Comparison of different lettuce types (*Lactuca sativa* L.) based on their bioactive compounds

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Abstract

In this study five lettuce types (Crisphead, Butterhead, Romaine, and Green and Red leaf lettuces) were compared and six bioactive compounds (iron, folate, vitamin C, β-carotene, lutein and total phenolic content) were evaluated. Input data was based on the review of Kim et al. (2016) which is about the nutritional value and bioactive compounds of lettuces. Lettuce types were compared based on their bioactive compounds using sum of ranking differences (SRD) method, which ranks the varieties quickly and efficiently using on *multicriteria* optimization. Romaine and Red leaf lettuce had the highest amount of bioactive compounds; followed by Butterhead and Green leaf types while Crisphead type was ranked as the last.

Keywords: *lettuce types, bioactive compounds, sum of ranking differences* (SRD)

Introduction

Based on FAOSTAT (2016), production quantity of lettuce and chicory was 24.896116 million tonnes which is 2.2% of the total production of vegetables (melon is not included). The largest producer in the world is China, which produces 54.2%. US has 20.5% and EU has 13.9% of the total lettuce and chicory production worldwide. Lettuce is usually consumed in salad mixes and eaten raw (DuPont et al., 2000).

Lettuce has 95% water contain and good source of fibre. Iron, folate, vitamin C, β-carotene, lutein and antioxidant compounds are the most important health beneficial bioactive compounds in lettuce (Kim et al., 2016; Nicolle et al., 2004; Serafini et al., 2002). Antioxidant capacity can vary by lettuce type, variety, growing conditions, postharvest handling and storage

(Baur et al., 2004; DuPont et al., 2000; Lee and Kader, 2000). Red lettuce types usually have higher vitamin C concentration than green types (Llorach et al., 2008). Flavonoids have beneficial effects against cancer, age-related neurodegeneration, arteriosclerosis and cardiovascular diseases (Hodgson and Croft, 2006; Erlejman et al., 2006). Lettuce is low in fat and total calories that can contribute to prevent from excessive energy intake (Kaur et al., 2014).

Balanced diet and consumption of fruits and vegetables are important for healthy life. According to World Health Organization's (WHO) statistics, health state depends on leadable factors in 73%. It has estimated that 14% of gastrointestinal cancer deaths caused by the scarce intake of fruits and vegetables, which also has responsible for 11% of ischaemic (*reduced blood supply to tissues*) heart disease deaths and for circa 9% of stroke deaths worldwide (Székely et al., 2015; EUFIC, 2012). In the last ten years the half of causes of death due to cardiovascular diseases and one-fourth owing to tumours at Hungary. Chronic but non-infectious diseases are: obesity, type 2 diabetes, high blood-pressure, coronary heart disease, stroke, inflammatory bowel disease (IBD) and cancer. Reduced negative impacts (tobacco use, alcohol use, physical inactivity, unhealthy diet) and regular consumption of fruits and vegetables are help ensure health and prevent diseases. Studies found connections between health benefits of fruits and vegetables consumption and reduced risk of chronic diseases (PBH, 2013; EUFIC, 2012).

Héberger (2010) implements the *sum of ranking differences (SRD)* method, Héberger and Kollár-Hunek (2011) validated and made software implementation. SRD-method has been applied in numerous fields. In food science has been successfully applied for validating methods and models (for column selection in chromatography (Héberger, 2010), for novel sensory panel performance evaluation techniques (Kollár-Hunek et al., 2013; Sipos et al., 2011), for JAR attributes on overall liking (Gere et al., 2015), for visual attention accompanying food decision process (Gere et al., 2016) for comparison of multianalyte proficiency test results (Škrbić et al., 2013). SRD-method was not applied for comparison of bioactive compounds of different types.

Materials and Methods

In their study review, Kim et al. (2016) summarises researches about bioactive compounds of different lettuce types. In that study iron, folate, vitamin C, β-carotene, lutein and total phenolic content were determined about *recommended dietary allowances* (RDA) of types of lettuce. In the present study Crisphead, Butterhead, Romaine, Green and Red leaf types of lettuce were

evaluated. SRD-method was used for ranking of lettuce types. Calculation were run in Microsoft Office Excel 2007 macro, which is written in Visual Basic programming language (available here): http://aki.ttk.mta.hu/srd/. Cases were sorted into rows and attributes were adjusted into columns these were required for the ranking to the theoretical best type. The method based on that the value is even more similar to the evaluated attribute how closer is to reference/standard SRD-value. In this study theoretical best (had higher values) type was the reference for the comparison of lettuce types. So theoretical best type were formed as that got the higher value (Max) from analysed attributes of every types. This is why we used in SRD-method's reference column that lettuce type, which had the theoretical higher values (Table 1.). Validation of SRD-method was made with permutation tests by using 3.000.000 compare ranks with random numbers (CRRN).

Table 1. The input data matrix of the SRD after normalization (Box-Cox transformation). The reference column (last column) contains the maximum values (Max)/theoretical best values

	Crisphead	Butterhead	Romaine	Green leaf	Red leaf	Max
Iron	17.393	18.221	17.690	18.114	18.453	18.453
Folate (B9)	8.818	9.647	9.589	9.234	9.661	9.661
Vitamin C	7.932	8.092	8.473	9.285	8.510	9.285
β-carotene	8.727	9.849	10	10.165	9.776	10.165
Lutein	8.390	9.751	10.277	10.371	10.020	10.371
Total phenolic	13.728	14.597	14.341	14.876	15.570	15.570

Reference column contains values of the theoretical best lettuce type, which based on studied types (reference column, RC=Max).

Results

Based on the results, on the theoretical model rankings, the order of different variety types was determinated. A variety type is much closer to the theoretical best of breed type, so higher the studied nutritional parameters are, so higher is the nutrition biological value of one variety. Thus, more lower the value of SRD is, more higher biological nutritional values can be named. Based

on the results the following order has emerged: Romaine and Red leaf lettuce were the best, these were followed by Butterhead and Green leaf types. The weakest was the Crisphead type.

Table 2. Ranking of type of lettuces and probability of random ranking (Bold means that the methods are significant at p=0.05 level. The grey coloured rows are the 5 % (XX1), 25% (Q1), 50% (Med), 75% (Q3) and 95% (XX19) percentiles of random ranking.)

Ranking results		**p%**		**MaxSRD=18**
Name	**SRD**	**x < SRD > =x**		**SRDnor**
Romaine	0	0	0.14	0
Red leaf	0	0	0.14	0
Butterhead	2	0.14	0.83	11.111
Green leaf	2	0.14	0.83	11.111
Crisphead	4	0.84	3.31	22.222
XX1	6	3.36	9.68	
Q1	10	22.71	41.59	
Med	12	41.75	62.15	
Q3	14	62.29	81.07	
XX19	17	94.99	95.01	

In the Table 2. XX1 represents the 5%, Q1 represents the 25%, Med represents the 50%, Q3 the 75%, and XX19 the 95% percentile. Since the SRDnor value, calculated for the different lettuce types, are less than to the random distribution belonging theoretical probability of 5% percentile (XX1) lane, so the ranking is considered significant with 5 % significant level in all variety types. The SRD column contains the cumulative absolute rank differences (SRD values) relative to the type of varieties. The column p% contains two probability values, due to the discrete distribution, one is certainly below and the other is surely above the 5 %. The graphical representation is shown in the Figure 1.

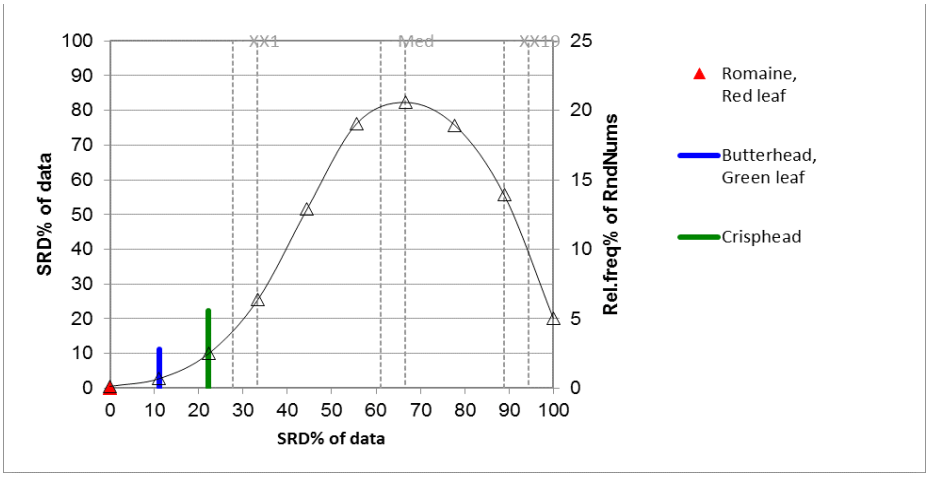

Figure 1. The scaled SRD values of the methods based on the 'theoretical best type of lettuce' of the methods determined by sum of ranking differences. The best scores of the examined species (Max) was used as reference column. Scaled SRD values are plotted on x axis and left y axis, right y axis shows the relative frequencies (black curve). Probability levels 5 % (XX1), Median (Med), and 95 % (XX19) are also given.

Discussions

The consumption of fruits and vegetables is part of a balanced diet. Based on the recommended daily intake values of the lettuce, the most important bioactive components are: iron, folate, vitamin C, β-carotene, lutein, total phenolic content, which play a prominent role in the prevention of many chronic diseases (Kim et al., 2016). That is why many researches focus on mapping the biological and nutritional values of fruits and vegetables, but currently only average values are described in the nutrition summary tables for consumers. There is a lack of the different kind of types, varieties detailed values, and on the types, varieties comparative recommendations are missing as well. The innovative approach of our research is, not to analyse separately the kind of lettuce types of bioactive components by one, but all property are taking into account at the same time when carried out the model evaluation. Kim et al. (2016) in their work carried out the assessment of the types of varieties only just separately. Based on the bioactive components of the variety types, taken together the several aspects of the SRD method, we compared the lettuce types. Using this method, we could set up a ranking between the different types.

Conclusions

Based on the results, the Romaine and the Red leaf lettuce showed the highest nutritional-biological values, they were followed by the Butterhead and the Green leaf lettuce, and finally by the Crisphead lettuce. Depending on these results, it is revealing that in Hungary the most common consumed type is the Butterhead lettuce. The salad-mix producers do not have sufficient knowledge on the nutrition biological values of the different lettuce types, as well as during the mixtures compilation other considerations will be applied: price, cleaning, tanning exemption, shelf life etc. The results of our work points on helping the consumers from the practical side to choose between the different lettuce types (if the main criteria are the maximizing of the nutritional-biological values). Resolving this, the SRD method is well suited for decision support tool, the ranking between the variety types can be determined quickly and efficiently. Of course, the carried out comparisons can be further expanded with involving new breed types or new biologically active components.

In our previous works (Gere et al., 2016; Sipos et al., 2016) we found from methodological side, that SRD works enough effectively if more than 10 performance properties will be involved, since it is better achieved to specify the individual rankings. Therefore, we propose to involve other quality characteristics for grade the lettuce types. Another methodological issue is that in the SRD-method the properties have equal importance, the weighting of the SRD is currently not resolved, but in the future it would be advisable to implement it, in addition to software support.

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