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Evaluation of the nutritional properties of flax, basil, chia and poppy seeds mixture as potential innovative food products

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Abstract

The study evaluates the nutritional values of flax, basil, chia and poppy seeds and answers the question regarding the use of mixing this seeds in order to produce innovative food products. Based on the mathematical models and graphical fingerprint, the use of basil seeds in different food recipe together with flax seeds, poppy seeds and/ or chia increases the quantity of vitamin K of the new food products. Due to this property, by adding basil seeds to any other presented seeds determine the creation of innovative novel foods.

Keywords: novel food, principal component analysis, fingerprint

1. Introduction

Food producers are looking for solutions to create healthy and nutritious *innovative food* products that are not only appealing, accessible, and exclusive, but also sustainable.

By definition *novel food* is the foodstuff that was not been consumed to a noteworthy extent in the European Union before 15 May 1997, when the earliest directive on novel food came into force. Examples of Novel Food comprise new sources of menaquinone (vitamin K), extracts from existing food (Antarctic Krill oil), agricultural crops from third countries (chia seeds, basil seeds), edible insects, plant sterols or food resulting from UV-treated food [1]. The concept is not new because throughout history new types of food, food technologies or food ingredients found their way to Europe from all over the world [2].

The study evaluates the nutritional values of flax, basil, chia and poppy seeds and answers the question regarding the use of mixing this seeds in order to produce innovative food products.

The history of the use of flax seeds goes back to 7000 BC [3], while the use of basil seeds goes 5000 BC [4], chia seeds 3500 BC [5] and poppy seeds 2700 BC [6]. All of this seeds were considered somehow magical, flax being cultivated by ancient civilizations for fiber and as a medicine [3], basil being considered a royal and or religious - ritual herb [4]. Chia seeds was used in medicine, as food or mixed as an ingredient in drinks, pressed for oil, at the same time considered sacred and used as a sacrifice in religious ceremonies by the Aztecs [5] while regarding poppy, people looked upon it as a magical plant being associated heavily with black magic wherever they were grown [7]. Today all these seeds alone or combined can participate to create innovative food in order to make nutritious and healthy offerings "that are not only enticing, accessible, exciting, and unique, but also sustainable" [8]. Flax seeds are oil seeds utilized in natural, health, and industrial products. Flax seeds gather many biologically active compounds, together with linolenic and linoleic acids, lignans, cyclic peptides, polysaccharides, alkaloids, cyanogenic glycosides and minerals [9].

In food industry **flax seeds** (*Linum usitatissimum* L.) are used in bakery or as an oil source for margarine and mayonnaise. There are many research studies proving that flax seeds show potential to cure different diseases (cardiovascular diseases, cancer, stroke and thrombosis, hyperglycemia) [3,10]. It has been shown that replacing cornmeal with flaxseed meal (15%) or

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corn flour with flaxseed oil (15%) in a basal diet has significantly decreased the multiplicity and size of the tumor in the small intestine and colon. Gomides et al, 2012 concluded that flaxseed meal and oil are effective chemo-preventive agents [11]. Flax is a high source of dietary fiber (5-10%), minerals (2.4%), protein (20.3%) and fats (37.1%) (Table 1) containing oil (36-48%), seed coat mucilage (6%) [13]. Flax seed contains both types of fiber (the soluble ground and insoluble types of fiber, and is also considered one of the oldest textile fibers [14]. Considered also a good source of wax and resins [3] as well as amino acids (for 100 g raw product): leucine (1.24 g), arginine (1.92 g), valine (1.07 g), alanine (0.925 g) isoleucine (0.896 g),tryptophan (0.297 g), threonine (0.766 g), lysine (0.862 g), methionine (0.37 g), phenylalanine (0.957 g) etc [15,16].

Basil (*Ocimum basilicum*) is a a herbaceous plant in the genus Ocimum, family Lamiaceae, native to tropical Asia. Basil is low in saturated fat, cholesterol and sodium. It is also a good source of protein, vitamin E, riboflavin and niacin, as well as a great source of dietary fiber, vitamins (A, C, K, B6), folic acid and minerals (calcium, potassium, iron, magnesium, manganese, zinc, copper and phosphorus) [17]. The volatile oil (0.10-0.20%) has a different chemical composition depending on the chemotype from which it comes: linalool, methylcavicol or estragol, cineole, camphor, α-pinene, methyl cinnamate, eugenol, oleanolic acid, anethole, (β-sitosterol; triterpene saponosides, tanoids, etc). The seeds are rich in mucilages [18].

Pharmacodynamic action of basil: "antispasmodic emollient, cough reliever, sedative, antiseptic, antibacterial, decongestant, disinfectant, immunomodulator, antipyretic, carminative, antiemetic, antiaterosclerotic, hypoglycemic (regulates blood sugar and carbohydrate conversion, fat), antitumor, prevents cell degeneration, protects the body from the action of mutagenic factors (ultraviolet radiation, pollutants), increases resistance, tones the nervous system and has antidepressant action, improves cerebral circulation, attention and power of concentration, stabilizes emotions, facilitates better expression of feelings and individuality in general (in combination with St. John's worth), aphrodisiac" [19].

Chia seeds (*Salvia hispanica* L.) are produced by an herbaceous annual plant belonging to the order *Lamiales*, family *Labiate* mint, the genus *Salvia*. The plant is native to Mexico and Guatemala [20]. Historical documents show that chia was used along with corn, amaranth, and beans by Aztec, Mayan and ancient Mesoamerican cultures for the preparation of medicines and foods. In pre-Columbian societies, it was the second most important crop after beans. In Aztec communities, chia was used for food but also for cosmetics and religious rituals [21]. Many studies have analyzed the chemical composition of chia seeds showing that they are high in "fat (30-33%), carbohydrates (26-41%), dietary fiber (18-30%), protein (15-25%), vitamins, minerals and antioxidants" [21]. Chia seeds and oil contain natural antioxidants and polyphenolic compounds [22]. Polyphenolic compounds contribute the most to the antioxidant activity of chia seeds. Antioxidant compounds reduce the risk of chronic diseases (cancer and heart attack), provide protection against disorders such as diabetes, Alzheimer's and Parkinson's disease [23]. Ω-3 fatty acids have the ability to block calcium and sodium channel dysfunction, which can cause hypertension, improve heart rate variability and protect ventricular arrhythmia [20]. In addition, feeding on chia seeds is reduction omega-6in plasma, which results in a lower ω-6: ω-3 ratio and has a subsequent cardio-protective effect [24]. Other studies demonstrate that chia seeds are a latent source of numerous bioactive peptides, necessary for the repair of affected tissue and well-being [20].

Chia seeds have "anti-platelet, anti-carcinogenic, laxative, hypotensive, cardiac tonic, cardiovascular protector" [25], anemia treatment, improves dermatitis, antidepressant, anti-anxiety, visual and immune enhancer and EPA and DHA blood enhancer. The occurrence of celiac disease, constipation and vasodilation, as well as the risk of kidney problems can be reduced by consuming whole and solid versions of chia together with its oil [24].

Poppy seeds (*Papaver somniferum*) are used mostly for medical reason, but also appreciated in the culinary field, in the production of bakery, oil and as an ornamental species. Opium poppy is one of the most valuable species of houseplants. Opium poppy remains the most important natural commercial source of drugs such as codeine, morphine, oripavine along with a variety of semi-synthetic products, including oxycodone and buprenorphine, derived mainly from thebaine [26].

Poppy genotypes are classified into three categories: industrial, when grown for the extraction of alkaloids from the capsules; culinary when grown for seed and oil production; both industrial and culinary when capsules and seeds are used for alkaloid extraction as well as for seed collection. Another dimension of the usefulness of the poppy plant is added by its ornamental use in some countries [26]. Compared to opium poppy plant, poppy seeds do not have the opium alkaloids, "but can become contaminated with alkaloids as a result of pest damage and during harvesting" [27].

The poppy seeds contain organic compounds, fatty acids, essential nutrients, minerals and enzymes. The oil is rich in unsaturated fatty acids and tocopherol and shows no narcotic properties, being recommended also for different infant formulas due to its dietary significance [28].

2. Materials and methods

For the present study were used nutritional databases (FoodB, USDA, DUKE) hundreds of research papers and studies. The nutritional values of the seeds (flax, basil, chia and poppy), were analyzed using MVSP and PAST [29] statistical programs.

3.Results and discussions

The evaluation of the nutritional values of flax, basil, chia and poppy seeds were performed using statistical programs and mathematical models like principal component analysis and cluster analysis. The models managed to answers the question regarding the use basil seeds with the flax, chia and poppy seeds in order to produce innovative food products. The data collected from the research papers and databases are presented in table 1 and figure 1. All the nutritional values are calculated as per 100 grams fresh matter.

Table 1.Nutritional values of flax, basil, chia and poppy seeds main compounds

Nutritional compounds	U.M.	Flax seeds	Poopy seeds	Chia seeds	Basil seeds
Water	g	6.96 [30]	5.95 [31]	5.80 [32]	4-9.6 [33]
Energy/100	Kcal/100	5.34 [30]	5.25 [31]	4.86 [32]	4.61 [34]
Proteins	g	18.29 [30]	18.00 [31]	16.50 [32]	14.8 [35]
Total Fat	g	42.16 [30]	41.60 [31]	30.70 [32]	19.2 [34]
Total Fibers	g	27.30 [30]	19.50 [31]	34.40 [32]	22.6 [35]
Total Sugars	g	1.55 [30]	2.99 [31]	0.25 [32]	63.8 [35]
Calcium/100	mg	2.55 [30]	14.40 [31]	6.31 [32]	11.538 [34]
Iron	mg	5.73 [30]	9.76 [31]	7.72 [32]	2.27 [35]
Magnezium/100	mg	3.22 [30]	3.47 [31]	3.35 [32]	0.3155 [35]
Phosphorus/100	mg	6.42 [30]	8.70 [31]	8.60 [32]	-
Potasium/100	mg	8.13 [30]	7.19 [31]	4.07 [32]	6.923 [34]
Sodium	mg	30.00 [30]	26.00 [31]	16.00 [32]	0
Zink	mg	4.34 [30]	7.90 [31]	4.58 [32]	1.58 [35]
Copper	mg	1.22 [30]	1.63 [31]	0.92 [32]	-
Selenium	mg	25.40 [30]	13.50 [31]	55.20 [32]	0.3 [36]
Thiamin B1	mg	1.64 [30]	0.16 [31]	0.62 [32]	-
Riboflavin B2	mg	0.16[30]	0.10 [31]	0.17 [32]	-
Niacin	mg	3.08 [30]	0.89 [31]	8.83 [32]	-
Vitamin B6	µg	0.47 [30]	0.25 [31]	0.00 [32]	-
Total Folate	µg	87.00 [30]	82.00 [31]	49.00 [32]	-
Folic acid B9	mg	0.00 [30]	82.00 [31]	49.00 [32]	-
Pantothenic Acid	mg	1.00 [37]	-	0.94 [38]	0.21 [39]
Vitamin K	µg	4.40 [37]	-	-	414.80 [39]
Vitamin E	mg	0.60 [40]	22.8 [41]	0.50 [41]	0.80 [39]
Fatty acids, total polyunsaturated	mg	28.70 [30]	28.60 [31]	23.70 [32]	14.70 [42]

Figure 1 shows the beneficial use of basil seeds in different ratio with flax seeds, chia or poppy seeds because it's increasing the content of vitamins in special vitamin K, total carbohydrates and minerals.

The Barchart diagram using logarithmic transformed data show the influence of each type of investigated seed type in term of nutritional compound to a potential new innovative product based on the mixture of seeds.

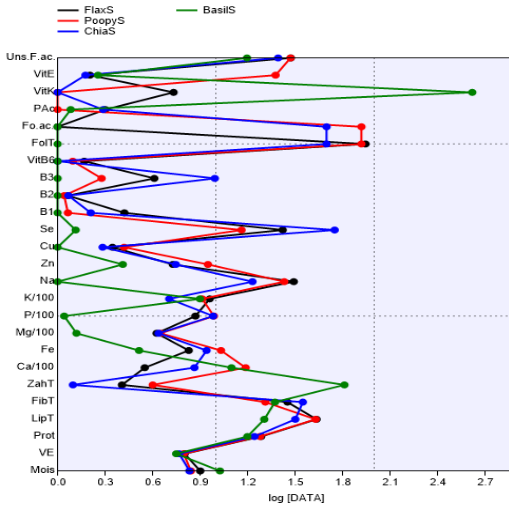

Figure 1. Graphical representation of nutritional data for the investigated seeds

Legend: *Flax seeds= FlaxS; Poopy seeds=PoppyS; Chia seeds= ChiaS; Basil seeds= BasilS; Moisture= Mois; Energy/100= VE; Proteins= Prot; Total Fat= LipT; Total Fibers= FibT; Total Sugars= ZahT; Calcium/100 =Ca/100; Iron= Fe; Magnezium/100= Mg/100; Phosphorus/100= P/100; Potasium/100= K/100; Sodium= Na; Zink= Zn; Copper= Cu; Selenium= Se; Thiamin =B1; Riboflavin =B2; Niacin= B3; Vitamin B6= VitB6; Total Folate= FolT; Folic acid B9= Fo.ac.; Pantothenic Acid= Pac; Vitamin K= VitK; Vitamin E= VitE; Fatty acids, total polyunsaturated = Uns.F.ac.*

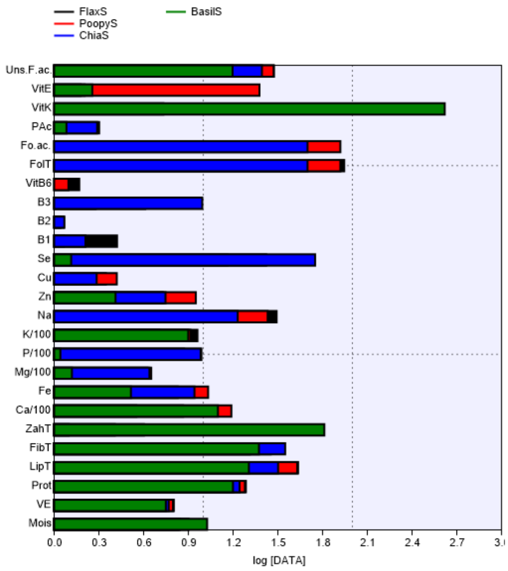

Figure 2. Barchart representation of the nutritional values of the seeds

Legend: *Flax seeds= FlaxS; Poopy seeds=PoppyS; Chia seeds= ChiaS; Basil seeds= BasilS; Moisture= Mois; Energy/100= VE; Proteins= Prot; Total Fat= LipT; Total Fibers= FibT; Total Sugars= ZahT; Calcium/100 =Ca/100; Iron= Fe; Magnezium/100= Mg/100; Phosphorus/100= P/100; Potasium/100= K/100; Sodium= Na; Zink= Zn; Copper= Cu; Selenium= Se; Thiamin =B1; Riboflavin =B2; Niacin= B3; Vitamin B6= VitB6; Total Folate= FolT; Folic acid B9= Fo.ac.; Pantothenic Acid= Pac; Vitamin K= VitK; Vitamin E= VitE; Fatty acids, total polyunsaturated = Uns.F.ac.*

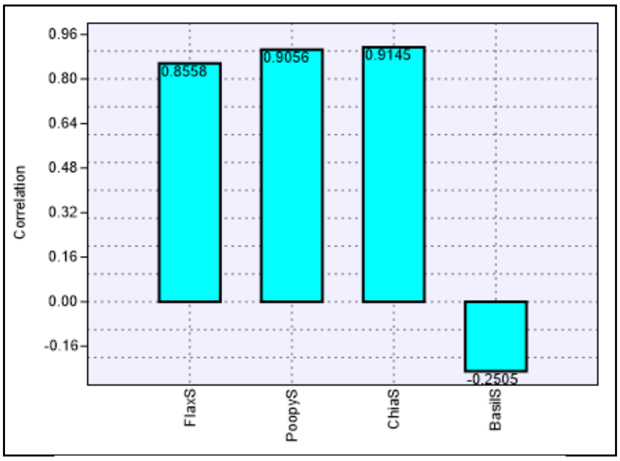

Figure 3. PCA loadings of transformed data for correlation matrix

Legend: *Flax seeds= FlaxS; Poopy seeds=PoppyS; Chia seeds= ChiaS; Basil seeds= BasilS;*

The Principal Component Analysis (PCA) has the role to summarize the information content from table 1 in order to make the trends more visible and to uncover the potential relationships between variables. For PCA the tables 1 data were square-root transformed, standardized and transposed. Due to the fact that highest percent of variance is represented by principal component 1 (61.289 %) and principal component 2 (24.188), the representation of vectors will be made on this 2 components.

According to figure 3 we observe that the data corresponding to basil seeds show negative correlation with the data corresponding to flax, chia and poppy seeds, which proves that basil seeds have a different behavior and nutritional composition compared to flax, chia and poppy seeds.

The PCA vectors representations of the investigated nutritional values of seeds are presented in figure 4.

Figure 4 shows that the nutritional values vectors corresponding to flax and chia seeds are in quadrant 1 showing that this 2 types of seeds present similar properties while the vectors corresponding to basil seeds nutritional values are situated in the third quadrant. The nutritional values vectors corresponding poppy seeds are distributed in the forth quadrant. The vectors corresponding to flax, chia and poppy seeds are distributed closer to each other while basil nutritional values vectors are situated at a bigger distance from the flax, chia and poppy seeds vectors. This confirms that basil seeds should be added to food products containing flax, chia or poppy seeds to complete the nutritional offer of these products.

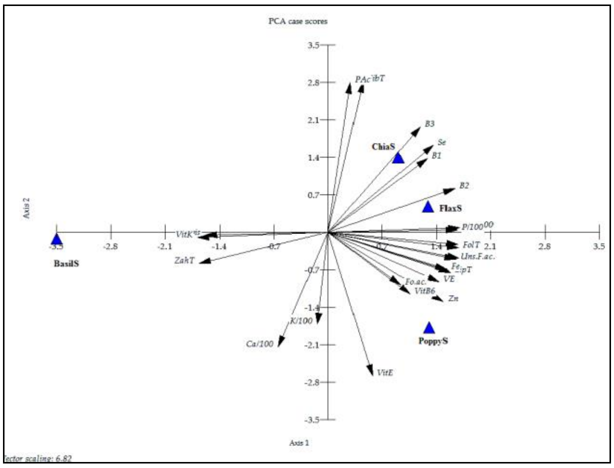

Figure 4. PCA graphical representation of investigated seeds nutritional values
Legend: *Flax seeds= FlaxS; Poopy seeds=PoppyS; Chia seeds= ChiaS; Basil seeds= BasilS; Moisture= Mois; Energy/100= VE; Proteins= Prot; Total Fat= LipT; Total Fibers= FibT; Total Sugars= ZahT; Calcium/100 =Ca/100; Iron= Fe; Magnezium/100= Mg/100; Phosphorus/100= P/100; Potasium/100= K/100; Sodium= Na; Zink= Zn; Copper= Cu; Selenium= Se; Thiamin =B1; Riboflavin =B2; Niacin= B3; Vitamin B6= VitB6; Total Folate= FolT; Folic acid B9= Fo.ac.; Pantothenic Acid= Pac; Vitamin K= VitK; Vitamin E= VitE; Fatty acids, total polyunsaturated = Uns.F.ac.*

The Nearest Neighbor Cluster Analysis using square-root transformed data (figure 5) and Squared Euclidean Function confirms the similarity between chia, poppy and flax seeds (correlation coefficient = 0.995).

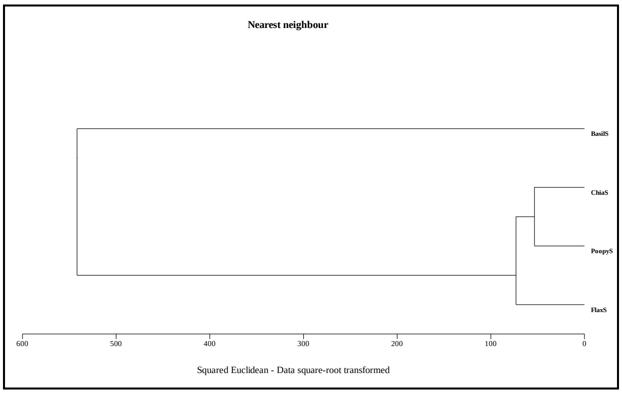

Figure 5. Cluster analysis of nutritional values corresponding to flax, chia, poppy and basil seeds
Legend: *Flax seeds= FlaxS; Poopy seeds=PoppyS; Chia seeds= ChiaS; Basil seeds= BasilS;*

Figure 6 corresponding to the graphical fingerprint representation of data shows what nutritional properties characterize each variety of seeds. From the absolute data fingerprint, we can observe that basil seeds contribute with a high content of vitamin K, chia with selenium, both poppy and chia seeds contribute with folic acid and flax seeds with total folate.

Based on the absolute fingerprint representation we can create innovative products containing the studied four seeds in different proportions according to the nutritional need of the consumer.

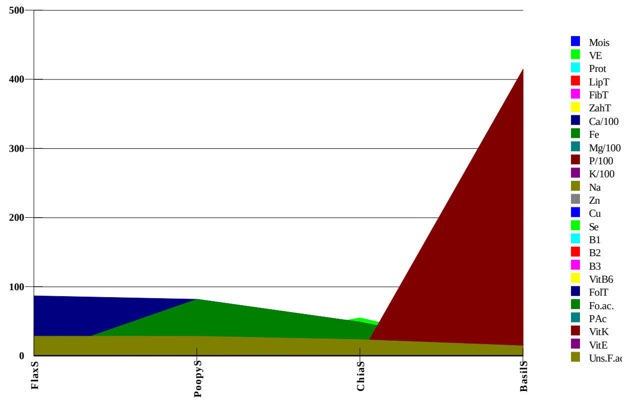

Figure 6. Flax, chia, poppy and basil seeds absolute data fingerprint
Legend: *Flax seeds= FlaxS; Poopy seeds=PoppyS; Chia seeds= ChiaS; Basil seeds= BasilS; Moisture= Mois; Energy/100= VE; Proteins= Prot; Total Fat= LipT; Total Fibers= FibT; Total Sugars= ZahT; Calcium/100 =Ca/100; Iron= Fe; Magnezium/100= Mg/100; Phosphorus/100= P/100; Potasium/100= K/100; Sodium= Na; Zink= Zn; Copper= Cu; Selenium= Se; Thiamin =B1; Riboflavin =B2; Niacin= B3; Vitamin B6= VitB6; Total Folate= FolT; Folic acid B9= Fo.ac.; Pantothenic Acid= Pac; Vitamin K= VitK; Vitamin E= VitE; Fatty acids, total polyunsaturated = Uns.F.ac*

4.Conclusion

Mixing flax seeds with chia and basil seeds, or poppy seeds with chia and basil seeds when creating different baking products or salads, the new obtained food products are not only innovative, but also novel, not only because of the use of chia, which was recently introduced to the EU consumers but also due to the high content of K vitamin which characterize the basil seeds composition.

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human or animal subjects (if exist) respect the specific regulation and standards.

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