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Chemical analysis of different cereals to access nutritional components vital for human health

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Abstract

In this study different cereal types such as whole wheat flour (WWF), refined wheat flour (RWF), raw basmati rice (RBR), parboiled rice (PBR) and hybrid yellow maize (HYM) were selected for analysis of nutrients. Their analysis showed that RWF which is abundantly being used in bread making by roadside ovens and bakeries is not only deficient in protein, fat and fiber but also poor in almost all micro and macro minerals as compared with WWF. This study also indicated that daily consumption of RWF in bread making and other eatables is causing malfunctioning in metabolism in major population. Similarly comparative analysis of RBR and PBR was carried out. This analysis indicated that vital micro nutrients are reduced during the processing of both types of rice. Balanced nutritional requirements can be achieved by combination of these two types of rice (RBR and PBR). HYM analysis was also carried out as it is generally consumed as breakfast cereal and also consumed as staple food in various countries. Its analysis in this study also highlighted its comparative nutrient values.

Key words: Analysis, Cereals, Flour, Minerals, Nutrition

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1. Introduction

In developing countries nutritional deficiencies are being observed in common man causing different kinds of health problems. The need was felt to understand the causes of deficiency in food by studying their daily cereal intake which is main part of every meal. Grains are important part of a healthy and nutritious diet. But all grains or grain products do not have equal nutritional values. Whole grains provide many health benefits and play an important role for the prevention of many diseases. This research indicated that increased consumption of whole grains can substantially reduce heart disease [1], play an important role in maintaining a healthy weight and body mass index (BMI). Consumption of whole grains also regulate blood glucose and insulin responses. That would help to prevent Type 2 diabetes [2]. The fiber in whole grains helps to maintain gastrointestinal health. Due to these benefits, USDA's 2010 Dietary Guidelines for Americans recommend that at least three servings a day should be of whole grains [3].

With the increase of population of the world a huge increase in the demand for cereals is predicted. It is estimated that over three billion people are currently micronutrient malnourished. This global crisis in nutritional health is the result of dysfunctional food systems that do not consistently supply enough of these essential nutrients to meet the nutritional requirements of common men [4]. One sustainable agricultural approach to reduce malnutrition among people at highest risk (i.e. resource poor women, elderly people, infants and children) is to enrich major staple food crops with micronutrients through nutritional enrichment strategies. Under present circumstances it requires to create awareness among common people not to consume nutrient deficient processed food especially white flour in their daily meals as it is established fact that white bread made up of refined wheat flour (i.e. naan, pouri and bakery products) are highly deficient of many vital nutrients causing malnutrition in general population.

Scientists have known for years that many of the health-promoting nutrients in grain are lost during processing and different unit operations. Consumer preference for fine white flour and processed rice means that nearly 75% of the nutrients found in these grains are lost. During processing protein, fiber, vitamins, minerals and antioxidants are generally reduced [5].

2. Material

2.1. Chemical and Material

The present research work was carried out in the laboratories of Department of Chemistry, The University of Faisalabad. The chemicals used during the entire study were of analytical grade while properly washed and oven dried Pyrex glass apparatus were used during the present study.

Samples of whole wheat flour (WWF) and refined wheat flour (RWF) were purchased from Shan Flour Mill while those of raw basmati rice (RBR) and parboiled rice (PBR) were purchased from local market and hybrid yellow maize (HYM) was acquired from Rafhan Maize Products Faisalabad. These were grinded in willy mill with 100 mesh screen. Each sample (500g quantity) was preserved in plastic bottles lined with polythene for analysis.

2.2. Methods

2.2.1. Moisture Percentage

The moisture content in each flour sample was determined according to AOAC (934.01) (6) by taking 5 gram sample and drying it in an oven at a temperature of 100±1°C under vacuum till a constant weight of the dried material is attained [6,7,8,9]. The drying oven was a Mammet model ULM 400 (Memmer Co., Germany) heated with forced-air circulation. The temperature control was within ±0.05°C. The control accuracy of inner temperatures was checked by a thermometer- Hart 8C 227-2562 RTD. The moisture content was calculated according to the following formula:

$$\text{Moisture (\%)} = \frac{\text{Wt. of original flour sample} - \text{Wt. of dried flour sample}}{\text{Wt. of original flour sample}} \times 100$$

2.2.2. Ash Percentage

The flours were tested for total ash content by taking 3g sample in tared crucibles and charred on a flame until it turned black and put into a muffle furnace maintained at a temperature of 550 °C for 5 hours or till a grey color of ash was obtained. The details described in AOAC International, 2002 [10] were followed for the estimation of total ash content. The ash content was calculated according to the formula given below:

$$\text{Ash (\%)} = \frac{\text{Wt. of ash}}{\text{Wt. of flour sample}} \times 100$$

2.2.3. Protein Percentage

The crude protein content in each of the flour was estimated according to the Kjeldahl's method by using the Kjeltec system 1002 [10, 11]. 5g sample was weighed and put into the digestion tube. 20 mL of concentrated H_2SO_4 (98%) and two digestion tablets as catalyst were added into the digestion tube. The digestion was carried out for 3-4 hours (till the digested contents attained transparent color). The digested material was allowed to cool at room temperature and diluted to a final volume of 50 mL. The ammonia trapped in H_2SO_4 was liberated by adding 40% NaOH solution through distillation and collected in a flask containing 4% boric acid solution, possessing methyl red indicator and titrated against standard 0.1N H_2SO_4 solution.

The factor 6.25 was used for the conversion of percent nitrogen into crude protein content for maize and 5.7 for rice and wheat. .

$$\text{Nitrogen (\%)} = \frac{\text{Volume of 0.1 N } H_2SO_4 \times \text{Volume of dilution made} \times 0.0014}{\text{Weight of sample (g)} \times \text{volume of dilution taken (mL)}} \times 100$$

2.2.4. Fat Percentage

The crude fat content in each flour sample was determined by taking 3g dried flour sample and running through Soxhlet apparatus for 6-8 hours using petroleum ether as a solvent by following the procedure described by AOAC International, 2002; Sullivan and Carpenter, 1993 [10,11]. First of all the sample is wrapped in a filter paper and is closed by pinning it. After that the sample was put in the Soxhlet apparatus and then 5 to 6 washings were given with the petroleum ether. The solvent was evaporated and percentage fat content was determined according to following formula.

$$\text{Crude fat (\%)} = \frac{\text{Wt. of fat}}{\text{Wt. of flour sample}} \times 100$$

2.2.5. Fiber Percentage

The crude fiber was estimated according to the procedure as outlined in AOAC Official Methods, 2002 [10]. It was carried out by taking 3g of each fat free flour sample of each cereal was digested first with 1.25% H_2SO_4, washed with distilled water and filtered, then again digested with 1.25% NaOH solution, washed with distilled water and filtered. Then ignited the sample residue by placing the digested samples in a muffle furnace maintained at temperature of 550-650 °C for 4 hours till grey ash was obtained. The percentage of crude fiber was calculated after igniting the samples according to the expression given below.

$$\text{Crude fiber (\%)} = \frac{\text{Weight loss on ignition}}{\text{Weight of flour sample}} \times 100$$

2.2.6. Starch Percentage

Starch in each flour sample was determined by weighing 2 gram of sample and boiling it with calcium chloride solution in open beaker, stirring and adding water to maintain the liquid level. Boiled for 30 minutes and cooled to room temperature with addition of 10ml stannic chloride solution and volume made to 100ml by addition of calcium chloride solution. Filtered through Whatman filter paper and angular rotation was measured using 100 mm polarimeter tube and starch was calculated as per following formula [11].

$$\text{Starch \% (d.b.)} = \frac{\text{Angular Rotation} \times 100}{\text{Weight of sample d.s. \%}}$$

$$\text{d.s.} \quad \frac{203 \times 2\text{dm}}{100 \text{ mL}} \times \frac{}{100}$$

Where 203 represent the specific rotation of starch in angular degree.

d.s. = Dry Substance

d.b. = Dry Basis

2.2.7. Minerals (micro & macro elements)

Each flour sample was charred by gentle heating and placed in muffle furnace maintained at 500^{o}C for 4 to 5 hours until a light grey residue is produced. The residue from dry ash was dissolved in 6N HCl and made 100 mL volume before analysis of mineral contents by atomic absorption spectrometer. (Nov Aa 400 Analytik Jena, Germany.). Atomic Absorption Spectrophotometer equipped with air acetylene flame was used [12, 13, 14].

3. Results and Discussion

3.1. Starch Percentage

Starch quantity varied significantly with processing as shown in the table 1. (Percentage of starch have been depicted with help of bar graph in Figure 1). WWF (70.8%) starch is much lower than RWF (78.4%) starch because of the fact that WWF contains higher amounts of fibre, so as the fibre content increases, it causes a decrease in starch content of particular cereal. Similarly RBR (80.4%) having higher quantities of starch content than PBR (79.9%). This also supports the above mention results as RBR has lesser amount of fibre than PBR. HYM contains72.4% starch content. The lower amount of starch in HYM is due to higher fat and fibre content of the cereal. The comparison between WWF and RWF shows that the processing removes many of the vital nutrients so starch content is on higher side in processed flour i.e. RWF. In case of rice a minute fluctuation arises due to processing, as starch content remains almost same in both of the dehulling processes. Hybrid yellow maize analysis for starch is according to the study conducted by Zilic et al. (2011) [15].

3.2. Protein Percentage

The proteins are polymers of amino acids and their amount in a sample represents its quality index. The crude protein is generally measured by assessing the amount of nitrogen in a sample. The results regarding protein content of different cereal types presented in Table 1 (Percentage of protein have been depicted with help of bar graph in Figure 2) indicated that highest level of protein is present in WWF (13.2%) compared with RWF (9.1%), HYM (9.1%), RBR (7.2%) and PBR (7.0%).

The results of the present study indicated that during the processing of cereals there is loss of protein. The results of the present study are in line with the earlier study conducted by Hussain et al. (2004) [16] in which he found that significant improvement in the proximate composition (ash, fat, crude protein and crude fiber) of different flours. These results are also supported by the findings of Zaib-un-Nisa (2000) [17].

3.3. Fiber Percentage

The crude fiber is a measure of the quantity of indigestible pentosans, cellulose, lignins and other constituents of this nature present in foods. The crude fiber has little food value but it gives bulkiness to the food and also facilitates to normalize certain physiological functions [18]. Bran is a major source of dietary fiber, which is helpful in reducing the risk of colon cancer and cardiovascular diseases. In rural areas of Pakistan whole wheat flour is consumed for flat and unleavened bread which contain high proportion of bran. The wheat varieties containing higher crude fiber may be beneficial to increase the uptake of fiber in the form of flat bread and as such reduces the chances of colon cancer and heart diseases [19].

The results regarding crude fiber content of different cereal types have been presented in Table 1 (Percentage of fiber have been depicted with help of bar graph in Figure 3). The results pointed out that crude fiber content varied significantly among different types of cereal. It is obvious from the results that crude fiber content of WWF (2.2%) is much higher than HYM (1.4%), RWF (0.48%), PBR (0.42%) and RBR (0.39%). These results show that there is loss in fibre content with the increase in processing of RWF, PBR and RBR.

3.4. Fat Percentage

The lipids including fats and oils are amongst the most important components of foods and are significant in our diet for several reasons. These are the main source of energy and supply necessary lipid nutrients. In foodstuffs the lipid compounds plays an important role in determining the overall physical characteristics like texture, flavor, appearance and mouth-feel [20, 21]. The effect of processing on the fat content of different flour types is given in Table 1 (Percentage of fat is depicted with help of bar graph in Figure 4). The highest fat content (3.45%) was found in the HYM whereas all other cereal types are lower in fat content as WWF (1.7%), RBR (0.44%), PBR (0.41%) and RWF (0.38%). As no processing is carried out in WWF so its fat content is higher than that of RWF, RBR and PBR which are prepared with the processing.

3.5. Ash Percentage

The ash content generally represents the concentration of mineral contents present in the given product. The presence of higher ash content indirectly reflects the availability of more minerals [22]. The ash content is generally influenced by the environmental conditions and malnutrition stages of wheat grains. The ash content of different type of flours of cereals in Table 1 (Percentage of ash is depicted with help of bar graph in Figure 5) indicated that WWF (1.6%) is rich in ash content. This ash content of WWF is higher than other cereals such as HYM (1.5%), RWF (0.52%), RBR (0.48%) and PBR (0.42%). Decrease in the ash contents of RWF, RBR and PBR is due to the processing of these cereals. Hence processing lower down nutritional quality of cereals.

3.2. Mineral Analysis

As this research work intended to locate the reasons for nutritional deficiency observed in common men, among the poor and elderly men. For this purpose it was not possible to analyze all groups of food of all the people of different segments of society/community. For this purpose most common cereals were considered. Cereals are considered to be central group of the balanced diet which represents the most common group which is being consumed by general population.

3.2.1. Micro Minerals (Fe, Zn, Cu)

The minerals that are low in quantity but vital for growth are considered to be micro minerals. All the cereals in this study i.e., WWF, RWF, RBR, PBR and HYM were analyzed for micro minerals such as Iron (Fe), Copper (Cu) and Zinc (Zn). The results regarding the amounts of micro minerals have been shown in Table 2. Amount of Iron is depicted with bar graph in Figure 6. Iron is present in much higher quantities in WWF (36.24 mg/100g) compared with other cereals as RWF (21.34 mg/100g), RBR (23.33 mg/100g), PBR (20.89 mg/100g) and HYM (26.60 mg/100g). Similarly zinc (Zn) is also present in higher amount in WWF (26.08 mg/100g) than HYM (17.20 mg/100g), RBR (15.58 mg/100g), PBR (14.11 mg/100g) and RWF (6.42 mg/100g). Amounts of Zinc are depicted with bar graph in Figure 7. As far as copper (Cu) is concerned, its quantity is higher in RBR (6.91 mg/100g) compared with other processed cereals as WWF (6.36 mg/100g), RWF (6.05 mg/100g), HYM (4.18 mg/100g) and PBR (3.50 mg/100g). Amounts of copper is depicted with bar graph in Figure 8

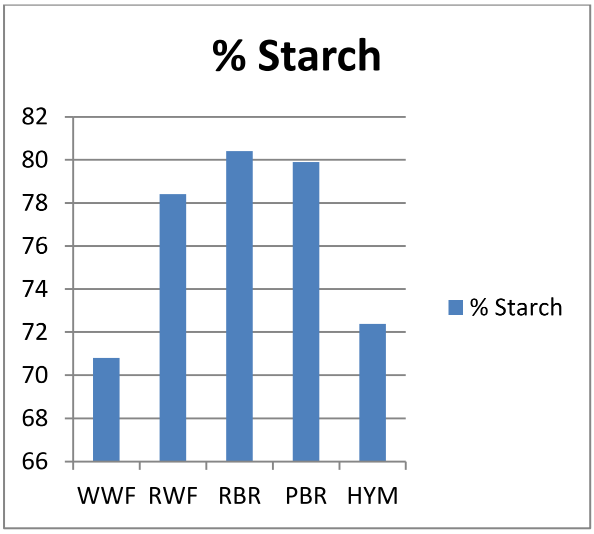

Figure 1. Comparative starch values for different cereals

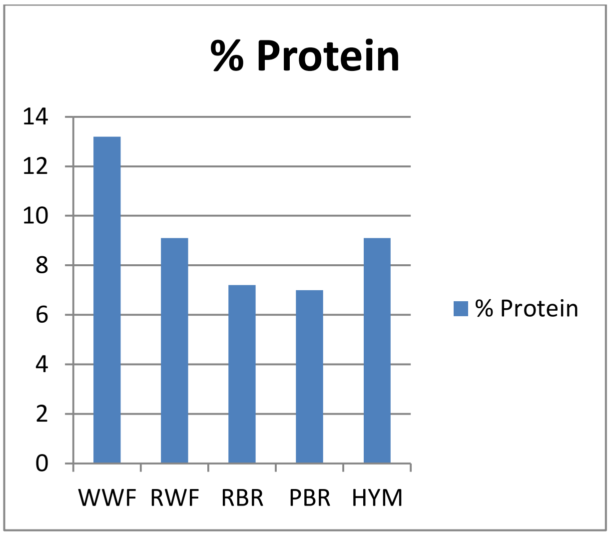

Figure 2.: Comparative Protein values for different cereals

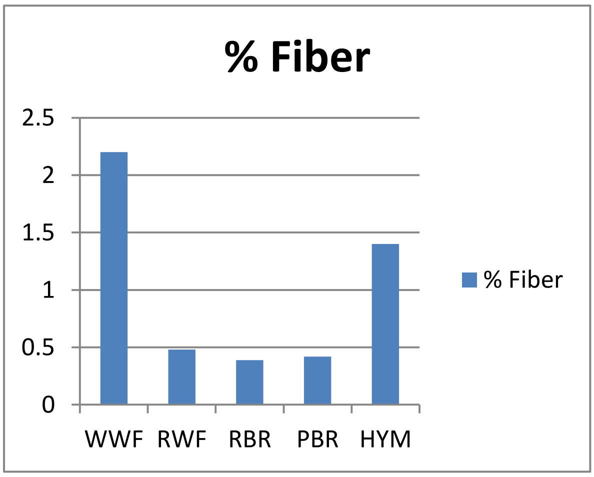

Figure 3. Comparative Fiber values for different cereals

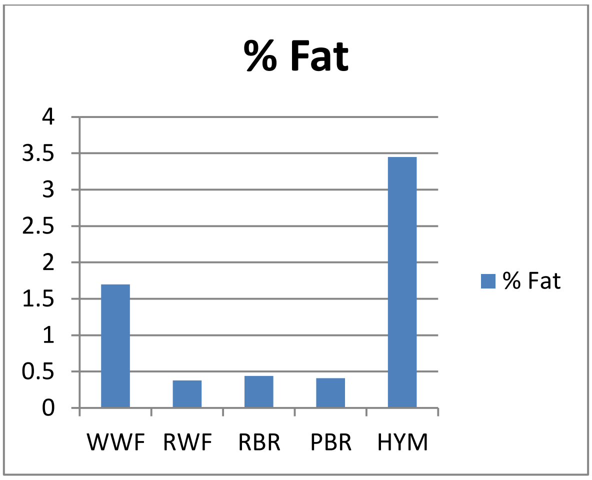

Figure 4. Comparative Fat values for different cereals

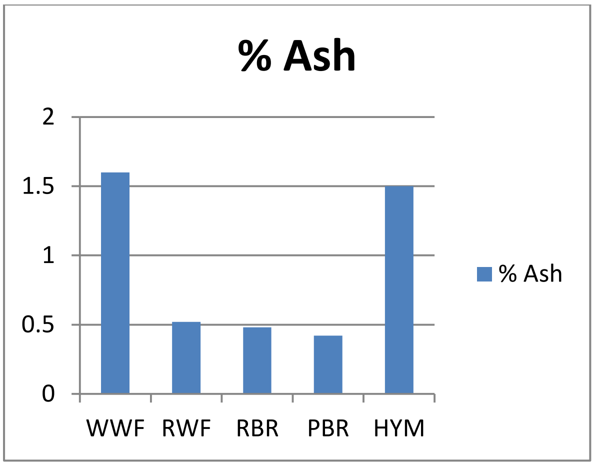

Figure 5. Comparative Fat values for different cereals

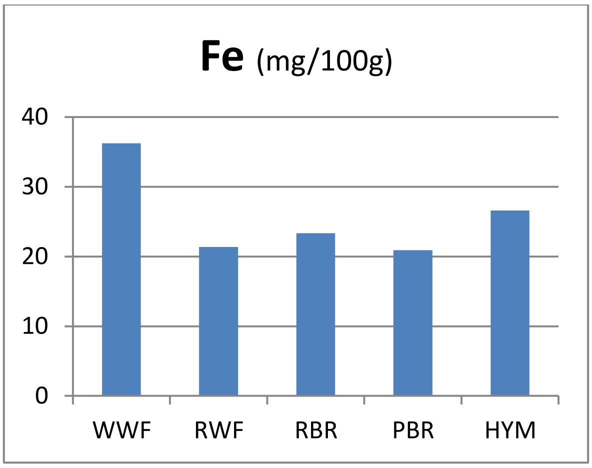

Figure 6. Comparative Iron values for different cereals

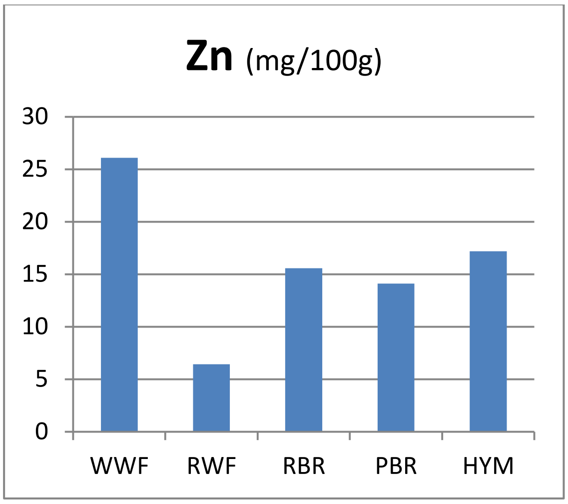

Figure 7. Comparative Zinc values for different cereals

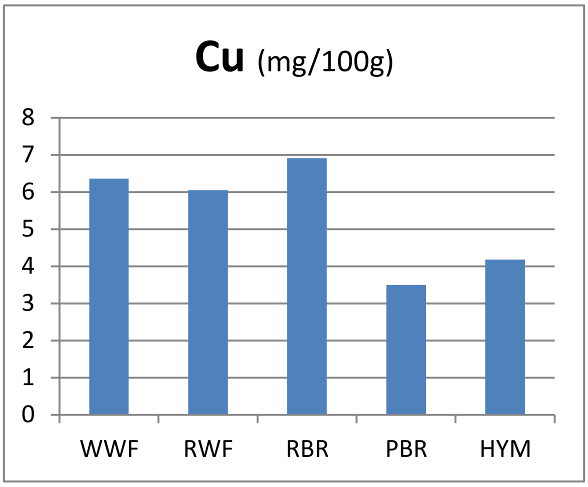

Figure 8. Comparative Copper values for different cereal

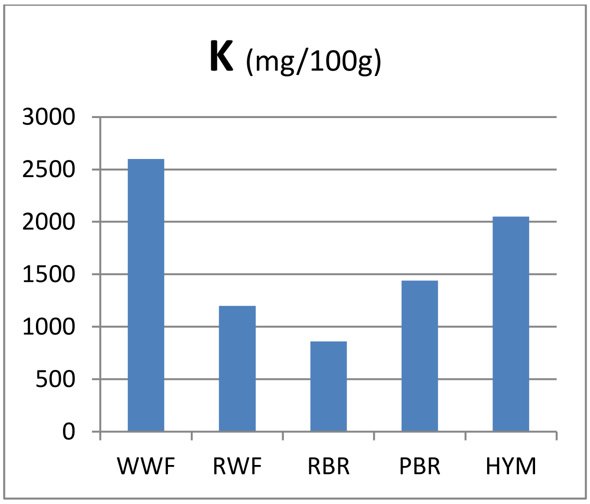

Figure 9. Comparative Potassium values for different cereal

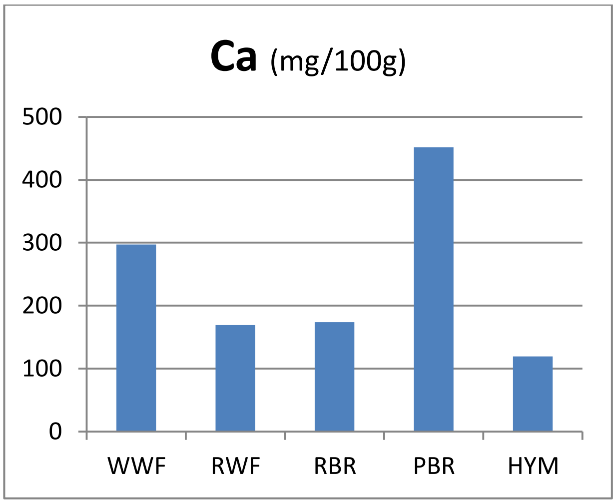

Figure 10. Comparative Calcium values for different cereals

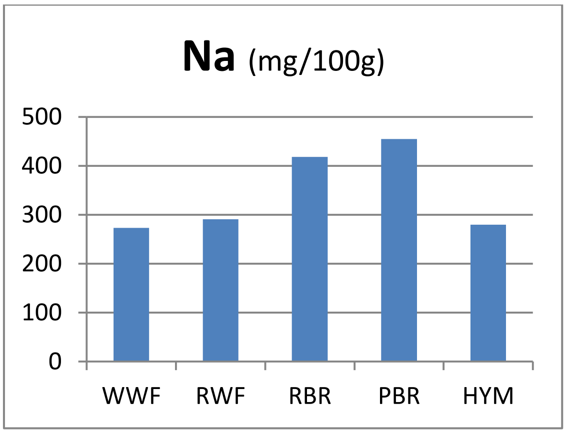

Figure 11. Comparative Sodium values for different cereal

Table 1. Proximate Analysis of Different Cereals on Dry Basis (d.b.)

Sample	% Moisture	% Starch	% Protein	% Fiber	% Fat	% Ash
WWF	11.8	70.8	13.2	2.2	1.7	1.6
RWF	11.3	78.4	9.1	0.48	0.38	0.52
RBR	12	80.4	7.2	0.39	0.44	0.48
PBR	11.6	79.9	7	0.42	0.41	0.42
HYM	12.2	72.4	9.1	1.4	3.45	1.5

Where
WWF= Whole Wheat Flour
RWF= Refined Wheat Flour
RBR= Raw Basmati Rice
PBR= Parboiled Rice
HYM= Hybrid Yellow Maize

Table 2. Mineral analysis of different cereals (mg/100g)

Sample	Micro Minerals			Macro Minerals		
	Fe	Zn	Cu	K	Ca	Na
WWF	36.24	26.08	6.36	2600	296.91	273
RWF	21.34	6.42	6.05	1200	168.90	291
RBR	23.33	15.58	6.91	860	173.50	418
PBR	20.89	14.11	3.50	1440	451.40	455
HYM	26.60	17.20	4.18	2050	119.20	280

Where
WWF= Whole Wheat Flour
RWF= Refined Wheat Flour
RBR= Raw Basmati Rice
PBR= Parboiled Rice
HYM= Hybrid Yellow Maize

3.2.2. Macro Mineral (K, Ca, Na)

These are the minerals that are present in huge quantities in the food. These include Potassium (K), Calcium (Ca) and Sodium (Na). The results regarding the amounts of macro minerals are shown in Table 2.

The amount of potassium (K) in different cereal types varied significantly. In WWF amount of K which is (2.6 g/100g) is higher among all these cereals i.e. HYM (2.05 g/100g), PBR (1.44 g/100g), RWF (1.2 g/100g) and RBR (0.86 g/100g) as shown in Table 2. The results show the decrease in the amount of K due to the processing. RBR contains less amount of K (0.86g/100g) which is less as compared with PBR (1.44g/100g). Amount of potassium is depicted with bar graph in Figure 9. This was due to the fact that dehulling of RBR affects at the outer surface of the rice as most of the K is present in the outer coating of rice. In PBR peddy is boiled which does not disturb the outer layer of rice. Hence PBR contains more K than RBR.

Calcium is a vital mineral which is present in high amount in PBR (451.4 mg/100g) compared with WWF (296.91 mg/100g), RBR (173.5 mg/100g), RWF (168.9 mg/100g) and HYM (119.2mg/100g). Amount s of calcium is depicted with bar graph in Figure 10.

Similarly amount of sodium varies among cereal types. Highest sodium content is found in PBR (455 mg/100g) compared with RBR (418 mg/100g), RWF (291 mg/100g), HYM (280 mg/100g) and WWF (273 mg/100g). Amount s of sodium is depicted with bar graph in Figure 11.

4. Conclusion

Refined wheat flour which is abundantly used in bread making and bakery products was found to be deficient in almost all nutrients as compared with whole wheat flour. Similarly analysis of two rice samples showed that raw basmati rice were found to contain lesser amounts of macro nutrients i.e. Na, K, Ca but starch and fat was on higher side as compared with parboiled rice which becomes deficient of vital micronutrients such as Fe, Cu and Zn during processing. This happens when paddy is boiled, dried and de-hulled to get finished product. These results showed that some vital macro and micro nutrients are being lost to some extent in both the processes. Balanced nutritional requirements can be achieved by combination of both types of rice (raw basmati rice and parboiled rice). Hybrid yellow maize analysis indicated that K, Zn, Cu is higher as compared with raw basmati rice, parboiled rice and also refined wheat flour while lower in Fe, Cu, Ca, Na as compared with raw basmati rice, whole wheat flour and refined wheat flour. It is concluded that a better nutrient diet can be obtained by selection of required cereals where processing steps are limited to retain the naturally occurring minerals and other nutrients which are helpful to maintain body requirements of a common man.

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