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A STATISTICAL APPROACH TO THE STUDY OF VITAMIN C AND CRUDE FIBER IN SOME HORTICULTURAL PLANTS TO INTRODUCE THE MEDITERRANEAN DIET

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ABSTRACT. In this didactic paper, using a statistical approach, we introduce the Mediterranean diet, recognized culturally as the patrimony of UNESCO, that promotes a consumption of agrifood, containing vitamin C and crude fibre, that have beneficial effects on the health. This contribution is based on previous papers, where a set of 26 species of horticultural plants, used in Mediterranean diet, was examined from the statistical point of view, obtaining easily accessible and useful results. In particular the recorded content of vitamin C and crude fibre of the considered plants, based on literature data, have been analyzed as two sample variables. Graphic representations and statistical studies are given for these 2 variables. From the average values found of crude fibre and vitamin C contents, ingested by the human organism through the consumption of the considered fruits and vegetables, it can be seen that it is necessary to follow a diet rich in vitamin C and crude fibre to prevent disease, in accordance with medical standards and directives coming from several national and international nutrition organizations, and thus to promote the Mediterranean diet, that represents the initial steps to longevity and good health.

1. Introduction

United Nations Educational, Scientific and Cultural Organization (UNESCO), founded by the United Nations in 1946 to give courage to the nations to work together in the fields of education, science, culture and communication, recognized the Mediterranean diet (UNESCO 2003) as its own protected patrimony, included in the list of oral and intangible heritages of humanity, in 2010. The Mediterranean Diet (MD) is a modern food model introduced and for the first time studied in a systematic way by the physiologist, epidemiologist and nutritionist Ancel Benjamin Keys, coming from the United States, who investigated the effects of this diet on the epidemiological incidence of cardiovascular diseases in a famous study based on the research in Seven Countries (UNESCO 2010), which pertains to Italy, Morocco, Spain, Greece, Cyprus, Croatia, Portugal. Keys understood the MD positive influence on disease prevention (Keys and Keys 1975). The results of Keys' studies have shown that populations of the Mediterranean basin had above average longevity and a very high protection from illnesses compared with populations of North

Europe and the United States. He correlated these features to the kind of Mediterranean food consumed by them, in which the horticultural plants play the main role.

In 1999 a research group from the Ministry of Health in Greece, starting from these epidemiological studies which demonstrate the efficacy of the Mediterranean diet on longevity, elaborated a dietary scheme, published using the name "Pyramid of the Mediterranean Diet for Adults". The benefit derived from fruits and vegetables due to the high presence of the vitamin C and crude fibre contents (that among other things contrast the nitrates negative effects (see Di Bella *et al.* 2019) is one of the subjects studied on the topic of Mediterranean diet (see Metro *et al.* 2018).

The purpose of this paper is to summarize and present in a didactic way a selection of results derived in previous papers (Matarese Palmieri and Scinelli 2015a,b) by a statistical examination of selected literature data (see Zangheri 1976; Salisbury and Ross 1984; Bianco and Pimpini 1990; Traverso 1990; Venturelli 1995), regarding the vitamin C and crude fibre contents in 26 different species of agricultural plants, and to discuss how their consumption has benefits on the human health, in agreement with the recommendations of Mediterranean diet to live better, longer and in good health (see also Matarese Palmieri and Scinelli 2014).

Vitamin C (or ascorbic acid) is a water soluble vitamin that has nutraceutical properties. It is an important antioxidant widely present in vegetables and fruits having important functions that prevent several diseases in the human organism. It strengthens the immune system and offers a variety of health benefits.

Crude fibre refers to the indigestible carbohydrate component, that is present in plant cell walls. The name is derived from the fact that it has a fibrous structure. Crude fibre is the measure of the quantity of indigestible cellulose, pentosan, lignin and other components of this type present in foods. It increases the bulk and speeds up the passage of food through the digestive tract, and therefore reducing the absorbtion of toxic substances.

In Sections 2 and 3 we introduce the variables X_1 and X_2 illustrating the vitamin C and crude fibre contents, respectively, in 26 fresh horticultural plants. Then, we present graphic representations and the average, M, and the standard deviation, σ, of these contents, calculated using the formula

$$M = \frac{\sum_{i=1}^{n} x_i f_i}{\sum_{i=1}^{n} f_i}, \tag{1}$$

with i = 1, 2, ..., n the number of the measures of the contents, x_i the values of these measures and f_i their relative frequencies,

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} (x_i - M)^2 f_i}{\sum_{i=1}^{n} f_i}}. \tag{2}$$

Finally, we discuss the benefits of consuming vegetables containing vitamin C and crude fibre in reducing the risk of various diseases and on directing attention to the Mediterranean diet according to the nutritional guidelines of international and national organizations.

2. Didactic method

In this didactic paper we introduce the Mediterranean diet using a statistical approach. This interdisciplinary method is one of the most recommended in education because it presents important current topics taking into account results obtained in correlated subjects, emphasizing the motivations that have pushed the promotion of the Mediterranean diet in preventing disease. The methods of univariate descriptive statistics are applied to analyze a set of fresh vegetables, by means of the construction of tables and graphs. More precisely, the vitamin C and crude fibre of the horticultural plants under consideration are examined one at a time and their values are considered like the values of two statistical variables, of which, knowing the frequency distribution, applying statistical methodologies, the average value and the standard deviation are calculated. The graphs of the vitamin C and crude fibre have been colored in order to put in evidence with the same color equal values and, then, their frequency distribution. The average values obtained in the analysis of the two statistical variables are discussed, taking into account the values recommended by the Scientific Committee for Food (SCF), to show how following the educational rules of the Mediterranean diet can lead to good health and prevent several illnesses.

3. Vitamin C content in a set of horticultural plants

In this Section we summarize a selection of results obtained by a statistical examination of vitamin C content (expressed in mg/100g of fresh weight of edible plant) present in the 26 considered horticultural plants (Matarese Palmieri and Scinelli 2015b), based on selected data obtained in literature (Zangheri 1976; Salisbury and Ross 1984; Bianco and Pimpini 1990; Traverso 1990; Venturelli 1995), in order to show the benefit of consuming a diverse diet rich in vegetables in order to reach the recommended dose of vitamin C, to have health benefits, following the medical standard of nutrition national and international organizations. In fact, vitamin C contrasts the negative influence of nitrates, that have been shown to change into nitrites during the food preparation or within the human organism (see Di Bella *et al.* 2019). Nitrates combined with amines, present in food or derived from protein degradation processes, occurring in the stomach, can produce nitrosamines, that are acknowledged as carcinogens.

Vitamin C can inhibit the conversion of nitrites to nitrosamines, transforming them into nitric oxide. In fact, vitamin C is essential to stimulate the immune system, it allows the human body to oppose diseases, enclosing the various types and forms of cancer. Vitamin C (ascorbic acid) is a water soluble vitamin. The human organism needs vitamin C because it is not able to satisfy its vitamin requirement through the process of organic synthesis and, therefore, it depends on the dietary contribution. Vitamin C is widely present in vegetables and fruits. Studies have shown that the quantity of available vitamin C is greater in fresh fruits and vegetables and those stored correctly, protected against light and heat, but less in frozen fruits and vegetables. In food vitamin C deteriorates quickly by the transport, storage, cooking, bruising, and cutting of the plants or fruits.

Vitamin C facilitates the absorption of iron, contributes to production of red blood cells, (thus, it is useful in the treatment of anemia), it is necessary to the body to synthesize collagen (that reinforces bones, cartilage, muscles and blood vessels). It has an important antioxidant action and increases the effectiveness of the antioxidant vitamin E and the

TABLE 1. Sample variable X_1: Content of vitamin C $mg/100g$ of fresh weight of edible plant in 26 vegetables

	26 HORTICULTURAL PLANTS	**VITAMIN C CONTENT**
FAMILY	GENERA AND SPECIES	
Asteracae	*Cichorium endivia* L. var. *latifolium* Hegi	8
	Cichorium intybus L.	24
	Lactuca sativa L.	7
	Scorzonera hispanica L.	12
Liliaceae	*Allium cepa* L.	32
	Allium porrum L.	15
	Asparagus officinalis L.	32
Brassicaceae	*Brassica oleracea* var. *italica* Plenck	116
	Brassica oleracea L. var . *Sabauda* L.	31
	Brassica rapa L.	60
	Brassica rapa L. var. *rapa*	60
	Raphanus sativus	21
Cucurbitaceae	*Cucumis melo* L.	29
	Cucurbita moschata	14
	Cucumis sativus L.	10
Convolvulaceae	*Ipomoea batatas* L.	21
Graminaceae	*Zea mays* L. var. *saccharata* Körn	11
Leguminosae	*Phaseolus vulgaris* L.	33
	Pisum sativum L.	35
Polygonaceae	*Rhéum rhaponticum* L.	8
Solanaceae	*Capsicum annuum* L.	140
	Lycopersicon esculentum Mill.	22
	Solanum melongena L.	7
	Solanum tuberosum L.	10
Umbelliferae	*Apium graveolens* L. var. *dulce*	13
	Petroselinum crispum	100

absorption of folic acid. It protects the brain and spinal cord from destruction by free radicals and helps the healing of wounds and bone fractures and maintains healthy teeth and gums.

Therefore, we define the sample variable X_1, describing the vitamin C contents corresponding to the 26 analyzed plants (see Table 1) and we give its graphic representation (see Figure 1).

From the values of vitamin C contents of Table 1, the average M_1 and the relative standard deviation σ_1, calculated using the formula (1) and (2), are:

$$M_1 = 33,50\, mg/100g, \quad \sigma_1 = 22,14\, mg/100g. \tag{3}$$

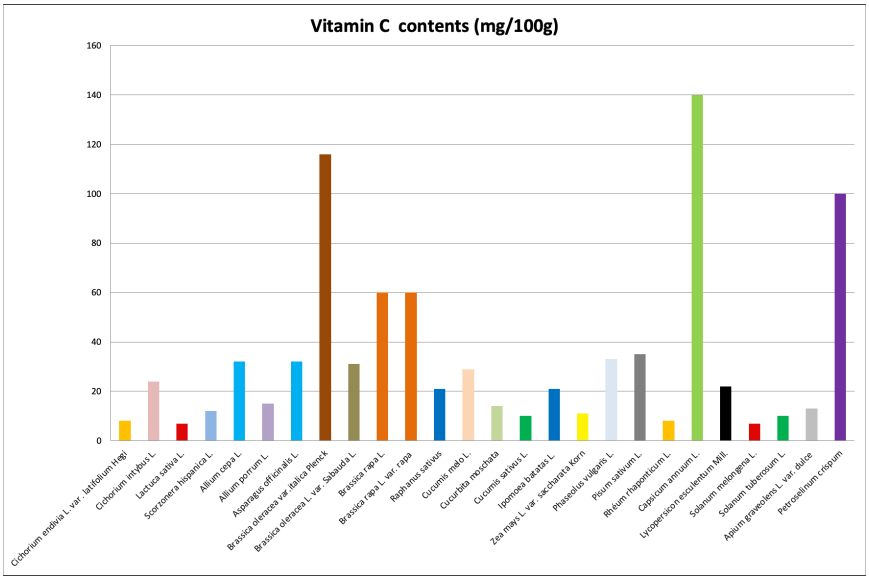

FIGURE 1. Sample variable X_1.

From (3) it is seen that, being the average value of vitamin C in 26 analyzed plants 33,50 mg/100mg, it is necessary to consume diverse fruits and vegetables in order to obtain the recommended level of vitamin C which a body in good health must intake to satisfy itsdaily needs. The recommended daily allowance (RDA) for vitamin C ranges from 15-75 mg/day for children, 75 mg/day for adult women, 90 mg/day for adult men and 85-120 mg/day for pregnant and breastfeeding women, respectively. The Scientific Committee for Food (SCF) has established these RDAs in agreement with medical recommendations, to convey health benefits, thus the Mediterranean diet represents the initial steps to increase good health and longevity. It must be taken into consideration that, for smokers and pregnant women, vitamin C intake should be increased and, independently, for babies the amount of vitamin C will increase proportionally with increasing body weight. High doses of vitamin C are not recommended in patients with renal insufficiency.

4. Crude fibre content in a set of horticultural plants

In this Section we summarize a selection of results worked out by a statistical analysis of crude fiber content (expressed in g/100g of fresh weight of edible plant) present in the 26 examined vegetables (Matarese Palmieri and Scinelli 2015a), based on selected data obtained in literature (Zangheri 1976; Salisbury and Ross 1984; Bianco and Pimpini 1990; Traverso 1990; Venturelli 1995) given in (Matarese Palmieri and Scinelli 2015a), in order to show that it is necessary to consume different horticultural plants to reach the minimum value of crude fibre to have health benefits, following the recommendations of national and international nutrition organizations.

TABLE 2. Sample variable X_2: Content of fibre crude in $g/100g$ of fresh weight of edible plant in 26 vegetables

	26 HORTICULTURAL PLANTS	**FIBRE CRUDE CONTENT**
FAMILY	GENERA AND SPECIES	
Asteracae	*Cichorium endivia* L. var. *latifolium* Hegi	0,8
	Cichorium intybus L.	0,7
	Lactuca sativa L.	0,6
	Scorzonera hispanica L.	2,1
Liliaceae	*Allium cepa* L.	0,5
	Allium porrum L.	1,2
	Asparagus officinalis L.	0,8
Brassicaceae	*Brassica oleracea* var. *italica* Plenck	1,4
	Brassica oleracea L. var . *Sabauda* L.	1,2
	Brassica rapa L.	0,9
	Brassica rapa L. var. *rapa*	0,9
	Raphanus sativus	0,7
Cucurbitaceae	*Cucumis melo* L.	0,6
	Cucurbita moschata	1,4
	Cucumis sativus L.	0,5
Convolvulaceae	*Ipomoea batatas* L.	0,7
Graminaceae	*Zea mays* L. var. *saccharata* Körn	0,8
Leguminosae	*Phaseolus vulgaris* L.	1,1
	Pisum sativum L.	2,2
Polygonaceae	*Rhéum rhaponticum* L.	0,7
Solanaceae	*Capsicum annuum* L.	1,6
	Lycopersicon esculentum Mill.	0,6
	Solanum melongena L.	0,9
	Solanum tuberosum L.	0,7
Umbelliferae	*Apium graveolens* L. var. *dulce*	0,8
	Petroselinum crispum	1,6

Dietary fibre takes its name from its fibrous structure and refers to the indigestible carbohydrate component present in plants. It is not degraded by the enzymes of the digestive system and thus it can not be assimilated and used as a source of energy. Crude fibre accelerates the speed of intestinal transit, it is able to slow down the adsorption of carbohydrates and lipids, retaining bile salts, bile acids and cholesterol, and thus, in part, preventing undesired reabsorption and increasing the rate of elimination. Crude fibre comprehends different components, like hemicellulose, cellulose, lignin, pectins, gums, mucilages and galactomannans and others that are of minor quantitative importance. These substances are resistant to the action of digestive juices of the gastrointestinal tract. Hemicelluloses are partially degraded by intestinal bacteria. The cellulose is part of the

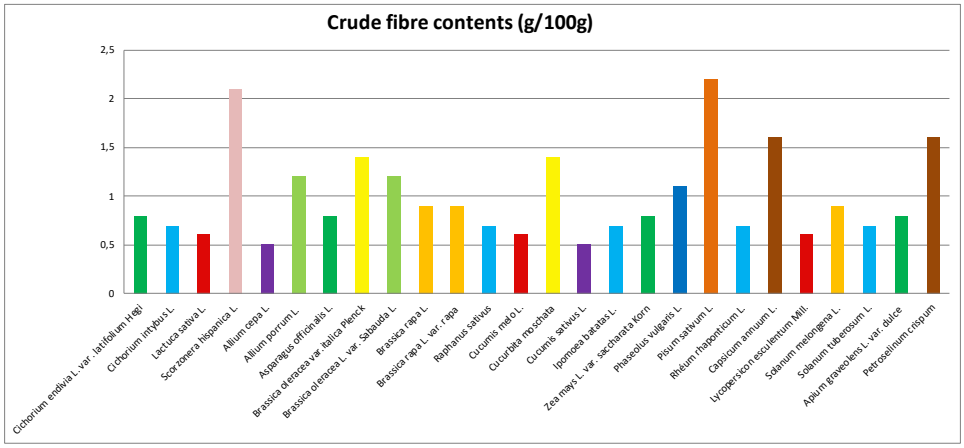

FIGURE 2. Sample variable X_2.

support structures and of the cell walls of plants, it is hydrophilic and has a great power of adsorption and swells in presence of water and it is partially degraded by the intestinal flora. It is largely eliminated. Lignin is linked to cellulose. Pectins, constituents of plant cell walls, are the cementing substance of plant cells and tissue, have high hydrophilic properties and are completely degraded by intestinal bacteria. The most important features of pectin is retaining large amounts of water. Furthermore, it is important for vasodilation. Moreover, the recommendations to include an adequate content of fibre in the form of plant foods is justified by the fact that diets at high crude fibre content have the advantage to supply quantities of micronutrients with antioxidant properties, that reduce the risk of degenerative diseases. In addition, crude fibre has a satiety effect, inhibiting the hunger center (and therefore products rich in crude fibres can be referred to as adjuvants in diets), a mechanical effect on intestine and, therefore, it reduces the risk of diseases linked to the digestive system.

Thus, we define the sample variable X_2 describing the crude fibre contents corresponding to the 26 analyzed vegetables (see Table 2) and we give its graphic representation (see Figure 2).

From the values of crude fibre contents of Table 2 the average M_2 and the relative standard deviation σ_2, calculated using the formula (1) and (2), are:

$$M_2 = 1,00 \ \ g/100g, \quad \sigma_2 = 0,44 \ \ g/100g. \tag{4}$$

From (4) it is seen that the average value of crude fibre in 26 analyzed plants is $1,00$ $g/100g$, thus, it is necessary to follow a diet rich in fibre in agreement with the directives of the Scientific Committee for Food (SCF), that has established a recommended daily allowance (RDA) of 25 g/day, indicating the nutrient amount of crude fibre content that a person in good health must intake to satisfy their own daily needs. This recommendation is motivated by the fact that the crude fibre has the benefit to provide quantities of nutrients that decrease the danger of disease. Therefore, the Mediterranean diet, associated with a

healthy lifestyle, takes the base level in the food pyramid, showing the crucial role of crude fibre in preventing disease.

5. Conclusions

In this didactic paper using an interdisciplinary method, by means of a statistical study of the vitamin C and crude fibre contents of a set of vegetables, we have put in evidence the importance of adhering to the educational guidelines defined in the Mediterranean diet in order to prevent diseases. Currently, there are many directives from international and national organizations for nutrition, like WHO (World Health Organization), FAO (Food and Agriculture Organization), EFSA (European Food Safety Authority), that recommend consumption of fruits and vegetables each day to ensure a balanced diet and to intake the indispensable content of nutrient feed to prevent diseases. In particular, Scientific Committee for Food (SCF) has established a recommended daily allowance (RDA) of 60 mg/day, as the amount of vitamin C content, and a RDA of 25 g/day as the amount of crude fibre content (both values referred to fresh weight of edible plant), that a person in good health must intake to supply their own daily requirement in order to be protected from illness.

The nutritionist Keys and Keys (1975) acknowledged that the MD, adopted by the populations of Mediterranean basin, acts against diseases and on longevity. In this paper, as a new didactic approach, we have summarized a selection of the results obtained in previous papers (Matarese Palmieri and Scinelli 2015a,b) by a statistical examination of selected data obtained in literature (see Zangheri 1976; Salisbury and Ross 1984; Bianco and Pimpini 1990; Traverso 1990; Venturelli 1995), regarding the vitamin C and crude fibre contents of fresh weight of 26 different edible plants, whose calculated averages are less than RDA fixed by the SFC to live in good health. Thus, it is necessary each day to ingest fruits and vegetables to ensure the indispensable nutrients to the human organism.

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References

Bianco, V. and Pimpini, F. (1990). *Orticoltura*. Patron editore, Bologna, Italia.

Di Bella, G., Cicero, N., and Scinelli, A. (2019). "A statistical study on nitrate contents in a set of some species of horticultural plants, used in Mediterranean diet". *Atti Accademia Peloritana dei Pericolanti* **97**(S2), 1–12. DOI: 10.1478/AAPP.97S2A24.

Keys, A. and Keys, M. (1975). *Eat Well and Stay Well: the Mediterranean Way*. Doubleday, USA.

Matarese Palmieri, R. and Scinelli, A. (2014). "A statistical anlaysis on nitrate, crude fibre, and vitamin C in some species of horticultural plants, used in Mediterranean diet for a good health". *Bollettino di Matematica Pura ed Applicata* **VII**(6), 93–107. DOI: 10.4399/978885487801310.

Matarese Palmieri, R. and Scinelli, A. (2015a). "A statistical examination on crude fibre content in a sample of horticultural plants, used in a diet with benefit effects for a healthy feed. A statistical approach". *Bollettino di Matematica Pura ed Applicata* **VIII**(6), 12–24.

Matarese Palmieri, R. and Scinelli, A. (2015b). "A study on vitamin C content in a sample of fresh horticultural plants, consumed for a healty feed. A statistical approach". *Bollettino di Matematica Pura ed Applicata* **VIII**(6), 1–12.

Metro, D., Tardugno, R., Papa, M., Bisignano, C., Manasseri, L., Calabrese, G., Gervasi, T., Dugo, G., and Cicero, N. (2018). "Adherence to the Mediterranean diet in a Sicilian student population". *Natural Product Research* **32**(15), 1775–1781. DOI: 10.1080/14786419.2017.1402317.

Salisbury, F. B. and Ross, C. W. (1984). *Fisiologia Vegetale*. Zanichelli, Bologna, Italia.

Traverso, O. (1990). *Botanica Orticola*. Agricole, Pavia, Italia.

UNESCO (2003). "Convention for the Safeguarding of the Intangible Cultural Heritage 2003, Paris, 17 October 2003". *Constitution*.

UNESCO (2010). "Decision of the Intergovernmental Committee: 5.COM 6.41". *Section of Intangible Cultural Heritage*.

Venturelli, F. (1995). *Invito alla Botanica*. Zanichelli, Bologna, Italia.

Zangheri, P. (1976). *Flora Italica*. CEDAM, Padova, Italia.

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