SUMMARY AND CONCLUSIONS

Cereals are staple foods for a large proportion of the world population. They contribute a significant amount of energy, protein, selected micro nutrients and antioxidant in the diet of populations all over the world in both developed and developing countries. Over the few decades, a large shift from consumption of coarse grains such as sorghum, barley, rye, maize and millet to more refined cereals, like polished rice and refined wheat has been observed especially among the urban population and higher income groups. Recently, refined carbohydrate and sugar from cereal have been identified as major risk factors for alarming increase in degenerative disease like diabetes, CVD etc, this has again highlighted the importance of coarse cereals and millets in diet. Millets are considered underutilized cereal, i.e., whose potential is not fully exploited. Their commercial exploitation is very limited, their consumption is poor due to lack of ready- to- use products similar to rice and wheat, and also due to the lack of awareness, research based studies on their nutritional quality and health benefits. Millets are designated as ‘nutritious grains’ due to its nutrients and antioxidant properties. Pigmented cereals like red sorghum, red rice have also been a recent area of study owing to its high carotenoid & TPC content and antioxidant properties. Therefore, these underutilized cereals have to be explored for their nutritional stability during processing and its utilization for value addition. In view of this, four cereals namely kodo millet, barnyard millet, finger millet and red rice were selected for the study and compared with wheat. They are rich source of calcium, iron, dietary fibre and antioxidant.

The study was undertaken to explore various aspects of selected underutilized cereals with following objectives 1. Evaluation of physicochemical characteristics and nutritional composition of selected underutilized cereals. 2. Analysis of antioxidant potential of selected underutilized cereals. 3. Effect of various processing methods on the physicochemical properties and functional component of selected underutilized cereals. 4. Evaluating/testing the suitability of selected grain for the development of value added product/s.

In the present study finger millet, red rice, kodo millet and barnyard millet were selected and explored for the functional properties namely dietary fibre, total polyphenols and antioxidant activity. The nutritional composition of selected
cereals was analyzed by applying standard AOAC method and antinutritional factor (Phytic acid) was determined by UV- spectrophotometric method whereas total dietary fiber (TDF) was analyzed by enzymatic-gravimetric method (megazyme kit sigma). The antioxidant profile of selected cereals was determined by evaluating the total polyphenol content (TPC) and total flavonoid content (TFC) while antioxidant activities were studied by the DPPH radical scavenging activity, reducing capacity and ferric reducing antioxidant potential (FRAP). Finger millet was found to contain high amount of calcium (337mg/100g) while barnyard millet was rich in iron content (18.3mg/100g). kodo millet (38.31%) and finger millet (19.06%) were found to contain appreciable amount of dietary fibre. Red rice contained high % DPPH scavenging activity (61%) and total carotenoid (146 µg/100g). In view of higher nutritional value there is a need for standardization of processing of cereals to enhance its antioxidant activity, to decrease anti-nutritional factors & enhance bio-availability of micronutrients.

The effect of processing viz. malting, microwave, extrusion cooking, roasting and pressure cooking on physicochemical characteristics, nutritional (ash, moisture, crude protein, crude fat, and crude fiber, calcium and iron) and antinutritional composition like phytic acid and antioxidant properties present in the selected cereals was studied. The malting and microwave treatments were optimized by response surface methodology, (RSM) while extrusion processing was carried out at different moisture and temperature combinations (M.C%/T °C- 15/90, 15/125, 20/90, 20/125). All the applied hydrothermal and bioprocessing treatments caused nonsignificant changes in protein, fat, crude fibre and carbohydrate content of selected underutilized cereals whereas they caused significant (p≤0.05) increase in mineral contents (viz- iron and calcium). All hydrothermal, thermal and bioprocessing treatments were found to reduce antinutritional factor in all the selected cereals. Among hydrothermal and thermal treatments extrusion was found best treatments for reducing phytate. Among bioprocessing treatments, greater reduction in phytic acid content was obtained by malting. While roasting showed highest antioxidant properties followed by extrusion, microwave, pressure cooking and malting treatments respectively.

All processing treatments considerably increased WAC and OAC in all selected cereals though highest increase in WAC was found in extrusion cooking while microwave cooking showed highest OAC. Bulk density showed
nonsignificant changes after processing. The lowest bulk density and highest expansion was observed in kodo millet and barnyard millet when compare to the control sample. Sensory scores after extrusion in finger millet and red rice were at par with control whereas barnyard millet and kodo millet showed higher scores than control sample.

Extrusion cooking has been investigated as a means of producing snacks meeting the dietary requirements of particular groups of the population. Extruded products mainly prepared from wheat, rice and corn as main ingredient have very good consumer preference mainly due to convenience, attractive appearance and texture; therefore, selected underutilized cereals were utilized for preparing ready to eat (RTE) extruded product. Linear-programming model was applied to meet the ICMR RDA of nutrients (Ca, Fe, Energy, Protein, CHO and crude fibre) for sedentary women and preschool children. Finger millet, kodo millet, barnyard millet and red rice composite flour formulations were designed for sedentary women and preschool using a linear programming (LP) model. LP formulated composite flour was extruded through single screw food extruder at different feed moisture (15%, 20% wb) and barrel temperature (90°C, 125°C). Effect of process parameters like temperature (90°C, 125°C) and feed moisture (15%, 20% wb) on physical properties (expansion ratio (ER), bulk density, color value), antinutritional factor (phytic acid) and antioxidant activity (TPC, DPPH, FRAP) of the RTE products was conducted. The developed products were subjected to sensory analysis by the semi trained panelist for consumer acceptance using 9-point hedonic scale. It was found that the sensory scores of RTE extruded product having temperature 125°C and 20% moisture combination for preschool children and sedentary women had sensory scores between 7.5 to 8.5 for texture, color and flavor and these values were higher than their respective control (semolina). The % DPPH radical scavenging activity and total phenolic content of the RTE product was 75.70%, 77.5% and 284 and 378mg/100g gallic acid equivalent for preschool and sedentary women respectively. Since, the developed extruded product are meeting the one-third requirement of major nutrients, it can be recommended as popular snack items for preschool children and sedentary women. The use of linear programming in an RTE snack product could make a great contribution in developing products according to the nutritional requirements of different age group. The millets are gaining popularity since it is gluten free. Due to its gluten free nature, these underutilized cereals can be
successfully used in breads, cookies or breakfast items. This study has shown a potential use of inexpensive and underutilized cereal flour in the preparation of extruded products. The challenge for future researchers is to understand the consumer’s preferences of underutilized cereals and work in this direction. Popularizing these cereals in form of gluten free RTE snacks or health mixes can be worked on.

**Conclusion:**

- Finger Millet contains exceptionally high amount of Calcium (337 mg/100g) while Barnyard Millet is rich in iron (18.3 mg/100g) and kodo millet contains highest total dietary fibre (38.31 %) among selected cereals.
- The results indicate that processing significantly increased the antioxidant activity (TPC, DPPH, Reducing power) of cereals when compared with the native cereals. Roasting showed maximum increase in TPC and DPPH radical scavenging activity among all the treatments.
- All the processing significantly decreased phytic acid content and the decrease was highest in malted cereals. Among thermal treatment extrusion showed maximum reduction in phytic acid content.
- The Extrusion condition of 125 °C and 20% moisture combination was found optimum in terms of expansion ratio, antioxidant activity and sensory qualities for utilizing kodo millet, barnyard millet, finger millet and red rice for commercial preparation of extrudates.
- The use of linear programming technique and RTE extruded products prepared by composite flour are fulfilling the nutritional requirements (calories, protein, iron and calcium) of preschoolers and sedentary women thus provide versatility for the development of high nutritive food products.

**Recommendations:**

On the basis of results of present study it can be recommended that

- Underutilized cereals uses may expand for multigrain products and applicability in niche markets for gluten-free products.
- Beneficial health effects of selected cereals emphasize their significance as a functional food ingredient in non-communicable disease (NCD) reduction and improving health.
- Composite flour prepared through linear programming for preschooler may also be used for developing other supplementary food for this age group. These supplementary foods or extruded products may also be recommended to undernourishment children for improving their nutritional status. The use of linear programming in an RTE snack product could make a great contribution in developing products according to the nutritional requirements of different age groups.
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