decline in the sugar content of beets has been 1.9 per cent, the smallest of the three figures involved.

Another possible cause is the lack of trimming of the sugar beet on the farms. There is less sugar in the two ends of the beet root but, since beets are purchased on the basis of weight, farmers try to deliver their product without trimming it in the hope of gaining larger profits. However, farmers did not trim their beets before 1942 either, so not much of the relative decline in sugar content cannot be attributed to this factor.

But despite this the effect of this practice should be closely examined. Research indicates that 19.2 per cent of the beet weight is attributable to its head and bottom and the remaining 80.8 per cent is its middle or main body. The sugar content of the ends is only 14.61 per cent of its weight, whilst that of the main body is 17.78 per cent. Experiments carried out in Iran have produced the same figures. If, therefore, we take a factory with a capacity of 1,000 tons of sugar beets per day (24 hours), assume that it operates for 100 days per year, and further assume that the waste of sugar due to trimming to be about 3 per cent of the total weight, then the total waste of sugar for untrimmed beets in a single day will be 609 tons.

The calculation has been made as follows:

$$\frac{100 \times 1{,}000\ (17.78 - 3)}{100} - \frac{100 \times 808\ (17.78 - 3)}{100} \quad \frac{100 \times 808\ (14.61 - }{}$$

Another easy calculation will show that this 609 tons of sugar waste due to untrimmed beets is equivalent to a reduction of 6 per cent in the sugar content of beets over the entire period of active production. It is therefore proved that bad trimming of beet roots was one of the reasons for the decline in sugar content before 1942. However, it is important to see what proportion of the subsequent 1.9 per cent decline is due to this factor. Even though roots have never been trimmed, since beet production has doubled after 1942, the effect of not trimming the beets has been dramatized and only about 3 per cent of the decline can be attributed to it.

The average yield per hectare for sugar beets has climbed from 10-13 tons in the years preceding 1943, to a maximum of 20 tons at the present time. During the past five years this increase has been due to the utilization of tractors, timely sowing and harvesting, chemical fertilizers and pest control with effective insecticides. However, most of this increase has been in the average weight of the beet roots, and since the larger roots have a lower sugar content than the smaller ones, this is a factor partly responsible for decline in the sugar content of beets. One might wonder why this is so in Iran because, in the advanced nations over the past 130 years, the yield per hectare has been raised from 15-20 tons to over 40 tons and at the same time the sugar content of beets has been increased from 13 per cent to 17 per cent.

The experiments I have carried out during the last thirty years have shown that the sugar content of larger beet roots (over 1 kilogram at the time of reaping) is about 1 per cent less than that of smaller ones (under 1 kilogram) from the same farm. This experiment has been carried out frequently, before and after 1942, in public as well as in private factories, and the result has been consistent. Because the beet production per hectare has doubled since 1942 the reduction in the sugar content due to outgrowth of beets has not been more than 0.5 per cent of their total weight. In other words, since the average weight of domestic grown beet roots does not exceed 1 kilogram each, we cannot attribute more than 0.5 per cent of the reduction in the sugar content of beets to its outgrowth. On the other hand, the relative weight of the two ends of a large beet root (over 1 kilogram) is considerably more than that of a small one (under 1 kilogram) and since the influence of this factor has already been calculated, the 0.5 per cent figure is

quite reasonable.

To elucidate the point further we shall present the following figures (indicating the four operation periods in the Marvdasht Sugar factory where the writer was in charge):

Year of Operation	Utilized beets (tons)	Sugar content %	Average yield per hectare (tons)
1937	38,141	17.8	11
1938	53,965	18.5	13
1939	54,600	18.4	13
1940	55,698	18.4	13.5

A close study of the above figures will show that the increase in production per hectare (at the time when imported seeds were sown) has not influenced the sugar content of beets. By refering to the the table we see that with a yield of 11 tons per hectare, the sugar content of beets has amounted to 17.8 per cent, whereas when the yield has reached 13.5 tons per hectare (an increase of 20 per cent)and the percentage of sugar content has jumped to 18.4 per cent. That is, an increase of 0.6 per cent of the weight of the beets.

Optimists might claim that the sugar content of beets has not actually decreased, but that deliberately underestimated in the books of the sugar factories to account for the wastage of sugar during the production process. However, in the light of my own experience as well as the existing situation in public and private factories, I can say that the above assertion is totally unfounded. Some factories may deliberately underestimate the sugar content of beets by only a fraction of one per cent, but this process cannot be carried on throughout the year, on each day of operation, in all factories. Even if we accept the assertion, there is no reason to believe that it was not practised even in the years when imported seeds were grown.

Conclusion

This survey leads us to two conclusions. Firstly, that the sugar content of beets grown from domestic seeds is about 1.9 per cent less than that of beets grown from seeds, before 1943. Secondly that, although 0.3 per cent of the decline can be attributed to the fact that the beets are not trimmed,

and 0.5 per cent of the decline can be attributed to the overgrowth of the beet roots, 1.1 per cent can only be attributed to the attempt to improve the seeds. It is worth noticing that the sugar content of beets grown in from Hamadan produced seeds is far greater than that of seeds produced in other areas, the worst being those of Ardabil.

No one questions the competence of those engaged in seed of improvement, or their honesty,however, they have adequate material and technical facilities at their disposal, and therefore we are entitled to expect better results in this area especially in view of the amount of irrigation facilities and sun available in Iran. Unfortunately, the opposite has been true and this 1.1 per cent decline means a loss of about 22,000 tons of sugar over an annual beet production of 2 million tons. If an increase in the sugar content had accompanied the increase in yield per hectare, the national economy would have benefited, investment would have been encouraged in this sector, and the price of sugar would have fallen a little. The writer is certain that those who are responsible for the improvement of beet seeds do not accept the view that the quality of the seeds influences the quality of the beets.

To clarify the issue further we shall take a look at the sugar industry in Turkey where climatic conditions resemble Iranian conditions quite closely. There the German firm of Klein and Anslin produce the required beet seeds and hand them over to the farmer. Despite the long periods of operations and the high yield of sugar beets per hectare in Turkey, the average content of Turkish beets was higher than Iranian ones over the last three years. In 1966 the average sugar content of Turkish beets was around 17.08 per cent whereas in Iran it was 16.5 per cent about 0.5 per cent less.In the years 1964 and 1965 the figures were similar.

A study of the figures presented in Table 1, using modern statistical techniques, yields even clearer results. Table 1, which is a crude table, gives the sugar percentages by factory and year. The blank spaces are due to the fact that some factories have not yet started operations and a few, like the Kahrizak factory have been closed for the past 35 years. If we were to calculate the averages according to the available statistics, distortions in our data, owing to the lack of information for some factories, would mark our conclusions. Therefore, we have used the "fitting constants method" in order to fill in the existing blanks. If a reciprocal effect does not exist between the years and the factories i.e. if the sugar content curves for

Table 2

Year	Kahrizak	Karaj	Marvdasht	Shahabad	Shahzand	Abkuh	Miandoab	T.Haydarieh	Rezayeh	Fasa	Chenaran	Kerman	Average
1932	17.65	18.41	18.20	17.74	18.54	17.90	19.02	18.32	18.41	17.96	19.09	18.80	18.34
1933	19.22	20.05	19.82	19.32	20.19	19.49	20.72	19.95	20.05	19.56	20.79	20.47	19.97
1934	18.70	19.51	19.28	18.80	19.64	18.96	20.15	19.42	19.51	19.03	20.23	19.91	19.42
1935	17.86	18.63	18.41	17.95	18.76	18.11	19.25	18.54	18.63	18.17	19.31	19.02	18.55
1936	17.95	18.72	18.51	18.04	18.86	18.20	19.34	18.63	18.73	18.26	19.41	19.12	18.64
1937	17.50	18.26	18.03	17.59	18.38	17.75	18.86	18.17	18.26	17.81	18.92	18.64	18.18
1938	17.61	18.37	18.16	17.70	18.50	17.86	18.98	18.28	18.37	17.92	19.04	18.76	18.29
1939	17.79	18.55	18.34	17.87	18.68	18.03	19.17	18.46	18.56	18.10	19.23	18.94	18.47
1940	18.13	18.91	18.69	18.22	19.04	18.38	19.54	18.82	18.91	18.45	19.60	19.31	18.83
1941	17.99	18.76	18.55	18.07	18.89	18.23	19.38	18.67	18.76	18.30	19.45	19.15	18.68
1942	17.08	17.81	17.60	17.16	17.93	17.39	18.40	17.72	17.81	17.37	18.46	18.18	17.74
1943	17.46	18.22	18.00	17.55	18.34	17.71	18.82	18.12	18.22	17.77	18.88	18.59	18.14
1944	16.74	17.46	17.26	16.82	17.58	16.97	18.04	17.37	17.46	17.03	18.10	17.82	17.38
1945	16.53	17.25	17.05	16.62	17.37	16.76	17.82	17.16	17.25	16.82	17.88	17.61	17.17
1946	16.59	17.30	17.10	16.67	17.42	16.82	17.87	17.22	17.30	16.88	17.94	17.66	17.23
1947	17.29	18.03	17.82	17.37	18.15	17.52	18.63	17.94	18.03	17.59	18.69	18.41	17.95
1948	16.88	17.61	17.40	16.96	17.73	17.12	18.19	17.52	17.61	17.18	18.25	17.98	17.53
1949	17.31	18.05	17.84	17.39	18.18	17.55	18.65	17.97	18.05	17.61	18.71	18.43	17.97
1950	17.33	18.07	17.87	17.41	18.20	17.57	18.67	17.99	18.07	17.63	18.73	18.45	18.00
1951	16.92	17.65	17.44	17.01	17.77	17.16	18.23	17.57	17.65	17.22	18.30	18.02	17.58
1952	17.14	17.88	17.67	17.23	18.01	17.38	18.48	17.80	17.88	17.44	18.54	18.26	17.81
1953	15.93	16.62	16.43	16.01	16.73	16.15	17.17	16.54	26.62	16.21	17.23	16.96	16.55
1954	16.59	17.30	17.10	16.67	17.42	16.82	17.88	17.22	17.30	16.88	17.94	17.66	17.23
1955	16.80	17.52	17.32	16.88	17.64	17.03	18.10	17.44	17.52	17.09	18.16	17.89	17.45
1956	16.52	17.23	17.03	16.60	17.35	16.75	17.80	17.15	17.23	16.81	17.86	17.59	17.16
1957	16.07	16.76	16.57	16.15	17.31	16.29	17.32	16.68	16.76	16.35	17.38	17.11	16.69
1958	16.47	17.18	16.99	16.56	17.31	16.70	17.75	17.10	17.18	17.18	16.76	17.80	17.54
1959	16.46	17.17	16.98	16.55	17.29	16.69	17.74	17.09	17.17	16.75	17.80	17.53	17.10
1960	16.70	17.52	17.32	16.88	17.64	17.03	18.10	17.44	17.52	17.09	18.16	17.89	17.45
1961	16.71	17.43	17.23	16.79	17.55	16.94	18.01	17.44	17.52	17.09	18.16	17.89	17.45
1962	16.33	17.04	16.84	16.42	17.16	16.56	17.60	16.96	17.04	16.62	17.66	17.40	16.97
1963	15.95	16.64	16.44	16.02	16.75	16.17	17.18	16.55	16.64	16.23	17.24	16.98	16.56
1964	15.86	16.55	16.36	15.94	16.66	16.09	17.10	16.47	16.55	16.14	17.16	16.90	16.48
1965	15.86	16.55	16.36	15.94	16.66	15.09	17.10	16.47	16.55	16.14	17.16	16.90	16.48
1966	15.79	16.47	16.28	15.87	16.58	16.01	17.01	16.39	16.47	16.07	17.07	16.81	16.40
	17.02	17.75	17.55	17.10	17.87	17.26	18.34	17.67	17.75	17.32	18.40	18.12	17.68

various factories run parallel to each other, we can fill in the blanks. We found that, if we calculated the logarithms of sugar content figures instead of percentages, we could safely dispose of any reciprocal effect which normally exists between factories and years of production. Thus, we made all the calculations and fitted the constants according to logarithms. After estimating the relevant figures for the whole table, we reversed the process, computed the corresponding anti-logarithms, and filled in the blank squares with the corrected estimates of sugar percentages by year for all the factories. These are shown in Table 2. In this table a column has been allocated to the average for all factories, for each year, and a line to the average for each factory. Fluctuations in the average sugar content for the 12 factories are shown on Figure 4.

Table 3

The three year moving averages

Year	Ave.	Year	Ave.	Year	Ave.	Year	Ave.	Year	Ave.
1932	-	1939	18.66	1946	17.45	1953	17.20	1960	17.20
1933	19.24	1940	18.42	1947	17.57	1954	17.08	1961	17.26
1934	19.31	1941	17.75	1948	17.82	1955	17.28	1962	16.96
1935	18.87	1942	17.56	1949	17.83	1956	17.10	1963	16.67
1936	18.46	1943	17.26	1950	17.85	1957	16.99	1964	16.51
1937	18.31	1944	17.45	1951	17.80	1958	16.97	1965	16.45
1938	18.53	1945	17.57	1952	17.31	1959	17.22	1966	-

Figure No. 4 demonstrates the above figures in the form of a graph. Although there is a consistent decline in the percentage of sugar, five distinct periods can be clearly identified: 1932 - 1938, 1939 - 45, 1946 - 54, 1955 - 58 and 1959 - 66.

Figure 4

Moving Averages for 3 years

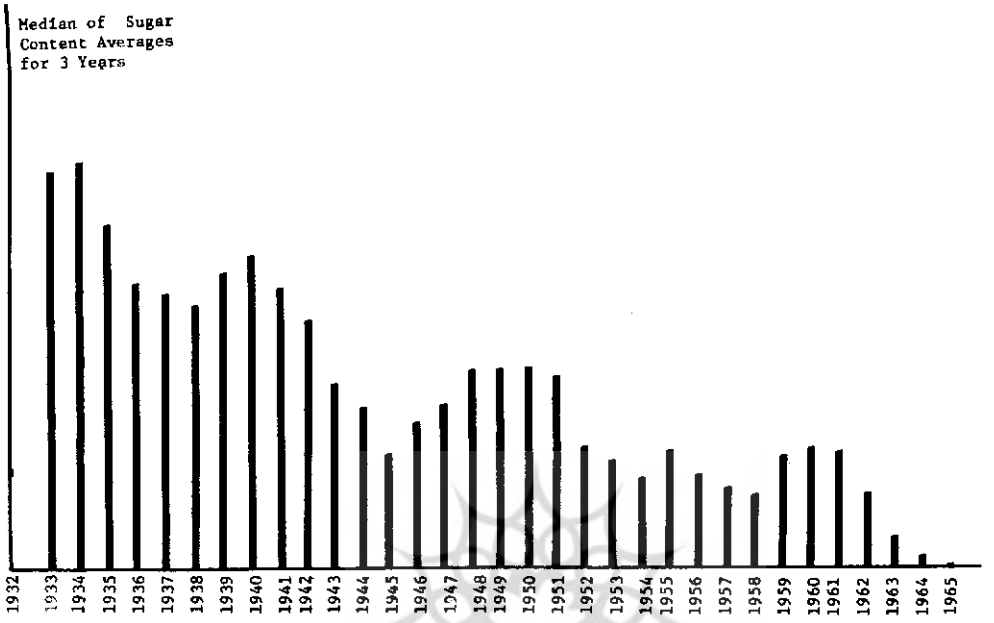
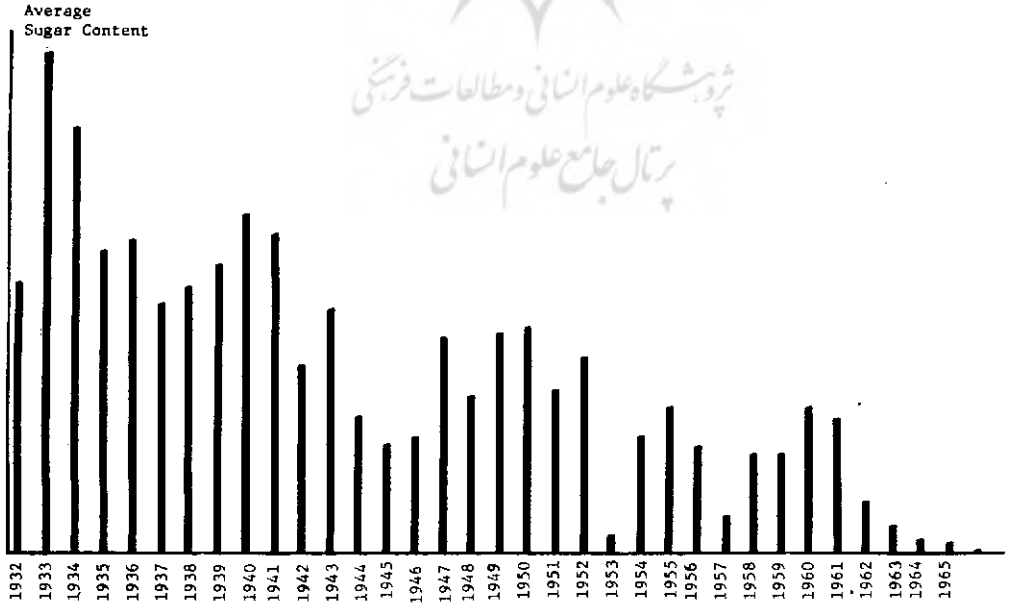


Figure 5

Average Sugar Content by Annual Fluctuations for 12 Factories



A comparison of Figures 2 and 5 shows a continuous downward trend in the sugar content of beets in Iran, and this is proved by using either the numerical of the statistical method. If we attempt to measure the influence of seed improvement on this continuous annual decline, which is unfortunately a general feature of all Iranian sugar factories, we come to the conclusion that the factors involved in the method of cultivation are responsible for a decrease of 1 to 2 per cent instead of 0.8 per cent, and consequently, a decline of 0.9 to 1.1 per cent is exclusively attributable to the seed.

However, to avoid being misled by statistics, and to verify these conclusions further, we propose that the following experiment be carried out:

1. The sugar factory in Bardsir, Kerman, should taken as a case study. It is a suitable factory in this respect because; a) it is one of the smallest in the country, needing the least quantity of seeds; b) its location in a remote area means that seeds cannot be delivered to it from other regions; c) even though foreign seeds have never been used here in the past, we can obtain a major clue to the decline in sugar content by comparing the average output for future experimental years (1968-70), with that of the past ten years.
2. Any seeds currently at the disposal of growers, or available at the factory's warehouses should be collected in the summer of 1967.
3. 75 tons of seeds should be purchased from a reputable foreign seed improvement and producing organization (such as Klein and Anslin of Germany),and delivered to the factory for the cultivation of 3,00 to 4,000 hectares of land in 1968, consisting of types A, E and Z in equal parts.
4. The same type of foreign seed should be used for the 1969 and 1970 crops.
5. The sugar content of beets produced in the years 1968 to 1970 should be compared with that of previous years.

If, after this experiment, the use of foreign seeds should prove to be an ineffective remedy, then the present controversy would be over, and the Institute of Seed Improvement should carry on its work as before.However, if the use of foreign seeds proves to be effective in raising the sugar content of beets, then the responsible authorities should base their decision on a rational judgment which takes account of the interests of the nation and of those who have invested in the sugar industry.

A brief estimate of the costs of the experiment shows that good quality

seeds, when delivered to the Kerman Factory for 50 rials per kilogram will mean an outlay of 3,750,000 rials in foreign exchange every year, including unforseen expenses. This would mean 12 million rials over a period of three years. As the factory owners are already paying 30 rials per kilogram for the seeds purchased from the Seed Improvement Institute, over half this sum is therefore depreciated.