CORRELATION BETWEEN ANTIOXIDANT CAPACITY AND TOTAL POLYPHENOL CONTENT IN FRUIT JUICE CONCENTRATES

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Abstract
In our current research, the total polyphenol content and antioxidant capacity of 6 types of 65% fruit juice concentrates (pomegranate, red grapes, oranges, lemons, apples, pineapples) were investigated and compared with TEAC and FRAP methods.
For each juice concentrate, a significant relationship was found between the total polyphenol content and the antioxidant capacity: the most outstanding values were measured for pomegranates, followed by red grapes, followed by oranges and lemons. At the same time, the TPC and FRAP values of apple and pineapple were significantly lower compared to the other 4 types of juice concentrates.

Introduction
In recent decades, numerous publications have proved the paramount importance of the balance between harmful free radicals and antioxidants that protect our bodies in preserving our health [1,2].
Among our diets, the best sources of antioxidants are fruits [3], so their regular consumption plays a significant role in maintaining our body's oxido-reduction homeostasis [4,5]. At the same time, the nutritional values of some fruits (vitamins and minerals, trace elements, flavonoids, polyphenols, etc.) differ significantly, so it is extremely important to choose the right fruit and consume it regularly in the right daily dose [6].
In the temperate zone, seasonal fresh fruits do not produce during the winter period, so most people prefer to consume southern fruits (lemons, orange pomegranates, grapes, pineapples) that are commercially available in winter, in addition to winter-resistant apple varieties that are abundant in summer and autumn in the temperate zone [7].
In our study, we sought to answer which of these foods can contribute most to our health by consuming them from a nutritional scientific point of view.

Experimental
Materials
We tested fruit ***juice concentrates*** with a ***dry matter content of 65%*** in accordance with food safety rules, strictly controlled, produced under the HACCP quality system, stored and distributed in an aseptic manner (Produced by Intercooperation Ltd.).
In our experiment, we used the juice concentrates of domestic and subtropical fruits, which are widely available in the domestic trade: pomegranates, red grapes, oranges, lemons, apples, and pineapples.

Analytical methods
For analytical measurements, the 65% juice concentrates were tested and prepared independently, diluted with distilled water when necessary.

Determination of total phenolic contents (TPC) by Folin-Ciocalteu method: The Folin-Ciocalteu spectrophotometric method by Singleton and Rossi [8], at 760 nm is an electron transfer based on assay and shows the reducing capacity, which is expressed as phenolic content. Gallic acid (GA) was used to prepare the standard curve. The results were expressed as µMGA/g of dry matter (DM).

Determination of antioxidant capacities by TEAC (Trolox-equivalent antioxidant capacity) method: The total antioxidant capacity was measured with Trolox-equivalent antioxidant capacity (TEAC) method described by Miller et al. (1993) [9]. The method is based on ABTS+ free radical scavenging by antioxidants measured with a spectrophotometer. For the calibration Trolox (the hydrophilic analogue of vitamin E) was used.

Determination of antioxidant capacities by FRAP (Ferric Reducing Antioxidant Power) method: Measurement of ferric reducing antioxidant power of the peel extracts was carried out based on Benzie and Strain's procedure [10.], at 593 nm. Ascorbic acid (AA) was used as a standard to prepare the calibration solutions. Results were expressed as µMAA/g DM.

Results and discussion

I.) Results of total phenolic contents (TPC) by Folin-Ciocalteu method

In the course of examining the total polyphenolic content of the 6 types of juice concentrate, it was found that the total polyphenol content of pomegranate juice is outstandingly the highest. Compared to the other juices tested, the following differences occur (in order): 2.1 – 2.1 – 3.0 – 7.0 – 13.6 times the TPC values measured in the red grape – orange – lemon – apple - pineapple samples. (Fig. 1.).

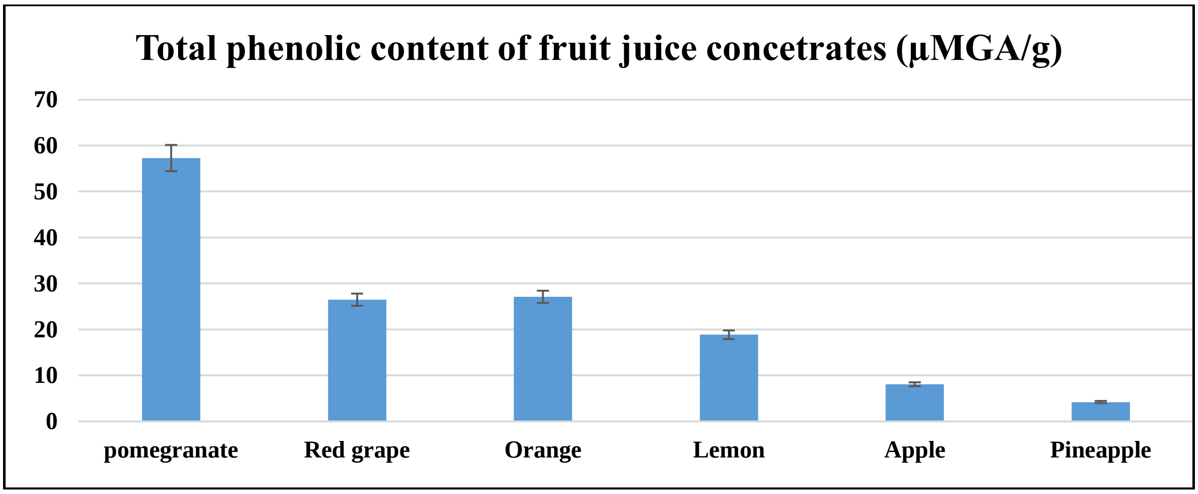

Figure 1. Total phenolic content of different fruit juice concentrates (µMGA/g)

II.) Antioxidant capacity measurement results using TEAC and FRAP methods

Antioxidant capacity can be defined as the combined effect of all antioxidant compounds in the examined sample. More than a hundred methods have been developed in recent decades to measure antioxidant capacity [8], but every examination method has its advantages and disadvantages. Neither method is suitable for accurately modelling the biochemical processes taking place in the body on its own, so it is of paramount importance to formulate a conclusion about the sample based on the combined results of several test methods.

In our current research, we also investigated the antioxidant capacity of 6 types of 65% juice concentrates using the TEAC method based on free radical capture capacity and the FRAP method based on iron-reducing ability (Fig. 2). Our results can be summarized as follows:

Due to the methodological difference between the 2 types of measurement in the 6 types of juice concentrate, the values of the antioxidant capacity measured in the same juice differ significantly (Fig. 2).

When comparing the six types of juice, we measured the highest free radical capture capacity (TEAC) in pomegranate juice and the smallest in apple juice. The antioxidant capacity of pomegranate juice is several times higher than that of the other samples, in order the following: 7.8 – 11.1 – 15.3 – 18.1 – 25.0- 15.3 times the red grape juice – orange juice – lemon juice – apple juice – pineapple juice TEAC values measured in the samples. The total polyphenol content of pineapple is about half that of apples (Fig. 1.), however, its antioxidant capacity, measured by the TEAC method, is almost twice that of apples (Fig.2.). This difference points to the fact that pineapple also contains significant amounts of other free radical capturing antioxidant compounds with non-phenolic components.

Using the FRAP method (Fig. 2.), pomegranate juice also measured the most outstanding antioxidant capacity, several times higher than in other fruit juices: red grape juice – orange juice – lemon juice – apple juice – pineapple juice compared to samples, pomegranate juice showed an antioxidant capacity of 2.9 – 3.3 – 4.1 – 17.6 – 45.5 times higher, which closely correlates with the total polyphenol content measured in these samples.

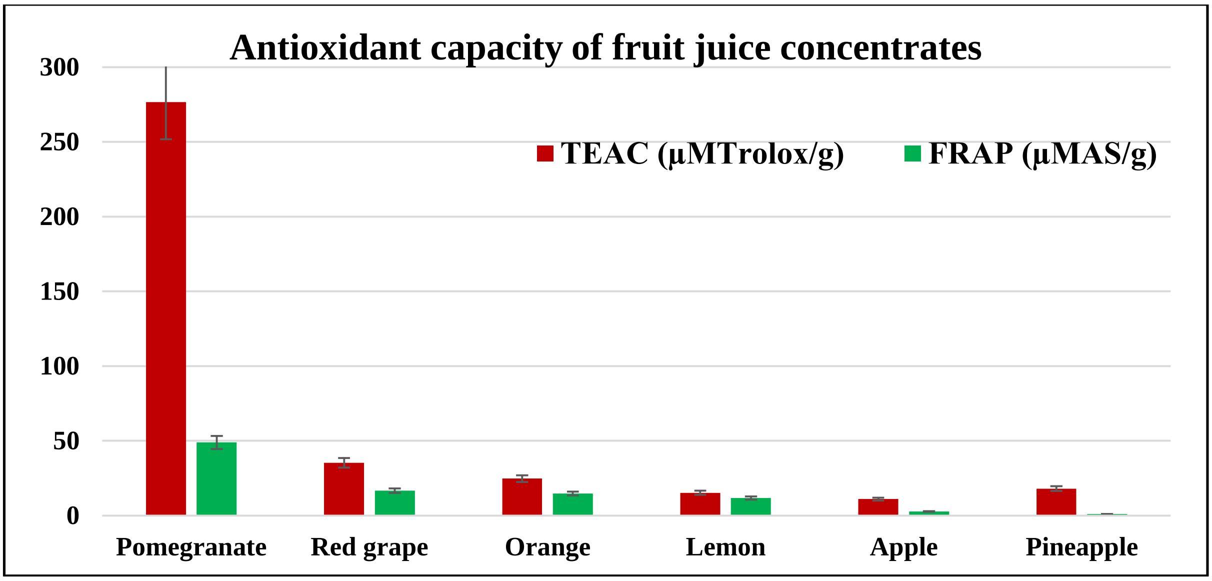

Figure 2. Antioxidant capacity of fruit juice concentrates measured by TEAC (µMTrolox/g) and FRAP (µAA/g) method

The highest correlation (R^2 = 0.9753) was observed between the polyphenol content and the antioxidant capacity measured by the FRAP method.

III.) <u>Discussion</u>

In the course of our study, it can be concluded that the antioxidant capacity values measured by both the TEAC and FRAP methods show a good relationship with the total polyphenol content measured in the 6 types of juice concentrates.
The multifaceted anti-inflammatory and health-protecting effects of plant phenolic components have been confirmed by numerous publications in recent decades [11]. Therefore, the total polyphenol content measured in each fruit juice and the correlated antioxidant capacity values can serve as a guide for which types of southern fruits to prefer to consume during the winter months in order to protect our health.

The analysis of the 6 types of juice concentrates examined by us showed that among the southern fruits, the total polyphenol content of pomegranate is outstanding, and with it the antioxidant capacity measured by both methods, followed by red grapes, then orange and lemon. The antioxidant capacity of pineapples measured by the TEAC method was similar to that of citrus fruits, however, the values of its phenolic components and the antioxidant capacity measured by the FRAP method were significantly lower compared to the juice concentrates listed above.

We measured the lowest antioxidant capacity values in apple juice using both methods (TEAC, FRAP), so their direct role in inflammatory processes does not seem significant. At the same time, it is important to point out that numerous publications have demonstrated the significant soluble fiber (pectin) content of apples, through which it can make a significant contribution to the normal functioning of the entire digestive system and thus the immune system [12].
Among the nutritional values of pineapple, bromelain, the major sulfhydryl proteolytic enzyme, which is not only involved in supporting the digestive system, but also has multiple activities in many areas of medicine, for example "cardiovascular diseases, blood coagulation and fibrinolysis disorders, infectious diseases, inflammation-associated diseases, and many types of cancer" in which possible application should also be highlighted [13].

Conclusion

In our current research, we examined the total polyphenol content and antioxidant capacity of 6 types of juice concentrate, using the TEAC method based on free radical capture capacity and the FRAP method based on iron reduction ability.
Our examinations have shown for all juice concentrates that there is a strong correlation between the total polyphenol content of fruit juices and their antioxidant capacity. Our results can serve as a guide for what type of fruit we should prefer to consume in order to maintain our health.

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