MINERAL COMPOSITION-RICE VS. WHEAT

PIRVULESCU LUMINITA[1], IANCU TIBERIU[1], ADAMOV TABITA[1], CIOLAC MARIANA RAMONA[1], BACTER RAMONA[2], POPESCU GEORGETA-SOFIA[3], BORDEAN DESPINA-MARIA[*3]
[1]University of Life Sciences "King Mihai I" from Timisoara, Faculty of Management and Rural Tourism, Romania
[2]University of Oradea, Faculty of Environmental Protection, Romania
[3]University of Life Sciences "King Mihai I" from Timisoara, Faculty of Food Engineering, Romania
*Corresponding author's e-mail: despinabordean@usvt.ro

Abstract: *In the last decade, globalization and accelerated consumption have led to a worrying increase in lifestyle-related diseases, among the most serious being diabetes and heart disease. Thus, numerous studies have been developed on reducing the incidence and severity of lifestyle-related diseases with a focus on the mineral content, antioxidant potential and glycemic index of foods. In this context, a number of cereal grains may show promise as medicinal and health foods. Rice and wheat are some of the most important plants in the human diet. They are rich in carbohydrates, protein, minerals (K, Mg, Zn, P and Fe), vitamins (riboflavin, thiamin, niacin and alpha-tocopherol) and dietary fiber. The PCA plot analysis underscores the distinct mineral compositions of rice and wheat flours, highlighting the broader nutritional differences between them. The paper makes a comparative study between data obtained by XRF analysis and average values from different databases on the mineral content of two cereal species: wheat and rice.*

Key words*: rice, wheat, chemical composition, minerals, XRF analysis*

INTRODUCTION

Rice *(Oryza sativa L.)* is one of the world's most important foods, feeding more than half of the world's population, with rice production being the main source of livelihood for many developing countries. [5] Considered a good substitute for wheat flour, rice flour is consumed in a variety of forms, including pasta, noodles, cakes and even bread. [5,14]

It is a plant with a rich genetic diversity, with many cultivated varieties having their own nutritional and health properties. [3] Each rice variety has its own consumption benefits and many nutritional properties. Thus, white rice is high in carbohydrates, brown rice is high in fiber and hypocaloric, black rice is high in anthocyanins, basmati rice is high in carbohydrates and fiber, and wild rice is rich in antioxidant properties. [3,15]

Rice is a very important source of carbohydrates, but also of vitamins (riboflavin, thiamin, niacin) and minerals (potassium, sodium, calcium, iron, magnesium, copper and phosphorus). Different rice varieties have different nutritional compositions in terms of mineral, protein and antioxidant content. Studies have demonstrated beneficial qualities such as the high biological value of amino acids in rice, the high content of essential fatty acids and selenium, and antihypertensive effects. [9,15] White rice is commonly eaten everywhere and is a very good source of manganese (provides over 30% of daily requirement), a good source of iron (provides 2.7 mg or 15% of daily requirement) and also contains B vitamins (especially thiamine, but also niacin and riboflavin). [9,14]

Wheat is the world's most important crop, grown in over 100 countries. It is of major importance in the food industry and is mainly used to produce flour. The stalks left over after harvesting are used as a raw material in the manufacture of cellulose, as well as in animal feed or as organic fertilizer. Bran, which is a residue from the milling industry, is a concentrated fodder rich in protein and mineral salts. [7,10]

Wheat is the most widely cultivated crop in the world and the fourth most produced after sugar cane, maize and rice. Wheat is currently grown on about 220 million hectares of arable land, mostly in temperate regions, and produces about 770 million tons of grain per year. [11]

Common wheat *(Triticum aestivum L.)*, also known as bread wheat, is the most widespread species of wheat and accounts for about 95% of the wheat grown. It is considered a key commodity in world trade and is widely used in the food industry due to its significant nutritional contribution to the human diet. As well as being a major source of starch and energy, wheat also provides large quantities of a number of essential or health-promoting components, notably protein, vitamins (especially B vitamins), dietary fibre and minerals. [1,10].

Wheat grains are a rich source of various mineral elements (potassium, calcium, zinc, copper, iron, manganese, copper, iron, manganese) that are important for both plants and humans, but they also contain toxic elements such as arsenic, lead, mercury and cadmium. [1,8] Tillage actions play an important role in soil mineral management. Intensive tillage has been shown to be the major cause of accelerated mineralization and loss of constituent elements such as carbon and nitrogen. In this context, conservation agriculture has been considered as a set of activities capable of achieving a sustainable increase in crop production needed to meet global food needs, together with conservation and protection of soil, water and biological resources. [1,2]

Wheat flour contains gluten, a protein that provides elasticity and helps dough rise and is very rich in protein and fiber, while rice flour is naturally gluten-free, and lower in protein and fiber compared to wheat flour. [6]

Rice flour is an essential ingredient in gluten-free diets due to its natural absence of gluten, making it safe and suitable for individuals with celiac disease or gluten sensitivity. Its unique properties and versatility in cooking and baking further contribute to its widespread use in gluten-free foods. [17]

MATERIALS AND METHODS

The study was conducted on samples of wheat flour and rice flour available on the Romanian market. The analyses of the samples were performed using X-MET8000 - X-Ray Fluorescence Analyzer, factory calibrated.

The evaluation of the results was also based on the nutritional tables corresponding to wheat and rice flours present in different databases (USDA and FOODB).

The data were statistically evaluated using the software PAST Version 2.17c (Hammer et al., 2001) and MVSP. [4]

RESEARCH RESULTS

The follow figure and table shows that the highest used database FooDB and USDA lack on informations regarding mineral content in different assortments of flour, in special wheat and rice flour and that the using the XRF analyzer we can improve the information regarding the wheat and rice flours available on the Romanian market.

Barium (Ba), Scandium (Sc), Tantalum (Ta), Gold (Au), Tin (Sn), and Molybdenum (Mo), these trace elements are detected in wheat flour but not in rice flour, according to the lab results (Figure 1).

Table 1.

Mineral composition [ppm] of wheat and rice flours

Element	Wheat flour Lab.	Lit. wheat flour FOODB [12]	Lit. wheat flour USDA [16]	Rice flour Lab.	Lit. rice flour FOODB [13]	Lit. rice flour USDA [16]
K	11700.00	4342.31	3940.00	6506.00	2147.66	820.00
Ca	1231.00	302.00	330.00	304.00	277.77	40.00
Zn	62.00	42.98	29.60	26.00	10.82	13.50
Ba	125.00			ND		
Sc	49.00			ND		
Ta	30.00			ND		
Au	23.00			ND		
Sn	44.00			ND		
Mo	19.00			15.00		
Cu	ND	3.95	4.75	19.00	1.50	2.14
Hg	14.00			ND	0.17	
Rb	15.00			12.00		
Ni	ND	0.25		ND	0.33	
Sb	ND			16.00		
Th	6.00			ND		
Tl	5.00			6.00		
V	ND			12.00		
Pb	4.00			4.00	1.50	
Zr	ND			ND		
Co	ND			16.00		
As	ND			3.00	0.21	

Legend: Wheat flour lab. = wheat flour minerals content based on laboratory results, Lit. wheat flour = wheat flour minerals content based on FooDB data, Lit. wheat flour USDA = wheat flour minerals content based on USDA data, Rice flour lab. = rice flour minerals content based on laboratory results, Lit. rice flour = rice flour minerals content based on FooDB data, Lit. rice flour USDA = rice flour minerals content based on USDA data

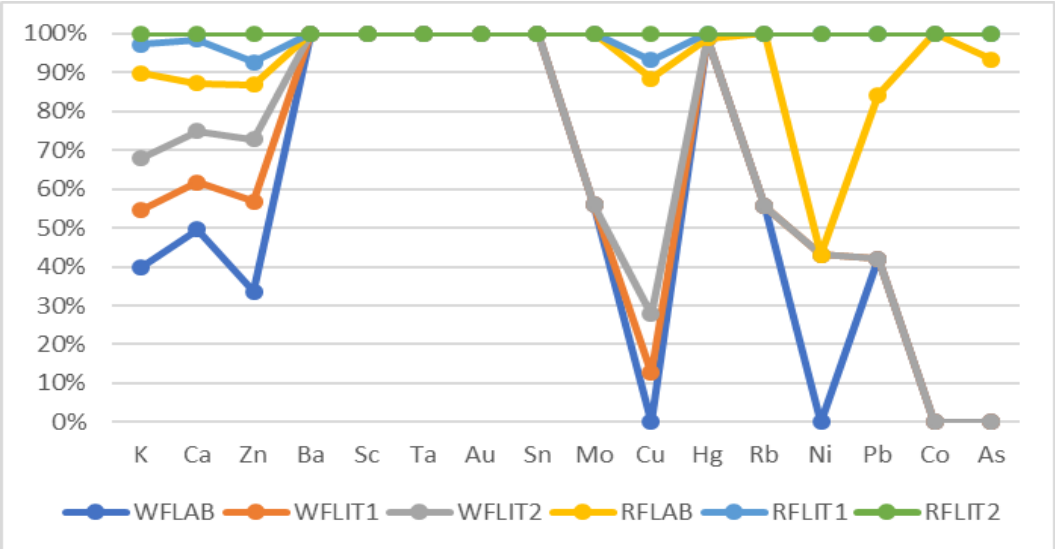


Figure 1. Representation of mineral content for wheat flour and rice flour, based on laboratory results and literature data

Legend: WFLAB = wheat flour minerals content based on laboratory results, WFLIT1 = wheat flour minerals content based on FooDB data, WFLIT2 = wheat flour minerals content based on USDA data, RFLAB = rice flour minerals content based on laboratory results, RFLIT1 = rice flour minerals content based on FooDB data, RFLIT2 = rice flour minerals content based on USDA data

The incidence of these elements show specific environmental or processing factors affecting the wheat flour. Copper was not detected in the lab analysis of wheat flour but was present in literature values. In contrast, rice flour shows a much higher copper concentration in lab results compared to literature values. Mercury was detected in wheat flour but not in rice flour. Lead is present in both but higher in rice flour lab results compared to FoodB values. Arsenic is detected in rice flour lab results but is significantly higher than the FoodB value, which indicates contamination of the rice samples with As.

Laboratory data:

Summing up the ppm values for all elements in wheat flour lab data we can obtain the total mineral content for wheat flour (13227 ppm);

Similarly by summing up the ppm values for all elements in rice flour lab data we can obtain the total mineral content for rice flour (6924 ppm):

Percentage Calculation:

Wheat flour LAB: 13227 / (13227+6924) =65.6%

Rice flour LAB: 6924 / (13227+6924)= 34.4%

The obtained percentages represent the relative contribution of each type of flour to the total mineral composition measured, showing the dominance of wheat flour regarding the overall mineral content, mostly due to its higher concentrations of potassium (K) and calcium (Ca).

FooDB Data:

Proceeding similarly for FOODB data values we will obtain the total mineral content for wheat flour (4691.49 ppm) and the total mineral content for rice flour (2439.96 ppm):

Percentage Calculation:

Wheat flour FOODB: 4691.49 / (4691.49 +2439.96) =65.8%

Rice flour FOODB: 2439.96 / (4691.49+2439.96)= 34.2%

USDA Data:

Proceeding similarly for USDA data values we will obtain the total mineral content for wheat flour (4304.35 ppm) and the total mineral content for rice flour (875.64 ppm):

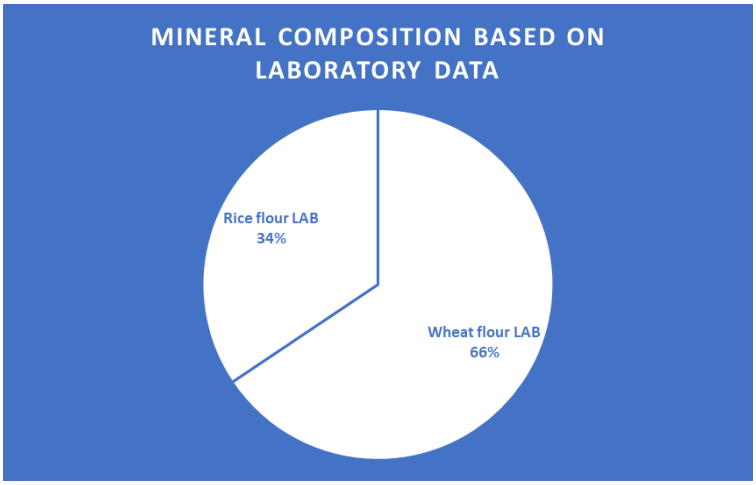
Percentage Calculation:

Wheat flour USDA: 4304.35 / (4304.35 +875.64) =83.1%

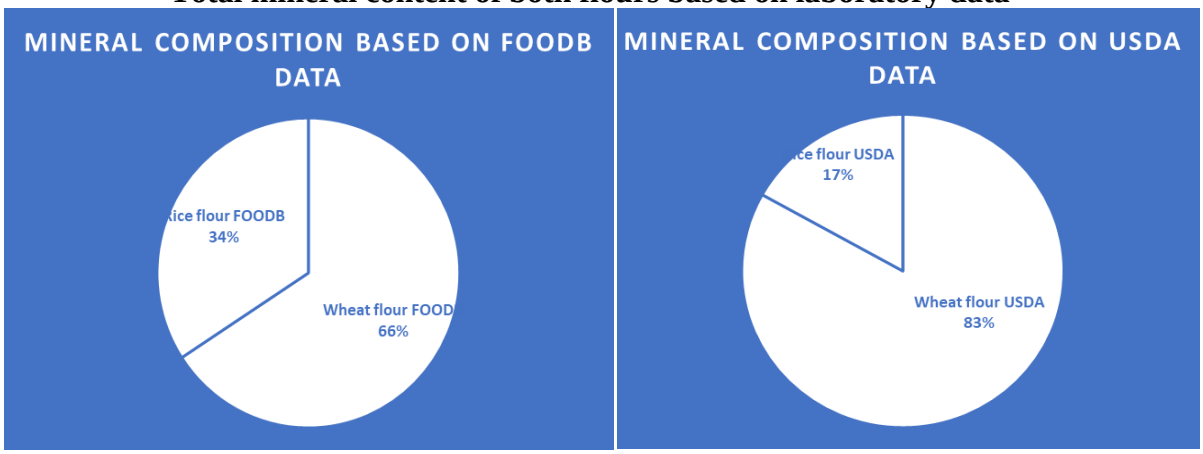
Rice flour USDA: 875.64 / (4304.35 +875.64)= 16.9%

As we observe (table1 and figures 1 and 2), both data sources show that wheat flour has a higher mineral content compared to rice flour. Wheat flour's ascendency in mineral composition is consistent across both USDA and FooDB data. Rice flour's mineral content is relatively higher in FooDB data (34.2%) compared to USDA data (16.9%).

Applying Principal Component Analysis we create a JointPlot graphic (Figure 3) which visually demonstrates the differences in mineral composition between wheat flour and rice flour samples. Wheat flour samples are associated with higher concentrations of certain minerals (K, Ca, Zn), while rice flour samples are characterized by higher concentrations of other trace elements (Cu, As, Co). This visualization helps to understand the underlying structure of the data and the main sources of variation in mineral composition between these two types of flour.



Total mineral content of both flours based on laboratory data



Total mineral content of both flours based on literature data

Figure 2.Comparison of total mineral content based on laboratory and literature data

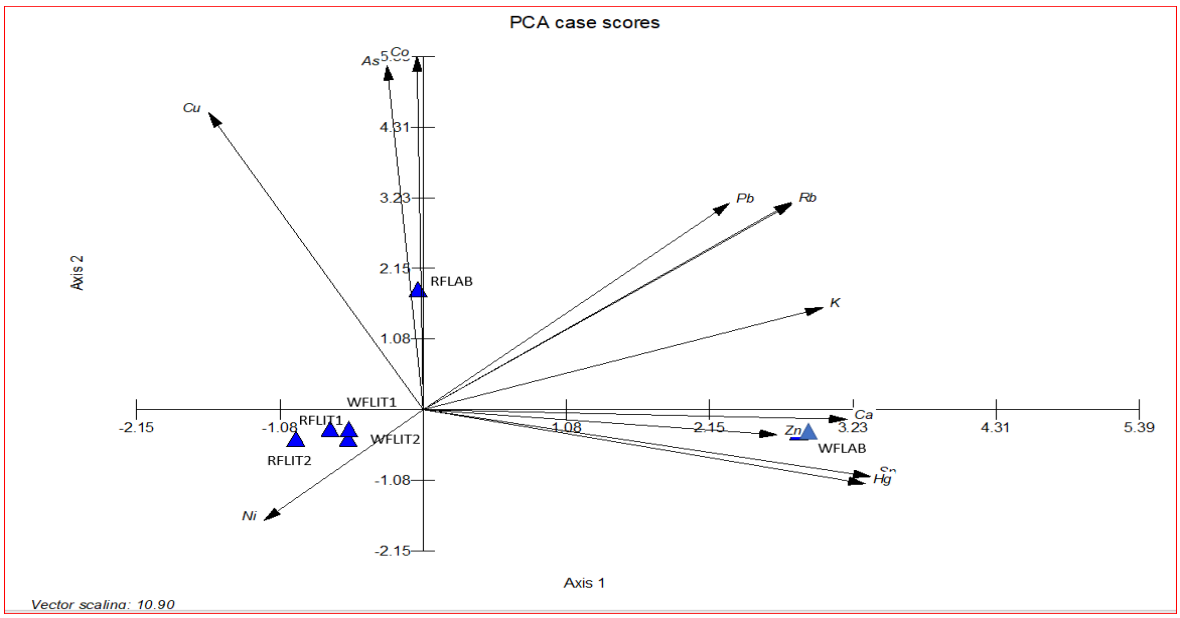


Figure 3. Graphical representation of Principal Component Analysis

CONCLUSIONS

Both flours show high content of potassium, calcium and zinc, wheat flour presenting 2-3 times more potassium and calcium compared to rice flour, which recommends that in the case of using rice flour for different food products to add materials which are able to supplement potassium and calcium, in special when preparing gluten free products based on rice flour.

Wheat Flour shows consistently higher mineral content across both data sources, making it a richer source of minerals.

Rice Flour is showing lower in mineral content in the presented cases, but laboratory data as well as FOODB data suggests that it may have more minerals than indicated by USDA data.

Due to the fact that laboratory results often show higher concentrations of elements compared to literature values, this may suggest differences in sample origin, environmental factors, or analytical methods.

The mineral analysis highlights significant differences and similarities in elemental composition between wheat and rice flour from lab and literature sources.

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