

Physico-Chemical, Functional and Proximate Properties of Standardised Millet Flakes

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Millet is the 5th most important cereals in the world after wheat, maize, rice and barley. It is a minor cereal containing abundant of nutrients but its consumption is lacking to a certain extent mainly due to the lack of ready-to-cook or ready-to-eat products and processing of millet to prepare ready to cook (RTC) foods can increase its economic and nutritional value. The processing, physical, chemical and nutritional aspects were analysed against the commercially available foxtail and proso flakes to standardise. The decorticated grains were steeped in 5 L of potable water at ambient conditions ($30 \pm 2^\circ\text{C}$) for 10 hr, autoclaved at 180°C under the pressure of 20 to 24 lbs/psi for 10 min dried at 50°C in a mechanical dryer to $18 \pm 1\%$ moisture content. The processed grains were rolled to flakes in a heavy-duty roller flakes machine with an aperture size of 0.25 mm. The commercial foxtail and proso flakes had higher values for all physical parameters than standardised ones.

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1. INTRODUCTION

Itagi et al. [1] evaluated the antioxidant and functional parameters of the maize grits, pearl millet, barley, sorghum, wheat and oats against commercial rice flakes. The highest equilibrium moisture content in grains with 46.0% and blistered flakes with 78.3% in barley followed by oats flakes 80.7%. In undefatted flours, the lowest soluble amylose content was in oats and highest in maize. The total amylose ranged from 15.0 to 22.0%, with wheat flakes having lowest and maize having highest in normal ones. In barley and wheat flakes, the solubility was quite high at room temperature with 21.0 to 24.0% because the grains are already gelatinized during the flaking process. At boiling water temperature, the solubility was highest in the wheat flakes compared to other grain flakes.

Foxtail is also known as Italian millet and German millet. It is generally grown as a rain-fed crop in India. It has an erect leafy stem that grows to 60-75 cm tall and bends quite a bit at maturity due to heavyweight of ear head. The foxtail grain contains 10.0 to 12.0% protein, 4.7% fat, 60.6% carbohydrates, 2.29 to 2.70% lysine and 0.59mg/100g of thiamine. In India, it is cultivated over an area of 0.87 lakh ha with total production of about 0.66 lakh tonnes per annum with productivity of 762.0 Kg/ha during 2015-16 [2].

The nutrient composition of proso millet was reported by Pilat et al. [3]. The results showed that they had starch of 72.58%, fat 8.43%, proteins 13.89%, amino acids 48.30 g/Kg, crude fibre 4.29% and total polyphenol content of 0.98%. The zinc content was 3.25mg, calcium 14.75mg, manganese 123.48mg, sodium 0.92mg, potassium 235.11mg and phosphorus 377.5mg per 100g of proso millets.

Aigal and Chimmad, [4] standardized foxtail flakes and compared the physicochemical and nutrient content with the rice and oats flakes. Foxtail millet flakes exhibited lower water holding capacity with 13.14%, water absorption capacity of 198.8%, water absorption index of 196.98, water solubility index of 2.59, oil absorption capacity of 99.7% and higher solid loss of 11.0% which are important factors in cooking gruels or porridges because higher the loss better would be the consistency. The nutritional composition

of foxtail millet flakes was about 9.50% moisture, 0.53% fat, 13.21% protein, 1.23% total ash, 9.06 % crude fibre, 53.40 % carbohydrates and 271.0 Kcal/100g of energy.

2. MATERIALS AND METHODS

The functional and nutritional parameters were also analysed for commercial and standardised flakes.

2.1 Procurement of Raw Materials

The foxtail millet (SiA-3085 variety) was procured from Agricultural College, PJTSAU, Polasa, Jagtial and proso millet (DHP-2769 variety) used in the present study was procured from MPIC, PJTSAU, Rajendranagar, Hyderabad.

2.2 Preparation of Foxtail and Proso Flakes

The selected millets were decorticated, steeped in 5 L of potable water at ambient conditions ($30 \pm 2^\circ\text{C}$) for 10 hr. The unabsorbed water was drained off and the tempered millets were autoclaved at 180°C under the pressure of 20 to 24 lbs/psi for 10 min and dried at 50°C in a mechanical dryer to $18 \pm 1\%$ moisture content. The grains were then rolled to flakes in a heavy-duty roller flakes machine with an aperture size of 0.25 mm. The rolled flakes were dried for 4-6 hr to approximate moisture content of about 10.5 % and stored for further investigations. The proso and foxtail flakes were further analysed for their physical, functional and nutritional parameters.

The physical parameters were thousand flakes weight, thousand flakes volume, specific volume, length, breadth, L/B ratio, expansion ratio and bulk density then the functional parameters were water holding capacity (WHC), water absorption capacity (WAC), water absorption index (WAI), oil absorption capacity (OAC), hydrophilic-lipophilic index (HLI), cooking time (CT), increase in weight after cooking (IWAC) and solid loss (SL) were assessed as per procedures of Aigal and Chimmad [4] and Takhellambam et al. [5].

The proximate composition includes moisture, total ash and protein were analysed by following standard procedure by AOAC [6,7,8], fat [9] and

crude fiber [10]. The carbohydrate content was computed by subtracting the total of moisture, ash, protein, fat and crude fibre from 100 [11] Energy content was computed by multiplying protein, fat and carbohydrate values obtained from the analysis by 4, 9 and 4 respectively and expressed as Kcal / 100 g [11].

3. RESULTS AND DISCUSSION

The physical, functional and nutritional parameters for standardised foxtail and proso millets were analysed and compared with commercially available variety.

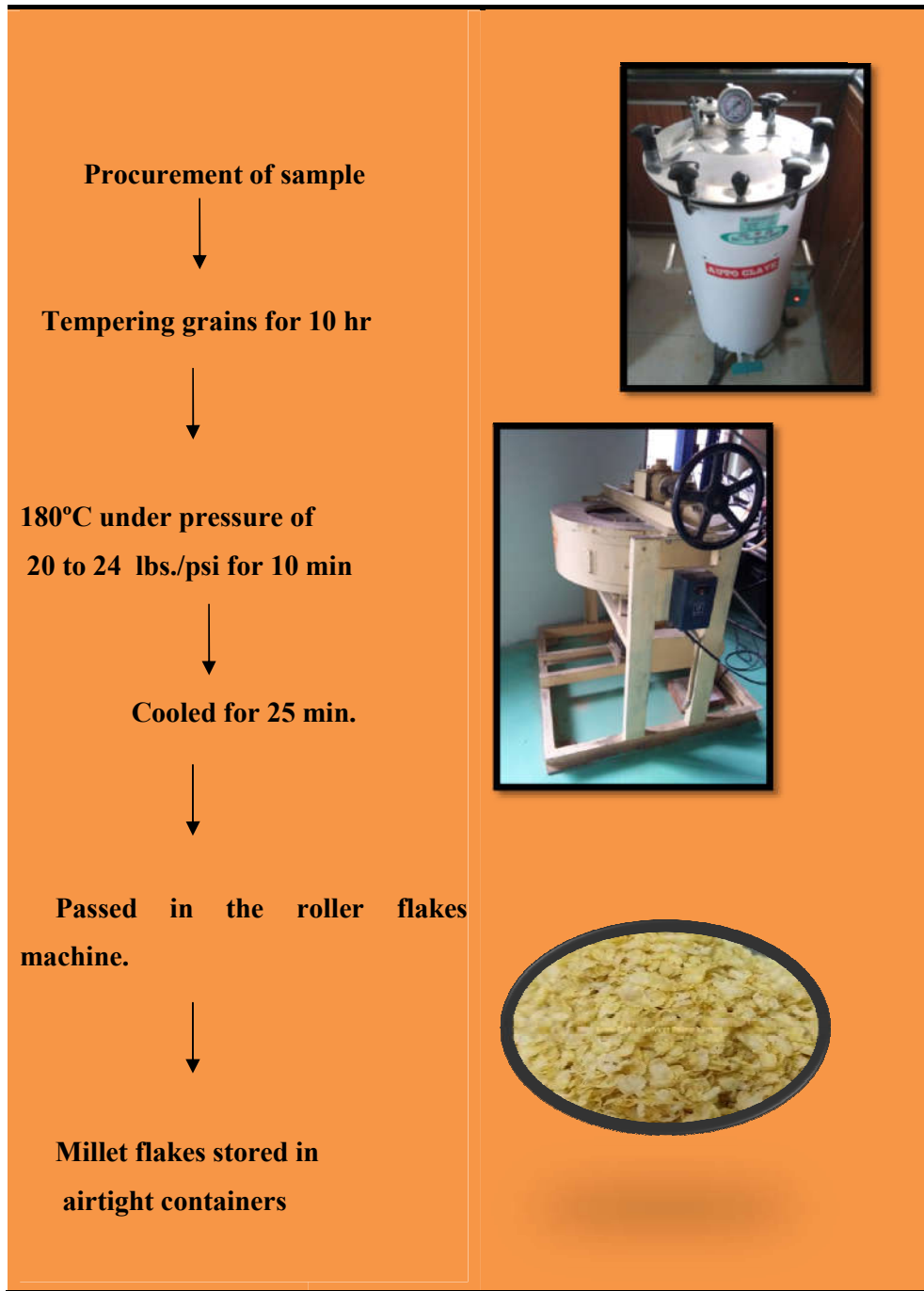


Fig. 1. Unit operations for the preparation of millet flakes

3.1 Physical Parameters of Commercial and Standardised Foxtail and Proso Flakes

The different physical parameters analysed were tabulated in Table 1 and percentage change was showed in Fig. 2. The results of physical properties of foxtail millet flakes (SFF) showed that there was 4.78% decrease in 1000 flakes weight, 2.27% in volume, 15.48% in specific volume, 31.25% in thickness, 21.05% in bulk density and 29.56% in L/B ratio. There was increase of 14.82% in length, 26.31% in breadth and 0.24% in expansion ratio. In standardized proso flakes (SPF) 10.16% of 1000 flakes weight, 0.24% in volume of flakes, 30.09% in specific volume, 2.22% in thickness, 41.66% in bulk density, 27.61% in L/B ratio and 16.04% in length decreased whereas 15.01% in breadth and 6.49% in expansion ratio increased when compared with commercial sample.

3.2 Functional Parameters of Foxtail and PROSO flakes

The functional parameters of developed foxtail and proso millet flakes were studied and the results were statistically analyzed and percentage change was presented in Table 2 and Fig. 3 respectively. Functional properties in SFF recorded a increase of 2.43% for WAI,

1.32% WAC, 0.15% WHC, 11.63% WSI, 2.25% OAC, 1.53% IWAC and 4.35% SL then 1% in HLI and 3.03% in CT was decreased when compared to commercial flakes.

In standardized proso flakes about 2.46% increase for WAI, 1.57% for WAC, 0.66% in WHC, 200.0% WSI, 2.58% OAC, 0.45% IWAC, 1.52% HLI and 50% SL was observed whereas 2.19% decrease in CT was seen compared with commercial proso millet flakes.

3.3 Proximate Analysis of Foxtail and Proso Flakes

The proximate nutrients of developed foxtail and proso millet flakes were premeditated and the results were statistically analyzed and presented in Table 3 and percentage change was showed in Fig. 4. Proximate analysis shows that when compare to commercial foxtail flakes showed an increase in moisture by 6.74%, protein 7.39% and crude fiber 13.12% in standardized foxtail flakes whereas a decrease in fat by 70.0%, ash 0.8%, carbohydrates 1.93% and energy by 9.78% was observed. The proximate analysis in standardized proso flakes showed an increase in moisture by 2.94%, protein 5.51%, crude fiber 4.91% and energy 7.86% whereas decrease in fat by 5.45%, ash 0.8% and carbohydrates 3.81% was observed.

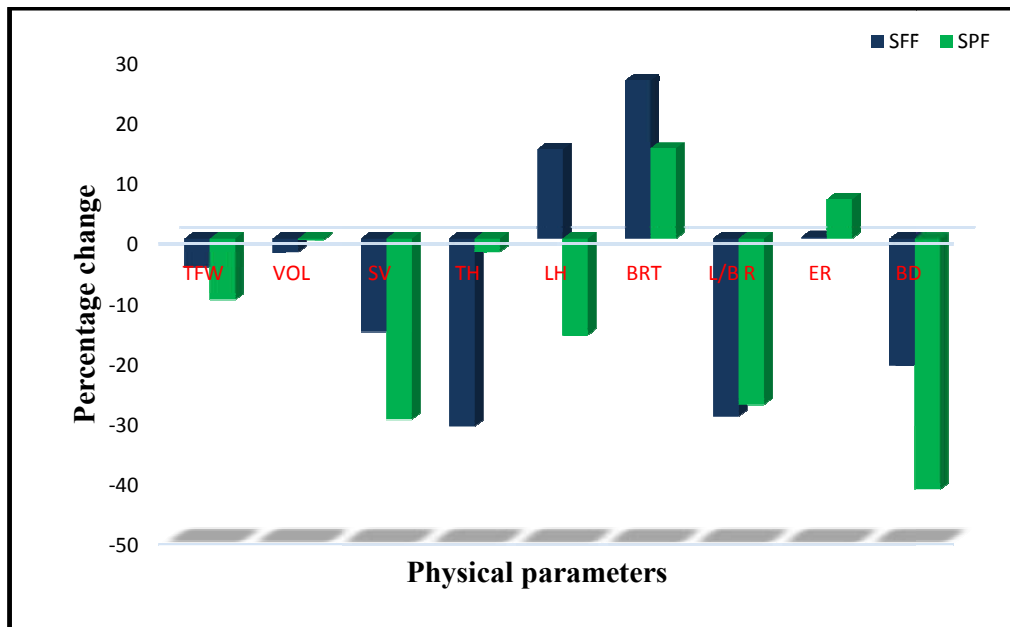


Fig. 2. Percentage change in physical parameters of standardized flakes

Note: SFF: Standardized foxtail flakes SPF: Standardized proso flakes

Table 1. Physical parameter of foxtail and proso flakes

| Sample | 1000 flakes wtg | 1000 flakes vol ml | Specific volume g/L | Thickness mm/inch | Length mm/inch | Breadth mm/inch | L/B ratio mm/inch | Expansion ratio | Bulk density g/ml |
|------------|-------------------------|--------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| CFF | 2.51 ^b ±0.10 | 14.96 ^b ±0.01 | 3.10 ^c ±0.02 | 0.48 ^d ±0.03 | 3.98 ^a ±0.08 | 3.42 ^b ±0.00 | 1.15 ^d ±0.02 | 8.04 ^c ±0.49 | 0.19 ^c ±0.01 |
| SFF | 2.39 ^a ±0.03 | 14.62 ^a ±0.03 | 2.62 ^a ±0.34 | 0.33 ^a ±0.00 | 4.57 ^c ±0.01 | 0.35 ^a ±4.32 | 0.81 ^b ±0.33 | 8.04 ^c ±0.01 | 0.15 ^b ±0.10 |
| CPF | 4.92 ^d ±0.02 | 16.06 ^c ±0.01 | 4.32 ^d ±0.03 | 0.45 ^c ±0.02 | 4.80 ^d ±0.06 | 4.53 ^c ±0.00 | 1.05 ^c ±0.01 | 4.62 ^a ±0.12 | 0.24 ^d ±0.00 |
| SPF | 4.42 ^c ±0.03 | 16.02 ^c ±0.00 | 3.02 ^b ±0.19 | 0.44 ^b ±0.00 | 4.03 ^b ±0.01 | 5.21 ^d ±0.01 | 0.76 ^a ±0.00 | 4.92 ^b ±0.12 | 0.14 ^a ±0.00 |
| Mean | 3.57 | 15.41 | 3.27 | 0.43 | 4.34 | 3.20 | 0.94 | 6.40 | 1.33 |
| SE of mean | 0.07 | 0.02 | 0.06 | 0.02 | 0.06 | 3.05 | 0.22 | 0.06 | 0.06 |

Note: Values are expressed as mean ± standard deviation of three determinations. Means within the same column followed by a common letter do not differ significantly at ($p \leq 0.05$). CFF: Commercial foxtail flakes SFF: Standardized foxtail flakes, CPF: Commercial proso flakes. SPF: Standardized proso flakes

Table 2. Functional parameters of foxtail and proso flakes

| Sample | WHC% | WAC% | WAI mg/g | WSI% | OAC% | HLI | CTMin | IWAC% | SL% |
|------------|------------|-------------|-------------|-----------|------------|-----------|-----------|--------------|------------|
| CFF | 13.12±0.00 | 196.2±0.0 | 192.3±0.0 | 2.32±0.00 | 97.47±0.03 | 1.99±0.00 | 0.32±0.00 | 195.7±0.3 | 11.47±0.03 |
| SFF | 13.14±0.00 | 198.8±0.0 | 197.0±0.0 | 2.59±0.00 | 99.37±0.33 | 1.97±0.00 | 0.31±0.00 | 198.7±0.3 | 10.97±0.03 |
| CPF | 3.00±0.01 | 196.9±0.0 | 156.8±0.1 | 0.01±0.00 | 77.78±0.33 | 1.97±0.00 | 0.91±0.00 | 434.7±0.3 | 0.01±0.00 |
| SPF | 3.02±0.00 | 200.7±0.7 | 160.8±0.0 | 0.03±0.00 | 80.13±0.00 | 2.00±0.00 | 0.88±0.00 | 437.3±0.3 | 0.03±0.0 |
| Mean | 8.07±1.52 | 198.11±0.54 | 176.71±5.44 | 1.23±0.00 | 88.68±2.95 | 1.98±0.00 | 0.61±0.87 | 316.58±36.00 | 5.61±1.68 |
| SE of mean | 0.000 | 0.49 | 0.07 | 0.00 | 0.25 | 0.00 | 0.00 | 0.47 | 0.02 |

Note: Values are expressed as mean ± standard deviation of three determinations. Means within the same column followed by a common letter do not differ significantly at ($p \leq 0.05$)

Table 3. Proximate analysis of foxtail and proso flakes

| Sample | Moisture (%) | Ash(%) | Protein (%) | Fat(%) | Fiber(%) | Carbohydrates (%) | EnergyKcal/100g |
|------------|--------------------------|-------------------------|--------------------------|-------------------------|--------------------------|--------------------------|---------------------------|
| CFF | 8.90 ^a ±0.00 | 1.24 ^b ±0.00 | 12.30 ^a ±0.00 | 1.80 ^d ±0.00 | 8.00 ^a ±0.00 | 67.76 ^d ±0.01 | 336.4 ^d ±0.00 |
| SFF | 9.50 ^b ±0.00 | 1.23 ^a ±0.00 | 13.21 ^b ±0.00 | 0.54 ^b ±0.00 | 9.05 ^b ±0.00 | 66.45 ^c ±0.02 | 303.5 ^c ±10.00 |
| CPF | 10.20 ^c ±0.00 | 1.25 ^c ±0.0 | 13.95 ^c ±0.00 | 0.55 ^c ±0.00 | 20.55 ^c ±0.00 | 53.50 ^b ±0.00 | 274.8 ^a ±0.00 |
| SPF | 10.50 ^d ±0.00 | 1.24 ^b ±0.00 | 14.72 ^d ±0.00 | 0.52 ^a ±0.00 | 21.56 ^d ±0.0 | 51.46 ^a ±0.01 | 296.4 ^b ±0.00 |
| Mean | 9.77 | 1.24 | 13.54 | 0.85 | 14.79 | 59.79 | 302.76 |
| SE of mean | 0.002 | 0.002 | 0.002 | 0.00 | 0.002 | 0.011 | 7.09 |

Note: Values are expressed as mean ± standard deviation of three determinations. Means within the same column followed by a common letter do not differ significantly at ($p \leq 0.05$). CFF: Commercial foxtail flakes SFF: Standardized foxtail flakes. CPF: Commercial proso flakes SPF: Standardized proso flakes

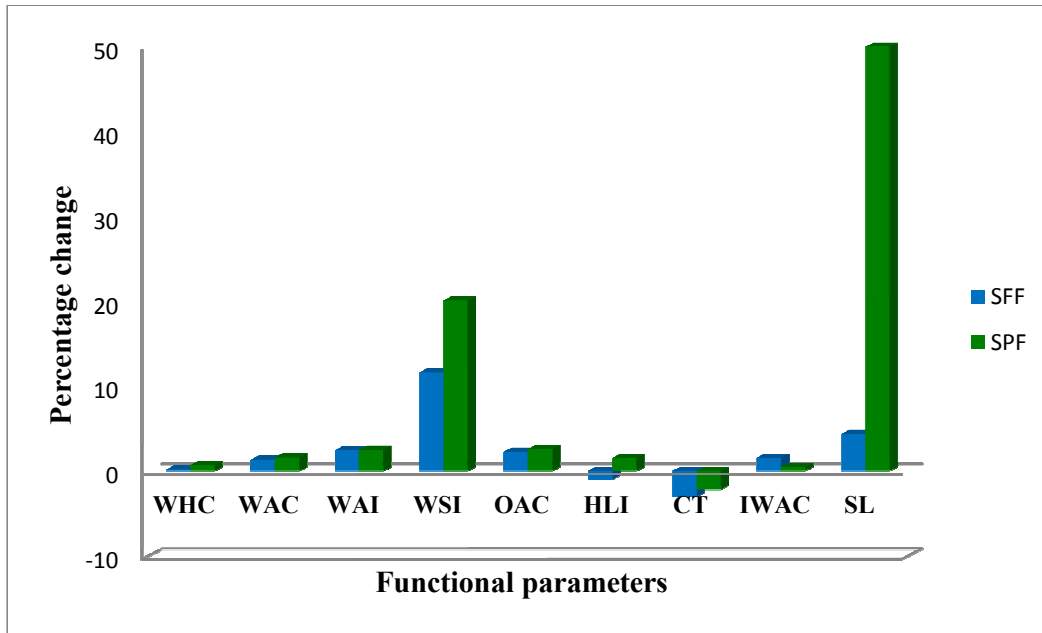


Fig. 3. Percentage change in functional parameters of standardized flakes

Note: SFF: Standardized foxtail flakes. SPF: Standardized proso flakes

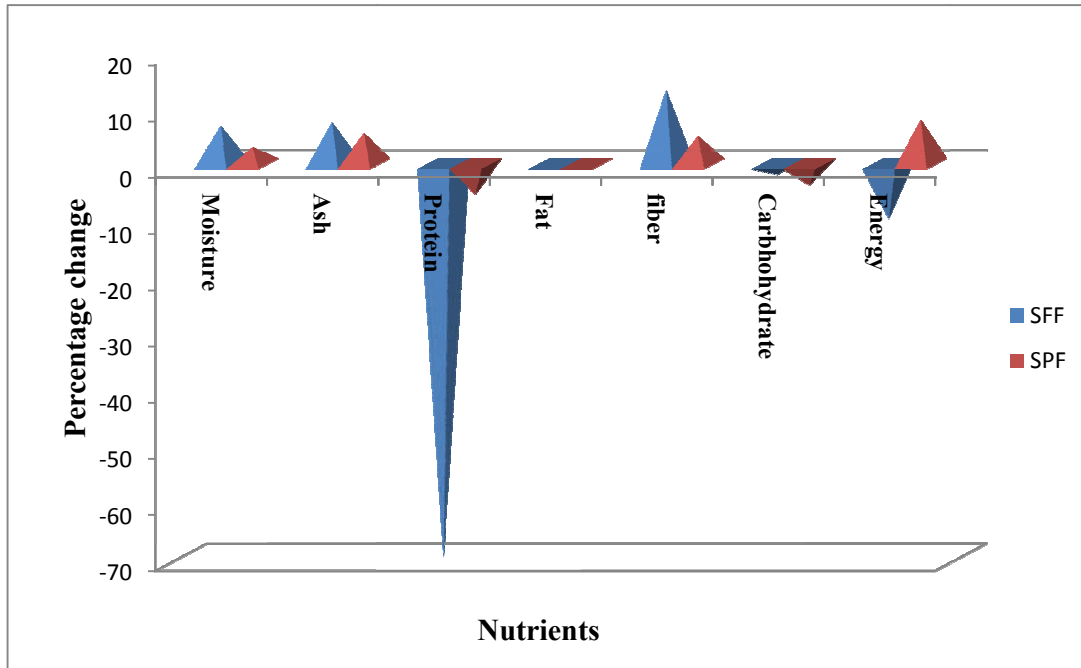


Fig. 4. Percentage change in proximate nutrients of standardized flakes

Note: SFF: Standardized foxtail flakes. SPF: Standardized proso flakes

4. CONCLUSION

The standardised and commercial flakes were analysed in terms of physical, functional and

nutritional parameters. The foxtail millet (SiA-3085 variety) and proso millet (DHP-2769 variety) was processed into the flakes and compared with the commercially available foxtail

and proso flakes. These flakes can be incorporated for development of value added products.

5. RECOMMENDATION FOR FUTURE RESEARCH

- Organoleptic evaluation is to be done on the breakfast items prepared with those flakes.
- Glycemic index can be identified on those flakes.
- Consumer evaluation study can be conducted.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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