Research Journal of Agricultural Science, 57 (2), 2025; ISSN: 2668-926X

http://doi.org/10.59463/RJAS.2025.2.03

STATISTICAL CORELATIONS BETWEEN BIOPHYSICAL CHARACTERISTICS FOR SOME GREEN VEGETABLE JUICES

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Abstract. *Natural green plant juices have excellent nutritional properties and many functional qualities being used very often in modern diets. Due to their biological and therapeutic values, these types of juices are considered functional foods having substantial benefits for health and body balance. The therapy with green plant juices improves the physical and emotional state of the body. Natural juices offer the nutritional benefits of components in a concentrated form with the possibility of a very easy and rapid absorption in the human body. In this study natural juices from green apples (Malus domestica), cucumbers (Cucumis Sativus), parsley (Petroselinum crispum), lime and spinach (Spinacia oleracea) were analyzed by the point of view of some biophysical characteristics such as density, viscosity, pH, electrical conductivity, surface tension and refractive index. The objective of this study was to evaluate and compare these characteristics for five distinct juices samples. All the data was statistically analyzed using Statistica10. The results showed a statistical correlation between the physicochemical parameters for the analyzed types of juices samples. These linear correlations determine the linear dependency between the studied biophysical parameters. In conclusion, plant juices therapy is an effective alternative for cell reconstruction and regeneration to optimal body health. A moderate consumption of green plant juices, as part of a well-balanced daily diet, offers benefits in maintaining good health and reducing the risk of illness.*

Keywords*: natural green vegetable juices, biophysical characteristics, statistical correlations*

INTRODUCTION

Fruits and vegetables are part of the food category, most important to humans, being necessary to maintain life and health. In the rational good nutrition, the important role of fruits and vegetables is well known through the valuable intake of vitamins, sugars, enzymes, pectic substances, cellulose, organic acids, flavors and minerals. Fruit juices are known all over the world, not only because of their taste and freshness, but also because of their beneficial health effects when they are consumed regularly. Natural juices have a beneficial effect on the body due to the multitude of nutrients that are assimilated in a very short time (VICENTE et all., 2009; LASCU, 2008).

Plant juices are liquid, non-alcoholic products with different degrees of clarity and viscosity, obtained by pressing or fine grinding of them, with or without addition of sugar or carbon dioxide. Juice is a refreshing liquid obtained by squeezing fruit, vegetables and sometimes from primordial herbs necessary for a balanced lifestyle (BANU et AL., 2004; ALUNGULESEI, 2016). Due to the curative effects in a range of acute and chronic diseases, the fruit juice diet is a successful technique used in modern medicine. It is recommended, prophylactic and curative, as an adjuvant, when the body accumulates significant amounts of acids; which has repercussions such as diabetes, aging, gout, and so on. Consumption of fruit juices with pulp is prescribed in the treatment and prevention of cardiovascular diseases, liver diseases, etc., natural juices that provide a high percentage of vitamins and minerals in the daily dose (ULGER et AL., 2016; BRATU, 2020).

The European Commission of Functional Foods in Europe focuses attention on the

effect of green plant juices, which provide a full set of active compounds, regulate the digestive system, alkalizes, energizes, detoxifies the body and acts as a functional food (WALKER, 2016).

The Apple tree is a perennial fruit tree of Asian origin belonging to the species *Malus domestica*, the *Roscaceae* family. Considered the fruit of vitality, apple is one of the most appreciated and popular fruits with over 30 minerals and trace elements. Fruits have a very complex content with high amounts of sugars (7-16%), organic acids, pectic substances (reduce cholesterol), multivitamins (C, A, B_1, B_2, PP, pantothenic acid), potassium, phosphorus, silicon, magnesium, zinc, copper) and fibers (VELCIOV et AL., 2022). Apple fruit considered to be an exceptional natural medicine with therapeutic properties in cardiovascular disease, atherosclerosis, hypertension, myocardial infarction, anemia and demineralization of the body, chronic hepatitis, constipation, insomnia, arthritis.

Cucumber (*Cucumis sativus*) is an edible, vegetable plant of the *Cucurbitaceae* family grown on a large scale. It is an annual herbaceous plant, one of the oldest crop plants, cultivated for its fruit. Cucumber fruit is a low-calorie food but with many nutritional values and a high content of water and phytonutrients. Due to its diversified content in nutritional principles, it is eaten fresh in salads, juices or processed into various foods, preserved by pickling or maturation. Cucumber (fruit) contains 95% water, dry substance 4-6%, 1.7% carbohydrates, 0.7-1.1% pectic substances, 0.44-0.57% mineral salts, fiber and also vitamins (ascorbic acid, pantothenic acid, nicotinic acid, complex B) (NIAC, 2010; POSTA, 2008).

Parsley *(Petroselinum crispum)* is a bi-annual herbaceous plant belonging to the *Apiaceae* family. Cultivated worldwide, this plant has been used in gastronomy and as a natural remedy for millennia. Both food and spice, the root, leaves and seeds are consumed raw and prepared. Consumed raw, parsley is very rich in vitamin C (190mg / 100g) more than lemon, orange or cabbage, along with vitamins A, B_1, B_2, B_3, B_5, B_6, B_9, K and E. It is an excellent source of carbohydrates, proteins, fiber, minerals (potassium, calcium, phosphorus, magnesium, iron, sodium), volatile oil, lipids and antioxidants (LASCU,2008; TEISAN, 1993).

From the botanical approach, spinach (*Spinacia oleracea*) belongs to *Amaranthaceae* family, native from Central Asia. Spinach leaves are consumed as food preparations, salads or juice, his properties being preserved only raw. The leaves contain large amounts of chlorophyll, folic acid, vitamin B_1, B_2, B_6, B_9, PP, C, E and K, carotene, protide, lipids, carbohydrates, mucilages, lutein, iron, and a specific substance called spinachin (LAMBERT, 2022; POP, 2024).

A moderate consumption, as part of well-balanced daily diet, green plant juices, offer benefits in maintaining good health and reducing the risk of illness. With its high content of chlorophyll, enzymes, minerals, salts and vitamins, green juices are increasingly appreciated as a natural remedy being easily assimilated in a very short time. Easily digested and assimilated, its components go directly and fill the body with the nutrients and energy in less than 20 minutes. Green plant juices slow down the body's aging process and help prevent cancer through its high content of antioxidants (flavonoids, polyphenols) (BOLOS, 2023; RUTA, TARCEA, 2018).

MATERIAL AND METHODS

In the experimental part it was prepared five distinct samples of apple juice, cucumber, spinach, parsley, limes of about 200 ml, separately and also another mixed sample resulting from the mixture of this five ingredients. The mixture of green plant juices from vegetables and fruits was obtained to the following recipe: 2 green apples 250g, spinach baby

http://doi.org/10.59463/RJAS.2025.2.03

150g, cucumber 250g, parsley 50g, 1/2 green lime. Samples of fruits and vegetables were purchased randomly from agro-food markets in Timisoara.

Natural juices from green plants were obtained using a Centrifugal Juicer, a pressing robot for fruits and vegetables. The resulting juice was a 100% natural product, without additives or preservatives, made with the robot device by mastication that extracts, crushes and presses, thus contributing to release the nutrients. For each of the fresh and clear prepared juices, taken into study, the physicochemical parameters were determined (pH, electrical conductivity, dynamic viscosity, refractive index, superficial tension and density) according to AOAC Official Methods of Analysis, 2000 (AOAC, 2000).

The aim of the study was to evaluate and test the linear relations between some characteristics (pH, electrical conductivity, dynamic viscosity, refractive index, superficial tension and density) in case of various types of juice samples obtained from apples, spinach, cucumber, parsley and lime taken separately and all in the mixture.

The pH and the electrical conductivity (G) were determined using the multiparameter analysis device CONSORT 3010. This is a multiparameter analysis equipment that allows measurement of pH, electrical conductivity and temperature. To carry out the measurements it was necessary calibration of the pH meter in the acid range. Two buffer solutions were used with known pH values, buffer solution pH = 7 and another with pH = 4. Conductometric methods are physicochemical analysis methods based on the determination of conductivity of the elctrolyte solutions. To conduct measurements, the conductometer must be calibrated, the conductance must be below 50 μS.

The refractive index was measured using the refractometry method, with the Abbe refractometer corrected to the equivalent reading at 20°C. The use of the refractometer requires a calibration check by measuring the refractive index of distilled water, which has a value of 1.3330 at t = 20 °C. The dynamic viscosity was obtained using the Ostwald-type viscometer by known formulas. For the relative density was used the pycnometer method and for the surface tension coefficient has been applied the stalagmometre metod (COZMA, 2016).

The data were statistically processed using Statistica10 program. The purpose of the statistical analysis was to highlight the correlations between the analysed parameters expressed by a linear functional dependence.

RESULTS AND DISCUSSIONS

Analysis of the physico-chemical parameters (pH, G, n, η, σ, ρ) are a basic indicator in investigating the nutritional properties of the natural green plant juices taken into study. Basic descriptive statistics (mean, minimum, maximum, the lower and higher quartile, standard deviation, coefficient of asymmetry and flattening coefficient for each parameter, variable, are presented in Table 1.

Table 1

Basic descriptive statistics for the physical-chemical analyzed parameters

Parameter	Mean	Minimum	Maximum	Lower quartile	Higher quartile	Variance	Standard deviation	Skewnes	Kurtosis
G	5.62333	2.05000	13.78000	3.79000	5.63000	17.2974	4.15902	2.02475	4.53132
pH	4.17667	2.38000	6.97000	3.31000	4.62000	2.4645	1.56989	1.18092	2.05040
n	1.12318	0.00000	1.36200	1.34100	1.34820	0.3028	0.55030	-2.44847	5.99617
η	1.29610	1.00120	1.74780	1.04040	1.40380	0.0745	0.27296	0.75212	0.51049

http://doi.org/10.59463/RJAS.2025.2.03

σ	74.53200	59.58600	88.38600	68.75300	83.27600	107.579	10.3720	-0.06360	-0.57551
ρ_{rel}	1.03223	1.01540	1.05270	1.01860	1.04130	0.0002	0.01403	0.22090	-0.88199
ρ	1.02843	1.01140	1.04840	1.01450	1.03920	0.0002	0.01403	0.16315	-1.21965

Electrical conductivity is one of the parameters that verifies the authenticity, freshness of a product. The electrical conductivity of a food product is a function of product characteristics (composition, sugar content and salts, pH, etc.) and is also influenced by the heating process, especially temperature. Table 1 shows that the average conductivity values of the studied juices are 5.62mS. The highest value was obtained for natural spinach juice (13,78 mS) and the smallest at natural green apple juice (2,05mS).

Natural juices contain a range of minerals, organic acids, fibers, salts and other bioactive substances. Minerals are present as the form of electrolytes, so they are easily absorbable by the human body. It is known that the solution's conductivity increases with its content in dissolved substances so, soluble salts, minerals and other components contribute to electrical conductivity differences (LAMSAL, JINDAL, 2014).

Being a measure of the acid or basic character of a solution, pH is an important factor in the processing of fruit and vegetable products. From table 1 the pH values of the analyzed green juices at 20°C varies between 2.38 and 6.97. The lowest value was obtained for lime juice (2.38) and the highest value for green spinach juice (6.97). Higher acidity (low pH) of preserved juices than fresh ones, recommends natural, fresh daily intake as a benefit in the treatment and prevention of many diseases (COZMA et AL., 2017).

Sugar (sucrose) is a carbohydrate that naturally occurs in fruits and vegetables. The high sugar concentration in fruit juices provides a high refractive index value. Regarding the refractive index, the smallest value (1.3439) was obtained in the case of mixed natural juice with all ingredients, and the highest value (1.3620) was obtained for the natural apple juice due to the soluble substance content, the sugar in the composition (COZMA et AL., 2015).

Viscosity is considered an important physical property for the quality of liquid foods. Natural plant juices generally present Newtonian fluid behavior, the increase in viscosity is the result of increased fiber, pectin and the amount of sugar present. From table 1, the minimum values of dynamic viscosity are 1.0012cP in case of mixed green plant juice while the maximum viscosity value is 1.7478 for lime juice. If the natural herbal juices contain considerable amounts of pulp or are highly concentrated, they may have additional flow resistance represented by a higher stretching request (MOMIN, THAKRE, 2015; COZMA et AL., 2017).

The purpose of the following statistical analysis is to highlight the correlations between the analyzed parameters, expressed by a linear functional dependence between them. The matrix of linear correlations between the variables (Table 2) reveals a strong positive linear correlation and statistically significant between the pH and the electrical conductivity G and between the refractive index n and the electrical conductivity G in case of the analyzed juices (ŻYWICA, BANACH, 2015).

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Table 2

Pearson matrix of linear correlation coefficients between the studied parameter

Matrix of Linear Correlation Coefficients									
Parameters	Mean	Standard deviation	G	pH	n	η	σ	ρ_{rel}	ρ
G	5.623	4.159	1,000	0,877	-0,964	-0,468	-0,734	-0,678	-0,676
pH	4.176	1.569	0,877	1,000	-0,873	-0,771	-0,572	-0,694	-0,715
n	1.123	0.550	-0,964	-0,873	1,000	0,462	0,704	0,486	0,490
η	1.296	0.272	-0,468	-0,771	0,462	1,000	-0,064	0,596	0,633
σ	74.532	10.372	-0,734	-0,572	0,704	-0,064	1,000	0,408	0,391
ρ_{rel}	1.03223	0.0140	-0,678	-0,694	0,486	0,596	0,408	1,000	0,998
ρ	1.02843	0.0140	-0,676	-0,715	0,490	0,633	0,391	0,998	1,000

From the Pearson matrix of linear correlation coefficients, there is a significant positive correlation between the pH and the electrical conductivity G. The linear functional dependence is mathematically represented by the equation of the regression line, $y = b_0 + b_1x$. This was used as a mathematical model to approximate the functional relation examined (Figure 1). The pH can be expressed according to the electrical conductivity G by the equation:

$$pH = 2{,}3147 + 0.33111 \cdot G$$

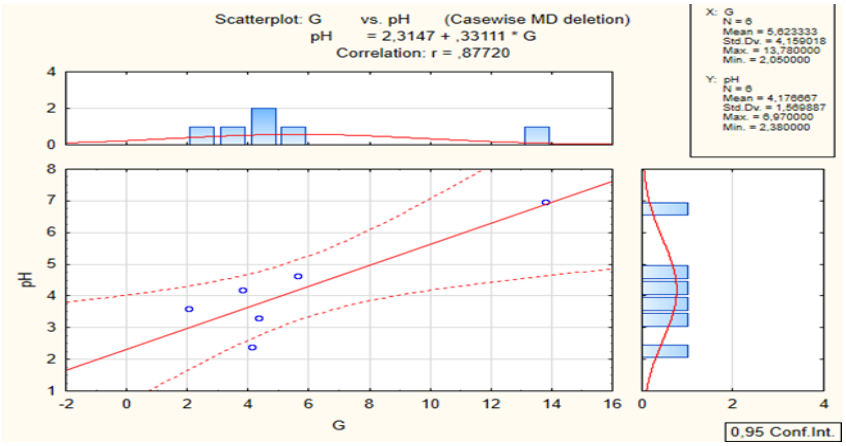

Figure 1. Linear dependence of the pH relative to the electrical conductivity G

Also, from the Pearson matrix of the linear correlation coefficients, there is a significant positive correlation between the refractive index n and the electrical conductivity G

http://doi.org/10.59463/RJAS.2025.2.03

of the analyzed juices. Linear functional dependence is highlighted in Figure 2 by the regression mathematical equation:

$$n = 1{,}8405 + 0{,}1276 \cdot G$$

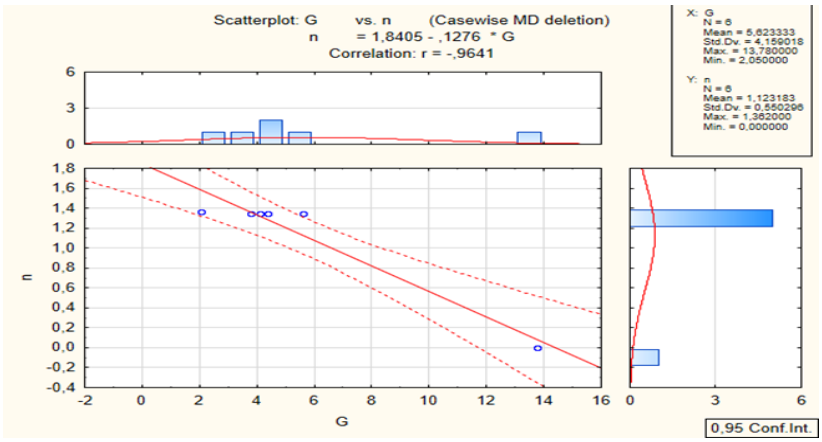

Figure 2. The linear dependence of the refractive index n relative to the electrical conductivity G

CONCLUSIONS

Evaluations of physicochemical parameters (pH, electric conductivity, refractive index, viscosity, surface tension, relative density) represent a significant indicator in the appreciation of biophysical properties. For analyzed green juices samples (apples, spinach, cucumbers, parsley, lime and mixed juices) it was noticed that their values differ from one category to another, results being comparable to the data from the literature.

The matrix of linear correlations between parameters reveals a positive and statistically significant correlation between the pH and electric conductivity also between the refractive index n and the electric conductivity for the analyzed plant juices.

There is a strong linear relationship, a statistically significant correlation between pH and G for the analyzed green plant juices. The soluble salts, minerals and other constituents contribute also to electrical conductivity differences. The results are according to the literature.

Rich in vitamins, minerals, antioxidants, pigments, dietary fiber and other nutrients, fresh juices from green vegetables and fruits act as a functional food, recommended to be consumed daily, being fast assimilated in a very short time.

Nowadays, plant juice therapy, easy to digest and assimilated is recognized as a simple, affordable and effective alternative for cell reconstruction and regeneration to an optimal body health

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