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Chemical Composition of Vegetables Oils The Usage of Analytic Hierarchy Process Technique in Preference of Consumer Vegetable Oils Buying

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In this research consumer preferences for refined oils marketed in Turkey are analyzed with respect to their characteristics. This analysis is also made according to physical characteristics such as view, odour and packaging as well as chemical characteristics such as quantity of oleic acid, amount of energy, composition values of oil acids. According to the research findings obtained from consumers, although the most important factor for purchasing is sale price, but it is understood that odour and the quantity of *trans* and *cis* oleic acid affects consumer preferences to an important extent. Analytic hierarchy process, a technique for decision making when evaluating customer preferences, is used. The analytic hierarchy process is a useful decision methodology that can be applied in vegetables oil preferences as well as in consumer. In this research, an evaluation is made of 5 oil breed by using the analytic hierarchy process according to criteria determined by 600 consumer.

Key Words: Analytic hierarchy process, Oleic acid, Monounsaturated, Consumer preference, Decision making.

INTRODUCTION

Vegetable oils are the products that provide energy to the body needs without adding special flavour to foods that are consumed. It is already known that like carbohydrates and proteins, oils are the basic elements in the nourishment of human body. Vegetable oils are healthier than animal fat since they do not include cholesterol. Involving A, D, E and K vitamins, vegetable oils are really important in the nourishment of human beings. As a result, they need to be consumed in adequate amounts in human being diets.

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In developed countries, oil consumption per capital is 27 kg. However in Turkey this rate is never beyond 18-19 kg. Although World Health Organization suggests that people should get 1/3 of their daily energy need from oils. The consumption per capital rate in Turkey is below this rate.

In Turkey, the most consumed sources of vegetable oils are sunflower, soy bean, olive, hazelnut and corn. In this study, the basic aim is to determine the features of oil consumers take into consideration while deciding to buy vegetable oils and the oil types preferred in the market. By determining the factors that are effective in the preference of consumers, the aim is to let producers take these factors into consideration during production and marketing.

EXPERIMENTAL

The research material was collected by questionnaire from 600 consumers in Istanbul, Izmir and Ankara cities of Turkey. Oil selection criteria were based on the review of prior literature and semi structured interviews were undertaken with many specialists from relevant departments including food engineering and agricultural engineering.

Analytic hierarchy process methodology (AHP): The AHP, was developed[1] a powerful tool for the analysis of complex decision problems. Due to its applications and ease of use, the AHP has been studied extensively for the last 20 years. The application areas of AHP include economic management problems, political problems, social problems and technological problems as classified generally and summarized[1].

The AHP consists of 3 main operations, including hierarchy construction, priority analysis and consistency verification. First, all decision makers need to break down complex multiple criteria decision problems into their component parts, of which every possible attributes are arranged into multiple hierarchical levels. After that, the decision makers have to compare each cluster in the same level in a pairwise fashion based on their own experience and knowledge. In making the paired comparisons 1-9 scale, derived from stimulus response theory, is used[2].

The pairwise comparison is based on evaluating 2 elements (goals or alternatives) at a time. Let $C_1, ...C_m$ be m criteria and $W = (w_1,...w_m)$ be their normalized relative importance weight vector, which is determined by using pairwise comparisons and it satisfies the normalization condition. The pairwise comparisons between the n decision criteria can be conducted by asking the decision maker or expert question such as which criterion is more important with regard to the decision goals and what its scale through (1-9). The answers to these questions form an pairwise comparison matrix. In situations where there is a group of decision makers, there can be differences in opinions about what the judgments should be. It is showed that[3] the geometric mean should be used on the judgments of many people for each paired comparison. The pairwise comparison matrix is defined as follows:

$$A = (a_{ij})_{m\times m} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & \cdots & a_{1m} \\ a_{12} & a_{22} & a_{23} & \cdots & a_{2m} \\ .. & .. & .. & & \cdots \\ .. & .. & .. & & \cdots \\ .. & .. & .. & & \cdots \\ a_{m1} & a_{m2} & a_{m3} & & a_{mm} \end{bmatrix}$$

where a_{ij} represents a quantified judgments on w_i/w_j. Each entry a_{ij} of the comparison matrix are governed by the 3 rules: $a_{ij} > 0$; $a_{ij} = 1/a_{ji}$ and $a_{ii} = 1$ of element i to j is the reciprocal of the comparison of element; that is, $a_{ij} = w_i/w_j$ for all i and j, (i, j = 1, 2,…m).

The pairwise comparison matrix A is said to be perfectly consistent, if the following condition is satisfied[4]

$$a_{ij} = a_{ik}a_{kj} \quad \forall\ i, j,\ k = 1....m$$

Form the pairwise comparison matrix A, the weight vector can be determined by solving $AW = \lambda_{max}W$. Where λ_{max} is the maximal eigenvalue of A. For determining the weight vector of a pairwise comparision matrix, the mostly used technique is the principal right eigenvector method (EVM), other methods are also suggested for calculating weights, including the logarithmic least-square technique, goal programming and others.

When EVM is used, consistency ratio (CR) can be computed as follows:

$$CR = \frac{CI}{RI}$$

where the consistency index CI is defined

$$CI = (\lambda_{max} - n)/(n-1)$$

and RI is a number found by averaging CI over a large number of random A matrices. Since the comparisons are carried out through personal and subjective judgements, some degree of inconsistency may occur. To guarantee the judgments are consistent, the final operation called consistency verification is incorporated in order to measure the degree of consistency among the pairwise comparisons by computing the consistency ratio. If it is found that the consistency ratio exceeds the limit, the decision makers should review and revise the pairwise comparisons. Once all pairwise comparisons are carried out at every level and are proved to be consistent, the judgments can then be synthesized to find out the priority ranking of each criterion and its attributes.

Preparation of FAME: FAMEs were prepared according to American Oil Chemists' Society Official (AOCS) Method Ce 2-66[5]. The FAMEs were obtained from the oils after alkaline hydrolysis, followed by methylating in methanol with 12.5 % BF_3 (boron trifluoride) catalyst. The final concentration of the FAMEs was *ca.* 7 mg/mL in heptane. FAMEs standards (99 % purity) were purchased from Nu-Chek-Prep Inc. (Elysian, MN).

Capillary gas-liquid chromatography (GLC) analysis: Analyses of the FAMEs by capillary GLC were carried out on a Hewlett-Packard 6890 chromatograph, equipped with a flame-ionization detector (FID) on a split injector. A fused-silica capillary column (Chrompack, Middleburg, The Netherlands) was used for the FAMEs analysis; CP^{TM}-Sil 88, 100 m × 0.25 mm i.d., 0.2 µm film. GLC operating conditions were: a temperature program of 130 ºC for 5 min, rising at a rate of 2 ºC/min to 177 ºC. The injector temperature was 225 ºC; detector temperature 250 ºC; carrier gas 1 mL/min helium.

Definition of crop selection criteria: The structuring of the hierarchy of selection of oil problem, which includes 3 levels. The top level of the hierarchy represents the ultimate goal of the problem, while the second level of the hierarchy consists of 6 main oil selection criteria, which are price, quantity of oleic acid, energy, view, flavour and odour. Finally, the bottom level of the hierarchy represents the alternative oils. Each selection criterion is briefly described below.

Price: The prices of vegetable oils marketed in Turkey and included in the study show variations. Because high prices affect preferences negatively, a comparison is made by taking the reciprocal of the actual price. A comparison of oils' prices and the relative weight each oil takes are shown accordingly in Table-1. Table-1 shows that sunflower and soya oil, the lowest priced oils, weigh 0.296. It is seen that becuase hazalnut oil is expensive, it is preferred less (0.089).

TABLE-1
OIL PRICE AND OIL PRIORITY WITH RESPECT TO PRICE

Oil	Price ($)	Priority
Hazelnut oil	10	0.089
Sunflower oil	3	0.296
Olive oil	9	0.099
Corn oil	4	0.222
Soya oil	3	0.296

Oleic acid: Recent positively directed studies on monounsaturated oil have effected a great leap in demand on oils with high oleic levels. In recent studies on which scientists agree, the presence of monounsaturated oil and poly/saturated oil plays a role in reducing the risk of heart disease. Monounsaturated oil do not affect the HDL (benign) cholesterol levels in blood, whereas they tend to lower the LDL (malign) cholesterol levels[6].

For the criteria of the quantity of oleic acid oils contain the priorities oils will take are obtained without pairwise comparisons and are shown in Table-2. For this criterion, the oils that have greater quantities of oleic acid will be at an advantage.

TABLE-2
OLEIC ACID LEVELS OF OILS AND PRIORITIES ACCORDING TO OLEIC ACID LEVEL

Oil	Oleic acid	Priority
Hazelnut oil	63.64	0.326
Sunflower oil	29.05	0.070
Olive oil	75.80	0.372
Corn oil	34.69	0.140
Soya oil	63.60	0.093

It can be seen in Table-2 that olive oil, which has the greatest amount of oleic oil, has the highest value for preference and is followed by hazelnut. Sunflower oil, which is the lowest in oleic acid value, has a priority of only 0.070.

Energy: Considering that the oils that have greater quantities of energy will be preferred more, comparisons are made without taking the reciprocals of the amounts of energy. In Table-3 it is seen that energy amounts have similar values. However, sunflower oil and soya oil have the highest levels of energy. Corn oil has the lowest level of energy.

TABLE-3
ENERGY AMOUNTS OF OILS AND PRIORITIES ACCORDING TO ENERGY AMOUNTS

Oil	Energy	Priority
Hazelnut oil	895	0.204
Sunflower oil	900	0.205
Olive oil	883	0.201
Corn oil	819	0.186
Soya oil	900	0.205

View: Because the criterion of view cannot be quantified, judgments about the view of oils are reached using the answers in a questionnaire with a 1-9 scale, which are shown in Table-4.

When the priority values of oils are analyzed according to the view criterion determined by consumer opinions, it is observed that olive oil takes the highest value and is followed by sunflower and corn oil. The consumers gave the highest value with respect to view to hazelnut oil.

Flavour: Similarly, priorities according to flavour are reached through pairwise comparisons in questionnaires. On analysis of Table-5, it is observed that olive oil received a weight of 50 and is followed by corn oil. The consumers gave soya oil the least weight with respect to flavour.

Odour: The weights given according to the odour of oils are shown in Table-6.

The data present in Table-6, show that olive oil get the highest weight as it did in many other features (0.400). Olive oil is followed by sunflower oil while soya oil is least preferred with a value of 0.05.

TABLE-4
PRIORITIES OF OILS ACCORDING TO VIEW CRITERION

Oil	Priority
Hazelnut oil	0.120
Sunflower oil	0.240
Olive oil	0.260
Corn oil	0.200
Soya oil	0.180
Consistency ratio	0.080

TABLE-5
PRIORITIES OF OILS WITH RESPECT TO FLAVOUR

Oil	Priority
Hazelnut oil	0.100
Sunflower oil	0.170
Olive oil	0.500
Corn oil	0.200
Soya oil	0.030
Consistency ratio	0.070

TABLE-6
PRIORITIES OF OILS ACCORDING TO ODOUR CRITERION

Oil	Priority
Hazelnut oil	0.100
Sunflower oil	0.300
Olive oil	0.400
Corn oil	0.150
Soya oil	0.050
Consistency ratio	0.090

RESULTS AND DISCUSSION

In Table-7, the composition of oil acids in 5 oils presented for consumer preferences. According to this, it is found that the oil richest in oleic acid is olive oil with 75.80 %. In recent studies, scientists agreed on the opinion that monounsaturated oils do not affect the HDL (benign) cholesterol levels in blood, whereas they tend to lower the LDL (malign) cholesterol levels[7]. Indeed, when we evaluate the above mentioned oils with respect to the monounsaturated oil acid olive oil ranks first with 75.80 %.

TABLE-7
VALUES OF COMPOSITION OF OIL ACIDS IN OILS PRESENTED FOR CONSUMER PREFERENCE

Fatty acids (%)	Corn	Sunflower	Rape seed	Hazelnut	Olive
Myristic $C_{14:0}$	0.04	0.07	0.05	0.04	0.02
Palmitic $C_{16:0}$	12.23	6.14	4.46	5.73	10.98
Palmitoleic $C_{16:1}$ *cis*	0.14	0.15	0.22	0.16	0.59
Palmitoleic $C_{16:1}$ *trans*	0.05	0.04	0.04	0.03	0.19
Margaric $C_{17:0}$	0.06	0.03	0.06	0.06	0.08
Stearic $C_{18:0}$	2.32	3.73	1.70	2.80	2.60
Oleic $C_{18:1}$ *cis*	34.69	29.05	63.82	63.64	75.80
Oleic $C_{18:1}$ *trans*	0.13	0.08	0.03	0.08	0.02
Linoleic $C_{18:2}$ *cis*	48.24	59.16	21.25	26.57	8.35
Linoleic $C_{18:2}$ *trans*	0.06	0.25	0.13	0.08	0.04
Linolenic $C_{18:3}$	1.03	0.08	7.14	0.31	0.69
Arachidic $C_{20:0}$	0.59	0.27	0.58	0.19	0.44
Behenic $C_{22:0}$	0.19	0.70	0.35	0.22	0.13
Lignoseric $C_{24:0}$	0.23	0.25	0.17	0.09	0.07
Total *trans*	0.24	0.37	0.20	0.19	0.25
Total saturated	15.66	11.19	7.37	9.13	14.32
Total monounsaturated	34.83	29.20	64.04	63.80	76.39
Total polyunsaturated	49.27	59.24	28.39	26.88	9.04
Total unsaturated	84.10	88.44	92.43	90.68	85.43

The fact that olive oil has highest levels of monounsaturated oil acids enables it to be at the same level hydrogenized[7] fat and oils in which antioxidant substances are added. Olive oil, includes high levels of oleic acid, is naturally liquid and preserves this characteristic throughout its shelf life without undergoing any chemical change in its structure[8].

The fact that oils are bitter, look cloud and contain sediments is not desired by consumers and light colour and flavour characteristic of the oil ranks high in consumer preference. The higher the level of unsaturated acid an oil contains, the higher the peroxide values will be because its oxidative stability[9]. In types with high levels of oleic acid (olive, high oleic safflower), the probability that the above mentioned negative consequences will occur is low[10].

After the formulation of hierarchical structure for the problem, comparisons were made step by step downwards the hierarchy and starting with the goals. The calculations were made a calculation table designed on MS Excel as a powerful spreadsheet tool[11].

After the operations of weighting and adding, the overall oil priorities are as in Table-8. It is seen that oil olive is the most preferred product with 28.9 % priority.

Sunflower oil follows olive oil in preference. Hazelnut oil, rich in oleic acid, is preferred least by consumers because of its price. Soya oil comes after hazelnut oil.

TABLE-8
FINAL WEIGHTS OF ALTERNATIVES

	Price	Oleic acid	Energy	View	Flavour	Odour	Priority vector
Weight	0.235	0.195	0.082	0.231	0.135	0.122	
Hazelnut oil	0.089	0.326	0.204	0.120	0.100	0.100	0.154
Sunflower oil	0.296	0.070	0.205	0.240	0.170	0.300	0.215
Olive oil	0.099	0.372	0.201	0.260	0.500	0.400	0.289
Corn oil	0.222	0.140	0.186	0.200	0.200	0.150	0.186
Soya oil	0.296	0.093	0.205	0.180	0.030	0.050	0.156

Conclusion

In this research, various characteristics (price, oleic acid, energy, view, flavour, smell) of refined oils marketed in Turkey are studied with respect to consumer preference. The analysis has revealed that consumers take price as the most important criterion when they choose oil (0.235). The price criterion is followed by view (0.231) and oleic acid (0.195), respectively. The precedence of the energy the oil provides is only 0.082.

When oils are analyzed with respect to price of the oils that are most preferred, it can be seen that the less priced sunflower oil and soya oil have a high value with respect to preference, whereas the higher priced hazelnut and olive oils have a lower value with respect to weight.

With respect to view, oleic acid, flavour criteria, olive oil, having the highest values, comes first in consumer preference with 28.9 % and is followed by sunflower oil with 21.5 %.

For consumers, hazelnut falls behind all others and is followed by soya oil. The reason why soya oil is preferred less is that its smell and flavour are not favoured by consumers.

Consumers trust most in olive oil for health, but complain that they cannot buy enough of it because of its price.

In the application, the criteria and the alternatives are limited to what the specialists thought is important to consider. Other criteria that are not taken into consideration in this study can have an effect on the production decision. It can change as a result of modifications in the criteria and alternatives forming the hierarchical structure. Thus it is important to note that the solution is determined on the basis of the alternatives and criteria chosen in the application.

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