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Research Article

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Selection of the Most Appropriate Plant Oil for Human Health with Priority Estimation

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Abstract Plant oils are reproduced from plant resources, which can be found in profusion all-around the world. Plant oils are mainly occurred from triglycerides. The triglyceride molecules are constituted of three types of fatty acids combined at a glycerol juncture. With 0 to 3 double bonds per fatty acid, the most widespread plant oils include fatty acids that alter from 14 to 22 carbon atoms in length. Due to the numerous diverse fatty acids existent, it is obvious that on a molecular level plant oils are created of numerous diverse kinds of triglycerides with many levels of unsaturation. The chemical formula of triglyceride molecules in plant oils varies to a great extent depending on the species. For this reason, the diverse chemical, physical and energy properties of plant oils are significant for use in the foods industry.

The aim of this paper is to select the most proper plant oil in human health by using multi-criteria decision making method. Among plant oil species, the problem of selecting the most proper plant oil is evaluated, using numerous criteria related properties.

Keywords Plant oil, Analytical Hierarchy Process, Physical and chemical properties, Renewable.

1. Introduction

For the basic needs of human body, the proteins and fats are two fundamental materials in supplying energy. Many kinds of plants contain diverse chemical materials exhibiting health advantage over properties of anti-inflammatory, antimicrobial, and antioxidative impacts. The plant oil has been claimed to have many useful health influences as a functional food. The plant oils, because of having important amounts of proteins, polyunsaturated fatty acids, and specially vitamins, play a significant role in the human health. Triacylglycerol and lipids exist in plant oils. The chemical composition of plant oils contains glycerides and unsaturated-saturated fatty acids. An unsaturated fatty acid is a fat in which there is minimal single double bond that exists in the fatty acid chain. The fat molecule is polyunsaturated if it includes more than single double bond and monounsaturated if it includes one double bond. Plant oil's fatty acid composition relies on the technology process in the course of plant oil production or it varies according to the resource plant [1, 2].

Lately, plant fatty acids have been regarded as functional nutraceuticals and food. A number of studies have documented their important effects in many bio-chemical pathways resulting in health impact due to their considerable hypolipidemic effect, antithrombotic, antiatherogenic, antiarrhytmic, anti-inflammatory, due to the potency of decreasing the serious disease risk. Specifically diabetes, cancer, cardiovascular diseases, osteoporosis, and other health promotion activities follow from their complex influence on blood pressure regulation, lipoproteins' concentrations, eicosanoids production' modulation, biological membranes' fluidity, the minerals' metabolism, and finally, on membraned enzymes' and receptors' function [3,4–10].

The selection of the healthiest plant oil is a complicated multi-criteria decision making problem. In this paper, the main properties of different plant oils have been investigated and their benefits and harmful effects on human health have been evaluated by experts at medical, pharmaceutical and chemical area. The aim of the present study is to determine of the most proper plant oil for human health with priority estimation.

2. Model Structure

To obtain a framework for relations with multi criteria decision-making issues, a hierarchy based model is structured. Among decision levels, the model adopts a unidirectional hierarchical connection. The methodology permits the hierarchical tree building and weighing each indicator through pairwise comparison between indicators and criteria by a matrix to obtain a coherent and consistent administration of both qualitative and quantitative data. To determine weights of criteria, such a method is used in this paper. In the process of choosing a plant oil, the goal would be to choose the most appropriate plant oil that satisfies various types of criteria. These criteria are often subdivided into several sub-criteria. This study involves four main criteria of top level. The sterol composition of the plant oils is cholesterol, bassikasterol, kampesterol, stigmasterol, beta-sitosterol, delta-5-avenasterol, delta-7-stigmastenol, and Delta-7-avenasterol. Fatty acid compositions of analyzed plant oils are considered as the second main group of criteria. 15 different fatty acids are evaluated under this group. All fatty acids are composed of C, H, and O but they have different chemical formulas. The third main criterion is the *structural* fatty acid contents of the plant oils. The fourth group of criteria is the degree of unsaturation. Unsaturation's 'unweighted' degree, unsaturation's 'partially weighted' degree, and unsaturation's'fully weighted' degree are considered as the sub-criteria under this group. Nine alternative plant oils are compared. The hierarchy composed of these criteria is constructed as shown in Table 1.

Table 1: Hierarchy of Criteria

Main Criteria	**Sterol Composition**	**Fatty Acid Composition**	**Structure**	**Degree of Unsaturation**
Sub-criteria	Kolesterol	Laurik	Carbon	Unweighted
	Brassikasterol	Miristik	Hydrogen	Partially weighted
	Kampesterol	Palmitik	Oxygen	Fully weighted
	Stigmasterol	Palmitoleik		
	Beta-sitosterol	Margarik		
	Delta-5-avenasterol	Stearik		
	Delta-7-stigmastenol	Oleik		
	Delta-7-avenasterol	Risinoleik		
		Linoleik		
		Linolenik		
		Araşit		
		Gondoik		
		Behenik		
		Erüsik		
		Lignoserik		

While measurements for some criteria are readily available, some others can only be estimated with respect to other variables. As it is the case in all multi-criteria decision making methods, the relative weights of such criteria need to be determined. This is accomplished by pairwise comparison of the factors, starting with the main criteria. Below are the resulting priorities of sterol composition, fatty acid, structure, and degree of unsaturation shown in Fig. 1.

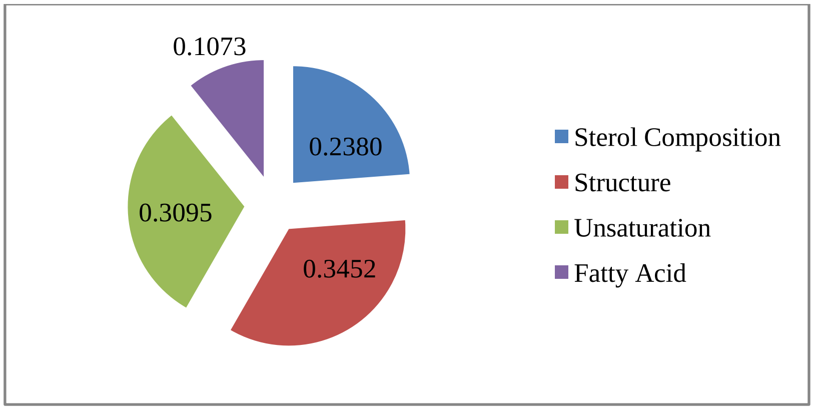

Figure 1: Main Criteria Properties

In the next step, there are groups of sub-criteria under each main criterion to be compared two by two. Each pair of sub-criteria related to the sterol composition is compared based on their impact on the criterion.

At this point, the comparison for sterol composition criteria has been made, and the method has reproduced the local priorities for this group. These priorities reflect on how much it supports to the priority of its primary, thus we need to obtain the "global priority" of each of the sub-criteria which shows the impact of each of the sub-criteria on the overall target of selecting the feasible plant oil. The global priorities along the hierarchy should add up to one. The global priorities of each of the sub-criteria are determined by multiplying their local priorities with the priority of its parent criterion which results in the following values for the sub-criteria under fuel property. Fig. 2 shows the resulting global weights for these criteria based on pairwise comparisons.

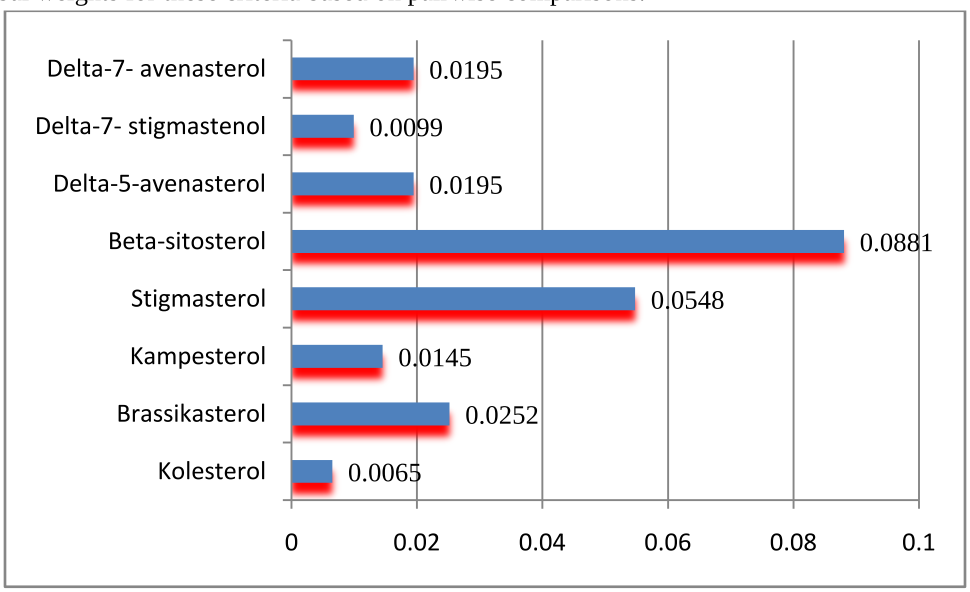

Figure 2: Global priorities of sub-criteria under sterol composition

Under fatty acid group, 15 types of fatty acid are compared pairwise in order to determine relative impact of each on the overall goal. Fig. 3 provides the calculated global priorities of these sub-criteria.

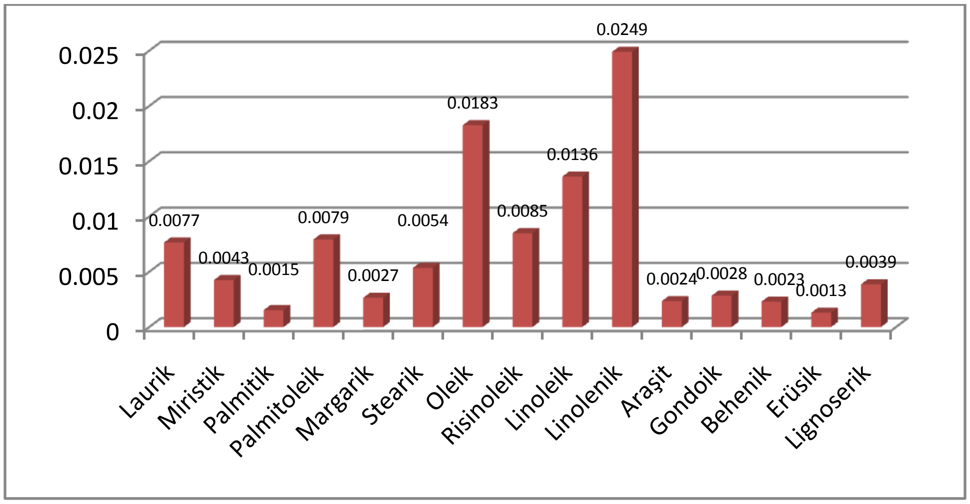

Figure 3: Global priorities of sub-criteria under fatty acid composition

The third group of sub-criteria involves the structural composition of the fatty acids in terms of C, H, and O. These three atoms are evaluated in terms of their impact on the quality of plant oil as well. The factors under the fourth group with three sub-criteria showing the degree of unsaturation are also compared two-by-two to consider the relationship between the properties of oil and the degree of unsaturation. All these elements are compared as to how significant impact they have on the overall goal. Table 2 below shows the global priorities of structural composition and degree of unsaturation.

Table 2: Sub-group priorities

	Structural Composition			**Degree of Unsaturation**		
Sub-criteria	C	H	O	Unweighted	Partially weighted	Fully weighted
Global Priority	0.0084	0.0048	0.0371	0.0021	0.0032	0.0051

3. Pairwise Comparison of the Plant Oils with Respect to the Criteria Set

After determining the priorities of each criterion with regard to the overall target of choosing the feasible plant oil and priorities of sub-criteria with respect to their related main criteria, the plant oil alternatives need to be compared pairwise with respect to each sub-criterion. Nine different alternatives are determined for the purpose of this investigation. The selected alternatives' sterol compositions are presented in Table 3.

Table 3: Sterol composition

Plant Oils	**Cholesterol**	**Brassikasterol**	**Kampesterol**	**Stigmasterol**	**Beta-sitosterol**	**Delta-5-avenasterol**	**Delta-7-stigmastenol**	**Delta-7-avenasterol**
Canola	1.3	13.0	38.6	1.0	57.9	6.6	1.3	0.8
Corn	0.6	0.2	24.1	8.0	66.6	8.2	4.2	2.7
Hazelnut	0.6	0.05	5.8	1.5	86.8	4.5	2.3	0.8
Olive	0.4	0.06	3.4	1.2	88.2	7.0	0.7	2.7
Palm	6.7	0.05	27.5	13.9	62.1	2.8	2.4	5.1
Peanut	3.8	0.2	19.8	13.2	69.0	18.8	5.1	5.5
Sesame	0.5	0.2	20.0	12.0	61.9	7.8	7.6	5.6
Soybean	1.4	0.3	24.2	19.1	60.0	3.7	5.2	4.6
Sunflower	0.7	0.2	13.0	13.0	70	6.9	24.0	7.5

The alternatives' fatty acid compositions are presented in the following Table 4.

Table 4: Fatty acid compositions

Plant oil	Lauric	Myristic	Palmitic	Palmitoleic	Margaric	Stearic	Oleic	Ricinoleic	Linoleic	Linolenicc	Arachidic	Gondoic	Behenic	Erucic	Lignoceric
Canola	-	-	4.51	0.36	0.14	2.00	60.33	-	21.24	9.49	0.62	1.49	0.35	0.42	0.16
Corn	-	-	11.81	0.12	-	2.13	27.35	-	57.74	0.63	0.34	0.33	-	-	0.14
Hazelnut	-	-	6.32	0.32	-	3.71	79.17	-	10.67	0.15	0.10	0,10	-	-	-
Olive	-	0.05	11.47	0.90	0.07	2.83	74.52	-	9.54	0.51	0.49	0.29	0.16	-	0.17
Palm	-	-	27.21	2.14	1.41	4.5	51.21	0.02	3.47	2.16	-	-	0.52	-	-
Peanut	-	-	10.33	-	-	2.79	47.63	-	31.52	0.64	1.07	1.48	2.86	0.10	1.30
Sesame	-	-	6.78	0.17	0.14	4.71	17.16	0.31	32.14	5.02	1.04	0.18	1.52	-	0.13
Soybean	0.08	0.12	11.44	0.16	-	4.14	23.47	-	53.46	6.64	0.33	0.22	0.27	0.07	0.13
Sunflower	-	0.15	10.02	0.07	-	0.06	21.71	-	45.12	-	-	-	-	-	0.09

Table 5 below shows the structural fatty acid contents of the alternatives. Percentage of C, H, and O in each plan-oil is provided in the table.

Table 5: The structural fatty acid contents of the alternatives

Plant oil	**C**	**H**	**O**
	(% w/w)	**(% w/w)**	**(% w/w)**
Canola	76.09	12.60	11.35
Corn	76.71	11.52	10.98
Hazelnut	76.57	11.94	11.42
Olive	76.91	11.66	10.95
Palm	76.09	12.44	11.27
Peanut	77.47	11.96	11.58
Sesame	77.02	11.98	10.87
Soybean	77.03	11.90	10.95
Sunflower	76.90	11.84	10.98

To measure the effect of degree of unsaturation on the plant oil properties, three sub-criteria are defined, associated with unweight, partially weighted, and fully weighted degree of unsaturation. Table 6 summarizes the degree of unsaturation of analyzed plant oils.

Table 6: The degree of unsaturation of analyzed plant oils

Plant oil	'Unweighted' degree of unsaturation (%)	'Partially weighted' degree of unsaturation [b]	'Fully weighted' degree of unsaturation (average number of double bonds) [c]
Canola	0.92	1.24	1.33
Corn	0.86	1.45	1.45
Hazelnut	0.90	1.01	1.01
Olive	0.85	0.96	0.97
Palm	0.51	0.62	0.62
Peanut	0.82	1.16	1.16
Sesame	0. 79	1.37	1.59
Soybean	0.84	1.44	1.51
Sunflower	0.89	1.57	1.57

[a] All unsaturated fatty acids assumed to have the same %weight.

[b] All unsaturated XX: y (y-2) fatty acids have a %weight of 2.

[c] XX: 3 fatty acids a weight% of 3, XX: 2 fatty acids have a weight% of 2 etc.

The next step in applying the technique is two by two comparisons of the alternatives with respect to each sub-criterion. In order to design an objective scheme for this purpose, the maximum and minimum values of the alternatives for each sub-criterion are determined. This range is divided into nine even ranges since the method requires pairwise comparisons on a scale from 1 to 9. Finally, each alternative is placed in one of these ranges based on their values to compare them with each other. Remainder of this section presents the priorities obtained under each sub-category using this scheme.

4. Conclusions

This study aims to find the most appropriate plant oil based on various criteria exist in the literature. A list of criteria is evaluated and divided into four groups. Each criterion is appointed a relative weight as a result of expert evaluations. Finally, AHP method is applied to the resulting scheme. Analytical Hierarchy Process is the most comprehensive of the five Multi-Criteria Decision Analysis techniques because it considers the significance of each of the criteria and incoherence in the rankings are confirmed. The application of the multi-criteria decision analysis techniques and the conclusions from this paper supply an idea of how multi-criteria decision analysis can be performed in plant oil selection. Based on the calculations above, the relative priorities corresponding to the attractiveness of each plant oil about all factors are presented in Table 7.

Table 7: Plant Oil comparison

Fuel	Sterol Composition	Fatty Acid Composition	Structure	Degree of Unsaturation	Total
Canola	0.5835	0.0068	0.0545	0.0408	**0.6856**
Corn	0.4045	0.0053	0.0215	0.0538	**0.5517**
Hazelnut	0.7231	0.0064	0.0292	0.0200	**0.7787**
Olive	0.7872	0.0050	0.0286	0.0188	**0.8396**
Palm	0.5007	0.0055	0.0387	0.0068	**0.4851**
Peanut	0.7047	0.0061	0.0977	0.0302	**0.8386**
Sesame	0.4843	0.0046	0.0374	0.0754	**0.6017**
Soybean	0.6596	0.0060	0.0376	0.0638	**0.7669**
Sunflower	0.6985	0.0072	0.0310	0.0799	**0.8166**

The obtained results indicate that the Olive with a global priority of 0.8396 is the option that contributes the most to the goal of selection the best plant oil that satisfies all the criteria selected. Peanut follows olive with a slightly less priority of 0.8386. This current paper can be reference to researches for healthy future generation.

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