PRESERVATION OF CHEMICAL AND ORGANOLEPTIC PARAMETERS IN DIFFERENT VARIETIES OF HAZELNUTS IN NITROGEN AND IN AIR.

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ABSTRACT

The paper describes storage experiments carried out with three varieties of shelled hazelnuts (cv. Roman, Piedmontese and Akcakoca). The object of the work was the evaluation, based on chemical and organoleptic analyses, of the storability in nitrogen as compared with traditional methods.

Storage was carried out at room temperature (approx. 22°C) in pure nitrogen in microsilos and in an apparatus simulating a silo of twenty meters height. Controls in air were kept in bags at - 20°, + 4°, + 35°C and at room temperature. Moisture content remained nearly constant in hazelnuts stored under nitrogen, while it decreased in the control samples. Lipolytic activity was higher in the nuts preserved in nitrogen because of the higher moisture content as shown by fat acidity analyses. On the other hand the anoxic environment slowed down the oxidative activity and preserved better organoleptic properties.

Fat, sugar and protein contents did not change during storage. After one year of storage, hazelnuts preserved in nitrogen rated significantly better in organoleptic tests than those in air at room temperature and slightly better or equal to those at low temperature.

Storability in nitrogen of the three cultivars studied decreased in the order: Piedmontese - Roman - Akcakoca. High mechanical pressure had an adverse influence on storability.

INTRODUCTION

In the course of recent years serious deteriorations occurred repeatedly during the storage of hazelnuts used by confectionary industries. On the basis of the result of storability studies (Radtke and Heiss, 1971; Barthel et al., 1974; Hadorn et al., 1977; Hadorn et al., 1978;), it has been decided that the best way for storing this kind of commodity is to keep the warehouse at controlled temperature and relative humidity. The temperature must be kept between three and six degrees centigrades and the relative humidity between fifty and sixty percent. Yet the increasing cost of energy makes this kind of storage more and more expensive.

Following the good results obtained with nitrogen atmospheres for cereal storage (Shejbal, 1976; Shejbal, 1979), we decided to apply the same technique to hazelnuts. The aim of this work was to evaluate the storability in nitrogen as compared to traditional methods. For future storage of shelled hazelnuts in large silos we had to know if the nuts at the bottom would be damaged by the mechanical pressure caused by the column of nuts. We also had to deal with the problem of a larger interstitial atmosphere in commodities other than cereals.

The results of this research can be used as a model for the behaviour of other high fat content seeds and dried fruits.

MATERIAL AND METHODS

Three varieties of hazelnuts were chosen: two Italian ones (Piedmontese and Roman) and a Turkish one (Akcakoca). A sample of each varieties of shelled hazelnuts was stored under different experimental conditions as described in Table 1.

The experimental preservation in nitrogen atmosphere of the three varieties of hazelnuts was carried out in cylindrical air-tight laboratory microsilos in stainless steel (useful volume 0.1 cubic meter). The microsilo and gas flow are shown schematically in Figure 1.

The interstitial atmosphere of the nuts was replaced by a rapid purge (100 liters per hour) from the top with a volume of nitrogen corresponding to the double of the silo volume. The oxygen - poor atmosphere was maintained by an automatic system of pressostats and

TABLE 1

Experimental storage conditions of three varieties of hazelnuts.

Storage Condition	Temperature	Rel. Humidity	% O_2 in Interst. Atmosphere
Control (C)	- 20°C	---	21
Low temperature and humidity (cool, air)	3 - 6 °C	50 - 60%	21
Ambient temperature, low humidity (amb., air)	18 - 25°C	50 - 65%	21
High temperature, low humidity (hot, air)	35°C	30 - 40%	21
Ambient temperature, nitrogen atmosphere (amb., N_2)	18 - 25°C	60 - 70%	max 0.5
Ambient temperature, nitrogen atmosphere, mechanical pressure (amb., N_2, P)	18 - 25°C	40 - 50%	max 1.0

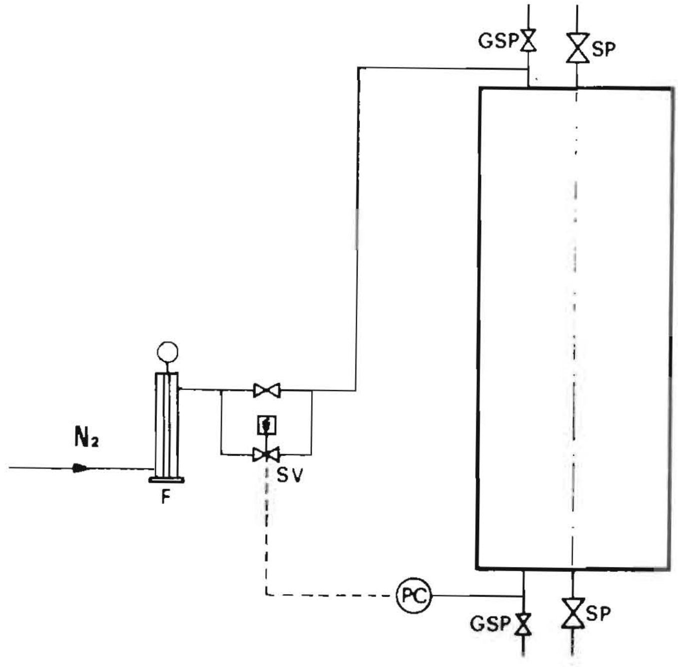

Fig.1. Cylindrical air-tight microsilo and gas flow sheets. F = Flowmeter; GSP = Gas sampling point; PC = Pressure control; SP = Sampling point; SV = Solenoid valve.

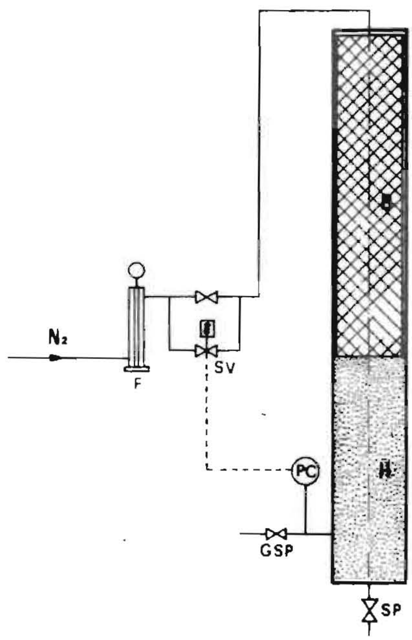

Fig.2. Apparatus simulating a silo of twenty meters height. B = Iron bar; F = Flowmeter; GSP = Gas sampling point; H = Hazelnuts; PC = Pressure control; SP = Sampling point; SV = Solenoid valve.

electric valves that bled in nitrogen whenever the internal over - pressure dropped under 200 millimeters of water (Shejbal, 1978).

The apparatus, simulating a silo of twenty meters height (Fig. 2), was a stainless steel tube with an internal iron bar which pressed the nuts at the bottom of the tube at the same mechanical pressure as at the bottom of a big silo. In this apparatus (useful volume 4 liters) Akcakoca hazelnuts were stored.

All the 10kg-samples in air were kept in cotton bags at the various experimental temperatures. The lenght of the storage trials was twelve months for the Roman and Piedmontese varieties and nine months for the Akcakoca variety. Temperature and relative humidity were recorded continuously and every fortnight analysis of the interstitial atmosphere composition in the microsilos was carried out.

Every three months samples were taken from each experimental storage condition and tested for (Hadorn et al., 1978):

Moisture (oven method)
Moisture (Karl Fischer)
Protein (Kjeldahl)
Fat
Surface fat
Ash
Alkalinity of ash
Glucose
Fructose
Sucrose
pH of a 10% suspension
Total acidity
Free fatty acids in the extracted oil
Induction period of oil at 110°C
UV - differential graph $E^{1\%}_{232}$
Fatty acid distribution
Enzymatic activity of a ground - up average sample
Enzymatic activity on the cut surface of individual hazelnuts
Microbiological and mycological examination

Visual assessment

Organoleptic test

The organoleptic pannel test classification should be interpreted as follows:

4 Equal to excellent

3 Equal to good

2 Equal to deteriorated, but acceptable

1 Equal to deteriorated, unacceptable

0 Equal to bad

Rating 2 is considered as the critical point underneath which it is not possible to use the nuts.

In all the graphes we report the absolute values found in the samples, taken every three months.

RESULTS AND DISCUSSION

The moisture content remains nearly constant in hazelnuts stored under nitrogen, while it decreases in low and ambient temperature air storage (Fig.3). This is an important fact for the activity of the

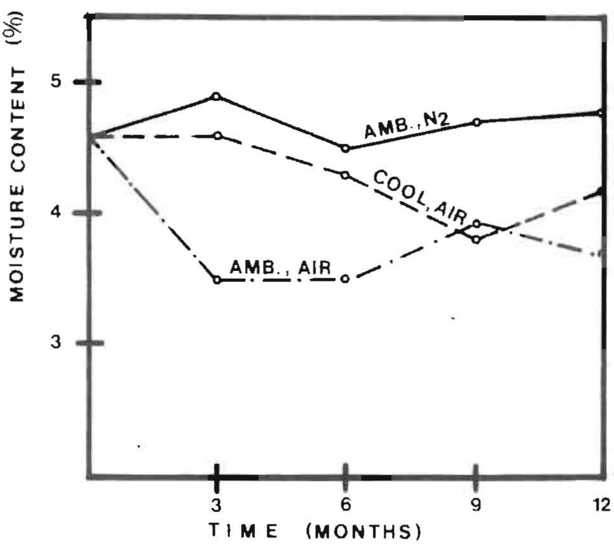

Fig.3. Moisture content of Piedmontese hazelnuts during storage under various conditions.

endogenous lipase in fats. The solubility of the lipolytic enzymes is the first step in the hydrolization of lipids; therefore at the higher moisture contents, the enzyme activity is higher. This is obvious from the results of the analysis of the fat acidity (expressed as percent of oleic acid).

The fat acidity of the hazelnuts preserved under nitrogen was significantly higher than of the other samples (Fig. 4). The control after twelve months remains almost constant. The hazelnuts in cool storage changed very little, followed by those kept at high temperature (because of the low humidity) and by those in ambient temperature.

The same trend was found in the Piedmontese and Akcakoca nuts. Yet we should note that the fat acidity of the nuts stored under nitrogen with mechanical pressure was significantly higher (Fig. 5), although the moisture content, due to repeated purges, was low (3.6%). In fact technical difficulties were encountered in maintaining an oxygen-poor atmosphere in this apparatus for a long time.

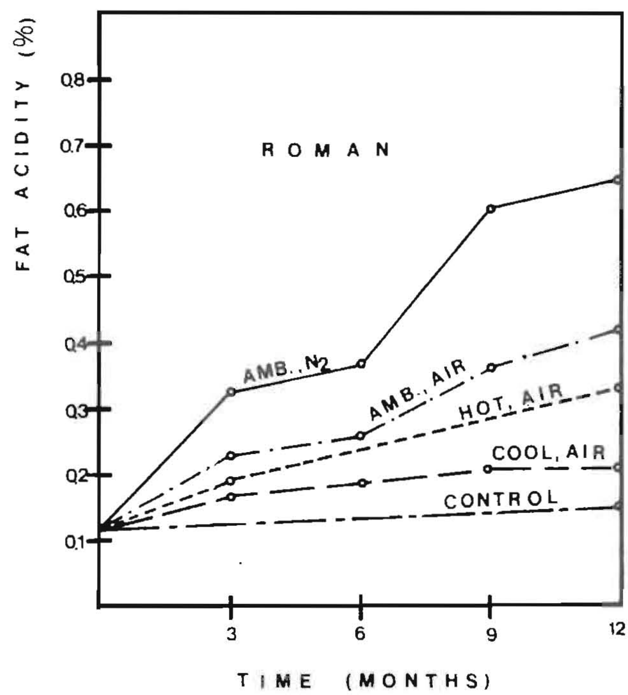

Fig.4. Increase of fat acidity in Roman hazelnuts during storage under various conditions.

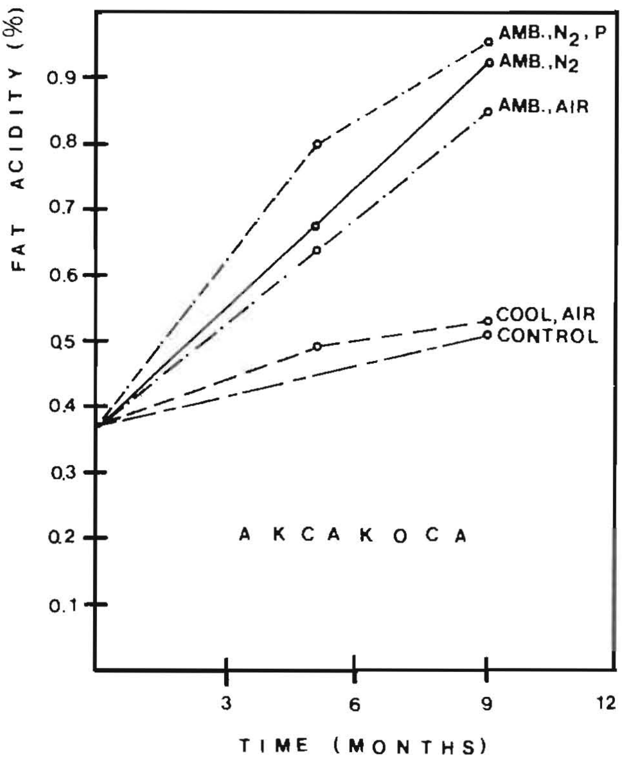

Fig.5. Increase of fat acidity in Akcakoca hazelnuts.

The fat acidity of Roman and Piedmontese hazelnuts never exceeded 0.7% which is considered as the critical point for the industrial use of the nuts. On the contrary the Akcakoca surpassed this critical point. The high values of the fat acidity did not always correspond to deterioration of quality.

Analysis of the intermediate compounds of the peroxidation, catalysed by the lipoxygenase, was carried out in order to detect the oxidative degradation of lipids. The spectrofotometric analysis of extracted oil showed, by the numbers of conjugated double bonds, the amount of the hydroperoxy fatty acids. These organic acids (Galliard, 1975) are toxic to the seeds and are converted into a set of more stable compounds, as aldehydes, with characteristic flavour properties.

The different steps (Yamamoto et al., 1980 a; Yamamoto et al., 1980 b) of the enzymatic reactions that lead to these volatile compounds are: lipids + lipase (H_2O) ⟶ fatty acids (linoleic acid) + + lipoxygenase (O_2) ⟶ hydroperoxy fatty acids ⟶ aldehydes. In the oxygen-poor atmosphere this lipid degradation pathway is slowed down immediately after the free acids are formed.

The extinction values, at 232 nm, of the isooctane solution of hazelnut oil from nuts stored in nitrogen atmosphere are comparable to those from cool storage (Fig. 6). Neither reveales any remarkable change.

The spoilage is speeded up in the presence of oxygen as well as at high temperature. The trend is the same for Roman hazelnuts.

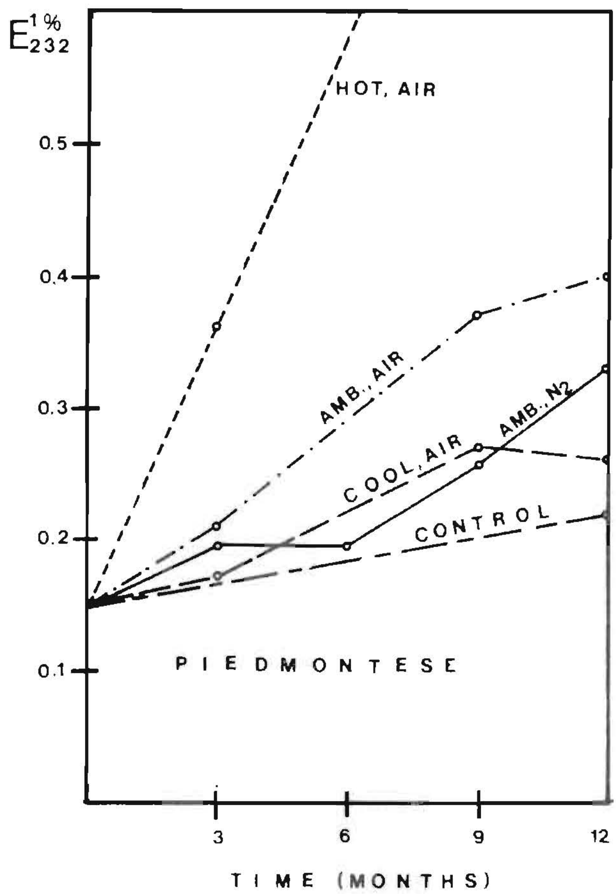

Fig.6. Increase of diene-extinction value in Piedmontese hazelnuts in the course of storage.

The graph in Figure 7 refers to the Akcakoca hazelnuts and confirms what said before. There is no difference between the nitrogen atmosphere and cool storage. The nuts under mechanical pressure rate slightly worse.

The organoleptic tests give a further confirmation of the substantial equivalence of the storage under nitrogen as compared to the traditional methods at low temperature.

Considering the histogram (Fig. 8), which refers to the organoleptic test of the Piedmontese nuts, it seems that the results of the various types of storage do not differ, even if in air storage at am-

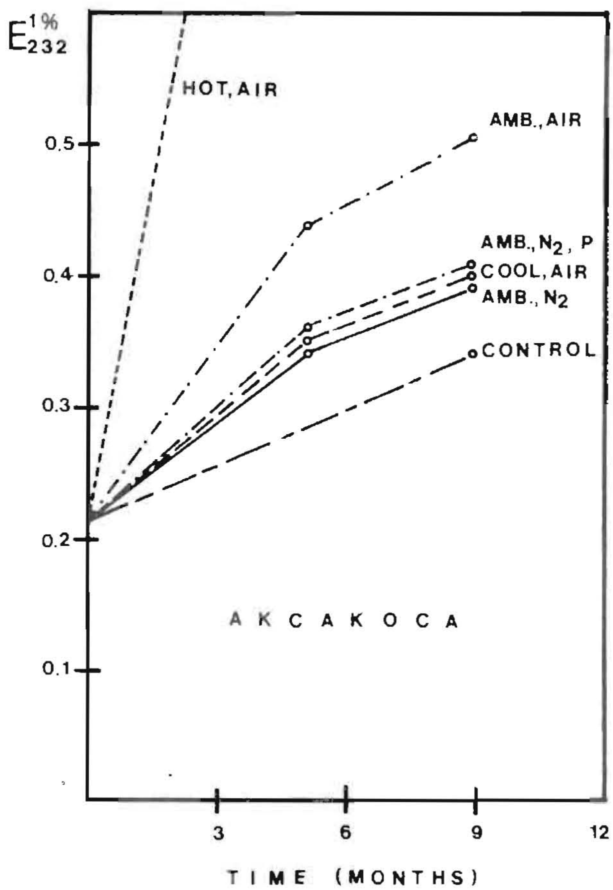

Fig.7. Increase of diene-extinction value in Akcakoca hazelnuts.

bient temperature the critical value (2.00) is reached.

This is due to the excellent quality of Piedmontese hazelnuts that makes the spoilage hardly noticeable.

In Roman nuts (Fig. 9) the general picture is clearer. After one year of storage in nitrogen atmosphere the same or slightly better rating is reached as in cool storage, while the nuts stored in air at ambient temperature are clearly worse.

The Akcakoca nuts (Fig. 10) completely confirm this trend.

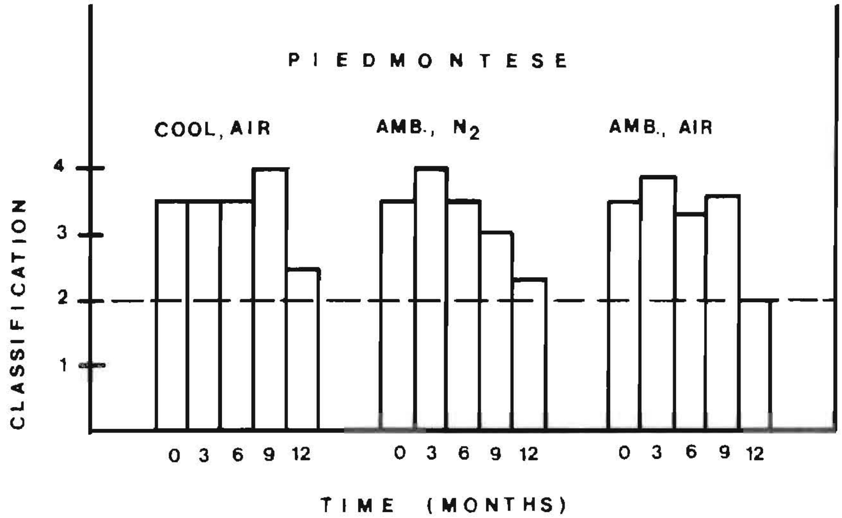

Fig.8. Organoleptic examination of Piedmontese hazelnuts during storage under various conditions.

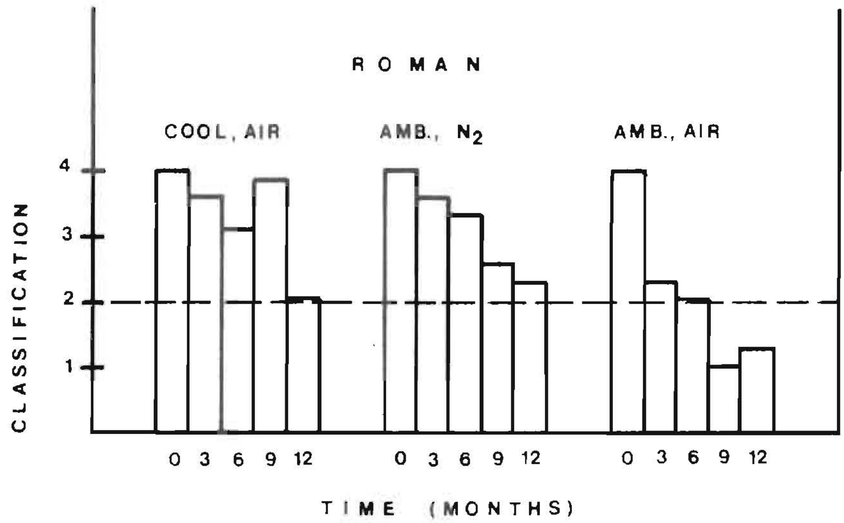

Fig.9. Organoleptic examination of Roman hazelnuts.

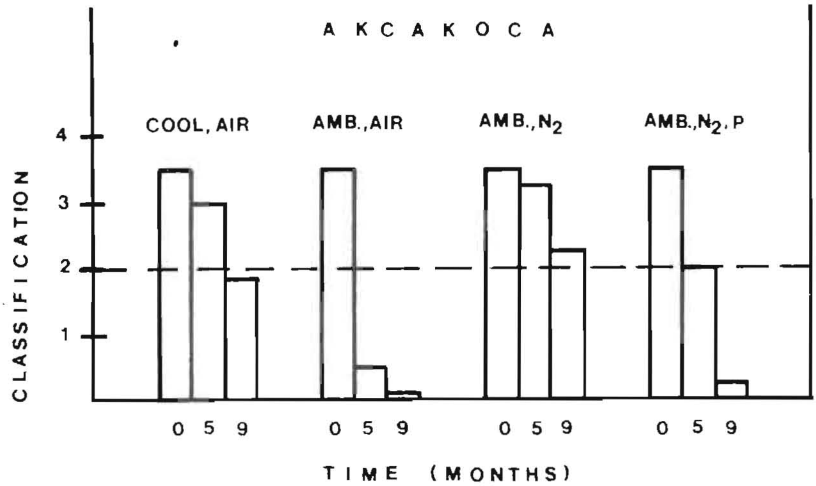

Fig.10. Organoleptic examination of Akcakoca hazelnuts.

CONCLUSIONS

All the observed data, summarized in Tables 2, 3 and 4, show that nitrogen storage is better or equal to cool storage.

Yet we have to observe the results of the storage under mechanical pressure more carefully. It seems that, in some way, mechanical pressure speeds up deterioration as is clearly shown by the results of the organoleptic tests. Yet it should be remember that in this simulation technical troubles with the airtightness of the apparatus were encountered and all the experiments were carried out at a high oxygen content (about 1%). Therefore mechanical pressure has probably an adverse influence on storability but, due to the technical problems, it was not possible to establish the exact importance of this phenomenon.

Furthermore it can be said that storability of the three varieties of hazelnuts, in this experiment, decreases in the order: Piedmontese - Roman - Akcakoca. However it should not be overlooked that the Roman and Piedmontese hazelnuts were superior in quality and were stored immediately after the harvest. On the contrary the Akcakoca nuts had been shiped from Turkey and were kept for a long time at customs. So the deterioration process had already started at the beginning of our storage. This contributed to the worse results with the Akcakoca variety.

TABLE 2

Composition and characteristic values of Piedmontese hazelnuts at the beginning and the end of storage.

Analyses		Time (months)			
		0	12		
			Storage condition		
			cool air	amb. air	amb.N_2
Moisture by drying-oven method (%)		4.6	4.2	3.7	4.8
Protein, N x 5.3, (%)		12.4	12.7	12.7	12.2
Fat (%)		68.7	68.7	68.5	68.5
Surface fat (%)		2.1	0.3	–	0.6
Ash (%)		2.0	2.2	2.1	2.2
Glucose, enzymatic (%)		0.03	0.01	0.02	0.03
Fructose, enzymatic (%)		0.03	0.01	0.07	0.03
Sucrose, enzymatic (%)		4.0	4.2	4.3	4.2
pH - value of 10% suspension		6.7	6.7	6.7	6.4
ffa (% oleic acid)		0.2	0.2	0.4	0.4
Induction period of oil at 110°C (hr)		13.50	12.50	12.75	12.50
uv - differential graph $E_{232}^{1\%}$		0.15	0.26	0.40	0.33
Fatty acid distribution (%) (total = 100%)	C_{16}	6.0	5.5	5.5	5.5
	C_{18}	2.5	2.2	2.3	2.4
	$C_{18:1}$	82.0	84.1	83.9	84.3
	$C_{18:2}$	8.8	7.7	7.8	7.3
Organoleptic test		3.50	2.50	2.00	2.25

TABLE 3

Composition and characteristic values at the beginning and the end of storage of Roman hazelnuts.

Analyses		Time (months)			
		0	12		
			Storage condition		
			cool air	amb. air	amb. N_2
Moisture by drying-oven method (%)		4.8	4.5	3.9	5.3
Protein, N x 5.3, (%)		12.7	12.9	12.9	12.5
Fat (%)		65.6	65.6	65.9	65.6
Surface fat (%)		6.8	1.2	3.6	2.7
Ash (%)		2.3	2.3	2.3	2.3
Glucose, enzymatic (%)		0.03	0.02	0.01	0.04
Fructose, enzymatic (%)		0.03	0.02	0.04	0.04
Sucrose, enzymatic (%)		4.7	4.3	4.9	4.9
pH - value of 10% suspension		6.6	6.5	6.5	6.3
ffa (% oleic acid)		0.1	0.2	0.4	0.6
Induction period of oil at 110°C (hr)		10.5	9.5	9.5	8.5
uv - differential graph $E_{232}^{1\%}$		0.26	0.33	0.43	0.24
Fatty acid distribution (%) (total = 100%)	C_{16}	5.4	5.0	5.0	5.1
	C_{18}	2.2	1.9	2.0	1.9
	$C_{18:1}$	79.1	81.4	81.4	81.0
	$C_{18:2}$	12.5	11.2	11.1	11.6
Organoleptic test		4.00	2.00	1.25	2.25

TABLE 4

Composition and characteristic values at the beginning and the end of storage of Akcakoca hazelnuts.

Analyses		Time (months)				
		0	9			
			Storage condition			
			cool air	amb.air	amb.N_2	amb.N_2P
Moisture by drying-over method (%)		4.0	4.6	3.2	4.3	3.6
Protein, N x 5.3, (%)		14.2	13.9	14.3	14.2	13.9
Fat (%)		68.5	67.4	67.5	67.6	67.2
Surface fat (%)		1.2	3.4	1.2	0.9	1.1
Ash (%)		2.0	2.1	1.9	1.9	1.9
Glucose, enzymatic (%)		0.02	0.04	0.03	0.03	0.02
Fructose, enzymatic (%)		0.02	0.06	0.03	0.03	0.02
Sucrose, enzymatic (%)		3.3	3.6	3.9	3.6	3.7
pH - value of 10% suspension		6.5	6.2	6.1	6.1	6.1
ffa (% oleic acid)		0.4	0.5	0.8	0.9	1.0
Induction period of oil at 110°C (hr)		11.75	8.25	9.75	9.25	9.25
uv - differential graph $E^{1\%}_{232}$		0.22	0.40	0.50	0.39	0.41
Fatty acid distribution (%) (total = 100%)	C_{16}	4.9	4.4	4.4	4.5	4.4
	C_{18}	2.2	1.9	1.9	1.9	1.8
	$C_{18:1}$	82.3	84.3	84.2	84.2	84.0
	$C_{18:2}$	10.0	9.0	9.1	9.0	9.4
Organoleptic test		3.50	1.75	0.00	2.25	0.25

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