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# Effect of Processing on Antinutritional and Carbohydrate Fractions of Browntop Millet

**Harichandana Ponnapalli and Sarojani J Karakannavar**

Department of Food and Nutrition, College of Community Science, University of Agricultural Sciences, Dharwad, 580005 India.

## ABSTRACT

*The mortality and morbidity due to non-communicable diseases are on the rise. Millets are the one-stop solution for ensuring food, nutrition and agricultural security. Due to their low glycemic index, high dietary fibre and nutritional content, they are the best alternative to keep lifestyle disorders at bay. Among millets, browntop millet is the least explored and the nutrients found in browntop millet are abundant and can help with a variety of health issues including diabetes but it also contains antinutrients that hinder their absorption. Therefore, in the present study, the most common processing techniques used by Indian families like soaking for 12 and 24 h, germination for 12, 24, 36, and 48h, and pressure cooking for 10 minutes were studied regarding their influence on antinutritional components, antioxidant properties and carbohydrate fractions of browntop millet. The results revealed that soaking and germination significantly affected the phytates, oxalates, tannins, starch digestibility and predicted glycemic index of browntop millet. The comparative examination of nine treatments revealed that the browntop millet sample soaked for 24 hours and germinated for 36 hours had an adequate reduction in phytates by 47.96% from 368.33 to 191.66 mg/100g and oxalates by 41.99% from 4.12 to 2.39 mg/100g and the starch digestibility was 75.67% without exceeding the glycemic score of 55. Soaking and germination significantly decreased total starch content and increased total, reducing and non-reducing sugars of browntop millet samples. Nevertheless, 24h soaking and 36h germination (BTM 7) was found with an optimal decrease in antinutrients while maintaining the low glycemic index of browntop millet flour. Therefore, 24h soaking and 36h germination (BTM 7) can be used for the development of various hypoglycemic food products.*

***Keywords:*** *Browntop millet, Soaking, germination, pressure cooking, processing, antinutrients, tannins, total sugars, reducing sugars, IVSD, predicted glycaemic index*

## INTRODUCTION

The arid areas of the world consume millet as a part of their daily diet. Millets are produced on roughly 17 million acres in India, producing 18 million tonnes annually and making about 10% of the National total grain production. They are considered Nutri-cereals for their sound nutritional content as it is a good source of protein, dietary fiber, B complex vitamins and minerals including iron, zinc, potassium, magnesium and calcium. They contribute to the improvement of conditions like diabetes and prevent other lifestyle disorders like cardiovascular diseases [1].

One of the most unfamiliar and unexplored millet varieties is browntop millet which is gaining importance in recent days. India is the traditional home of browntop millet (*Panicum ramosum*), as it thrives in the arid plains of Karnataka and Andhra Pradesh, particularly in the districts of Tumkur, Chitradurga, Chikkaballapura and Bellari [2].

Browntop millet is a tiny grain with a green tint [3]. This millet has the highest fibre content when compared to other millets at about 12.0%. Owing to this ability, browntop millet may be used as a preventative measure for a number of common illnesses, including diabetes [2]. Though it is a beneficial grain that yields many health benefits through its sound nutritional composition, it possesses certain components called antinutritional factors, particularly phytates and oxalates. These antinutrients are the major culprits as they decrease the availability of the minerals and vitamins present in browntop millet. To increase nutrient availability a variety of processing methods like soaking, germination, roasting, fermentation and cooking were employed from ages. Resulting products like starch and flour from the millet were being used in the preparation of instant mixes, weaning mixes, porridge, baked items and in the health industry [4].

Apart from reducing the antinutrients, such processing techniques also enhance the browntop millet's digestibility, which might also increase the predicted glycemic index (pGI). Foods or diet with a low glycemic index (GI) is hypothesized to stabilise blood sugar levels by lowering postprandial glycemia and are preferred as they prevent diabetes mellitus and many other lifestyle disorders. As per the research that is currently published, the influence of soaking, germination and hydrothermal treatment such as pressure cooking on the antinutritional components and predicted glycemic index of browntop millet is minimal. Therefore, it is crucial to comprehend how these processing techniques affect browntop millet as it might help us learn more about the health benefits of these grains and how to incorporate them into our daily diet. Hence the objective of the present study is:

**Corresponding Author:* ***Harichandana Ponnapalli***
*Email Address:* ***chandanaponnapalli@gmail.com***

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- To study the effect of soaking, germination and hydrothermal treatment like pressure cooking on antinutritional components, anti-oxidant properties and carbohydrate fractions of browntop millet

## MATERIAL & METHODS

**Research location:** The present study was conducted at the Department of Food Science and Nutrition, College of Community Science, University of Agricultural Sciences, Dharwad.

**Materials:** Dehusked browntop millet was procured from Green Organics, Dharwad. Analytical grade reagents were utilized throughout the investigation.

**Preparation of unprocessed and processed browntop millet flour**

The unprocessed and processed browntop millet grains were analyzed for antinutrients, antioxidant and carbohydrate fractions. The most effective technique was chosen based on its ability to lower antinutrients while maintaining a healthy carbohydrate quality that could be advantageous for diabetes patients.

**Preparation of unprocessed browntop millet flour (UPBTM):**

Dehusked browntop millet grains were washed and drained.

↓

Dried at 60$^0$C

↓

Shredded and sieved using 150µ sieve size to obtain unprocessed brown top millet flour.

↓

Packed in low density polyethylene (LDPE) bags for further analysis.

**Preparation of processed browntop millet flours**

Browntop millet grains were washed, drained and completely dried at 60$^0$C

↓

Soaked for 12 and 24h in distilled water at room

↓

Germinated for 12, 24, 36 and 48h at room temperature for each soaking period.

BTM1: 12h soaking, 12h germination
BTM2: 12h soaking, 24h germination
BTM3: 12h soaking, 36h germination
BTM4: 12h soaking, 48h germination
BTM5: 24h soaking, 12h germination
BTM6: 24h soaking, 24h germination
BTM7: 24h soaking, 36h germination
BTM8: 24h soaking, 48h germination

↓

Dried at 60$^0$C

↓

Germinated browntop millet grains were pressure cooked for 10min

↓

Dried at 60$^0$C

↓

Shredded and sieved using 150µ sieve size to obtain soaked, germinated and pressure-cooked browntop millet flour.

↓

Packed in low density polyethylene (LDPE) bags for further analysis.

**Estimation of antinutritional components**

The obtained unprocessed and different treatments of processed (soaked, germinated, and pressure-cooked) browntop millet flours were analyzed for antinutritional components like phytates and oxalates using standard procedures.

**Phytates**: The phytate content of the unprocessed and processed browntop millet flours was estimated by following the method of [5]. Finely ground sample was weighed into a 125 ml Erlenmeyer flask. TCA of 3% was extracted. The suspension was centrifuged and a 10ml aliquot was added with $FeCl_3$ solution. One or two drops of 3% TCA were added to the heated contents. Later, 3 ml of 1.5 NaOH was added and filtered through Whatman No.2. The precipitate was dissolved with 40 ml hot 3.2 N $HNO_3$. The paper was washed with several portions of water collecting the washings in the same flask. The flask was cooled and diluted with water. Twenty ml of 1.5 M KSCN was added and diluted to volume and the colour read immediately within a minute at 480nm.

**Oxalates**: The oxalate content of unprocessed and processed browntop millet flours was estimated by following the method of [6]. Exactly one gram of the sample was placed in a 250 ml volumetric flask, 190 mL of distilled water and 10 ml of 6 M HCI were added. The mixture was then warmed in a water bath at 90°C for 4 h and the digested sample was centrifuged at 2,000 rpm for 5 min. The supernatant was then diluted to 250 cm. Three aliquots of the supernatant were evaporated to 25 ml, the brown precipitate was filtered and washed. The combined solution and washings were then titrated with concentrated ammonia solution in drops until the pink colour of methyl orange changed to yellow. The solution was then heated in a water bath to 90°C and the oxalate was precipitated with 5% $CaC1_2$ solution allowed to stand overnight and then centrifuged, the precipitate was washed with hot 25% $H_2SO_4$, diluted to 125 mL with distilled water and titrated against 0.05 M KMnO4
Calculation: 1ml 0.05 M$KMnO_4$ = 2.2mg oxalate.

**Antioxidant activity**

**Tannins:**The tannin content of the unprocessed and processed browntop millet flours was estimated by the Folin-Denis reagent method according to [7]. Powdered and defatted sample extracts were prepared using 85 percent methanol containing one per cent sulphuric acid. The supernatant was used for estimation. Tannins were estimated calorimetrically using the Folin-Denis reagent (FDR) based on the measurement of the blue colour formed by the reduction of phosphotungstic molybdic acid present in the Folin- Denis reagent in an alkaline

solution. The absorbance was read at 760 nm. Tannic acid was used as the standard.

**Estimation of carbohydrate fractions**

The obtained unprocessed and different treatments of processed browntop millet flours were analysed for carbohydrate quality like *in vitro* starch digestibility, predicted glycemic index, total starch, types of starch, total sugars, reducing and non-reducing sugars using standard procedures.

***Invitro* starch digestibility (IVSD)**: IVSD of the unprocessed and processed browntop millet flours was estimated by following the method of [8]. Sample of 500 mg in 25 ml water cooked in boiling water bath for 15 min. Then the cooled sample was added with 0.2 M glycine-HCL buffer containing 10 mg pepsin and incubated at 37 °C for 2 hours. The slurry was neutralized with 0.2 N NaOH and the volume was made up to 100 ml. Ten ml of this aliquot was taken and 0.05 M phosphate buffer containing 7.5 mg pancreatin and 7.5 mg of amyloglucosidase was added and incubated at 37 °C. The sample was withdrawn at 30, 60, 90 and 120 min of incubation and the reducing sugar released was determined using Nelson Somogy's method. Glucose was used as standard and the degree of hydrolysis was expressed as milligrams of glucose liberated from food after correction for blank values.

Rapidly digestible starch (RDS), slowly digestible starch (SDS) and residual starch (RES) was calculated by the following formulae [9].

RDS = Glucose released at 30 min x 0.9

SDS = (Glucose released at 120 min – Glucose released at 30 min x 0.9

RES = Total starch – (RDS+SDS)

**Predicted glycemic index (pGI):**The predicted glycemic index of unprocessed and processed browntop millet flours was assessed following the equation given by [10] employing the IVSD at 90min. $pGI = 39.21 + 0.803 (Hydrolysis\ index_{90})$

**Total starch content:** The total starch of the unprocessed and processed browntop millet flours was estimated by following the method of [11]. The sample was repeatedly treated with hot 80 per cent alcohol to remove sugars. The residue rich in starch was solubilized with perchloric acid and the filtered extract was treated with anthrone sulphuric acid to determine glucose. The glucose value was multiplied by 0.9 to convert it into the starch value.

**Total, reducing and non-reducing sugars:**The total and reducing sugars were determined as per the procedure given by [5]. The reducing sugars when heated with alkaline copper tartrate reduce the copper from the cupric to cuprous state and thus cuprous oxide is formed. When cuprous oxide is treated with arsenomolybdic acid, molybdic acid is reduced to molybdenum blue. The blue colour is compared with the set of standards in a colorimeter at 620nm. Non-reducing sugar was computed by subtracting reducing sugar from total sugar.

Non reducing sugar = (Total sugar – reducing sugar) × (0.95)

Where, 0.95 is the conversion factor.

## RESULTS AND DISCUSSION

**Effect of processing on the antinutritional components of browntop millet**

The phytate and oxalate content of unprocessed and processed browntop millet flours are given in Table 1. The UPBTM flour had 368.33±5.77mg/100g of phytic acid and 4.12±0.05mg/100g oxalic acid. After processing (BTM1 to BTM8) the phytate content reduced &ranged from 323.33±2.88 to 118.33±7.63mg/100g while the oxalate content reduced &ranged from 3.92±0.09 to 2.04±0.04mg/100g.As the hours of soaking increased from 12 to 24 and germination from 12 to 48 there was a significant ($P<0.01$) decrease in these antinutritional components and it was found that the phytates were decreased by 67.87% while oxalates were decreased by 50.48% in 24h soaked and 48h germinated (BTM 8) sample when compared to unprocessed browntop millet (UPBTM) (Table 1).

Leaching out or seepage of phytic acid upon hydration as well as the activation of phytases during soaking and germination could be the possible reasons for a decrease in phytate content [12]. Phytases are the enzymes that hydrolyze the phytate molecules [13]. It has been recently documented that considerable amounts of the phytates present in cereals and legumes have been eliminated by activating phytases [14]. These could be the potential reason for the reduction of phytates in soaked and germinated browntop millet in the present study. A comparable decrease in the phytate content from 0.58 to 0.33 g/100g was found in unprocessed pearl millet flour to soaked and germinated millet flour respectively in a study performed by [15]. Similarly, phytate content in raw and germinated pearl millet flour reduced from 0.57 to 0.26 g/100g respectively in a study analyzed by [16].

The release of oxalate-degrading enzymes like oxalate oxidase and oxalate decarboxylase has caused a decline in oxalates during soaking and germination [17]. The findings of [18] in which the oxalate content was reduced from 5.16mg/100g in raw finger millet flour to 2.35 mg/100g in germinated finger millet flour are also on par with the results of the present study.

A lot of recent evidence shows that phytates and oxalates have a high affinity to chelate calcium, magnesium, iron, zinc etc. which renders them unavailable for bodily absorption. This could be a cause of concern for public health and nutrition, sooner or later leading to micronutrient deficiencies, inadequate growth and development eventually causing mortality and morbidity [19]. Thus, appropriate household food processing techniques like soaking, germination and pressure cooking can be beneficial as they reduce phytates and oxalates almost by half of the original amount.

***Table 1: Effect of processing on phytates and oxalate content of browntop millet***

| Treatment | Soaking (hrs) | Germination (hrs) | Pressure cooking (min) | Phytates (mg/100g) | Phytate reduction (%) | Oxalates (mg/100g) | Oxalate reduction (%) |
|---|---|---|---|---|---|---|---|
| UPBTM | - | - | - | $368.33^{a}$±5.77 | - | $4.12^{a}$ ±0.05 | - |
| BTM1 | 12 | 12 | 10 | $323.33^{b}$±2.88 | 12.21 | $3.92^{b}$ ±0.09 | 4.85 |
| BTM2 | 12 | 24 | 10 | $263.33^{d}$±7.63 | 28.50 | $3.56^{c}$ ±0.04 | 13.59 |
| BTM3 | 12 | 36 | 10 | $206.66^{e}$±15.27 | 43.89 | $2.98^{d}$ ±0.04 | 27.66 |
| BTM4 | 12 | 48 | 10 | $178.33^{f}$±7.63 | 51.58 | $2.32^{e}$ ±0.06 | 43.68 |
| BTM5 | 24 | 12 | 10 | $300.00^{c}$±13.22 | 18.55 | $3.62^{c}$ ±0.08 | 12.13 |
| BTM6 | 24 | 24 | 10 | $243.33^{d}$±7.67 | 33.93 | $2.93^{d}$ ±0.08 | 28.88 |
| BTM7 | 24 | 36 | 10 | $191.66^{ef}$±2.88 | 47.96 | $2.39^{e}$ ±0.06 | 41.99 |
| BTM8 | 24 | 48 | 10 | $118.33^{g}$±7.63 | 67.87 | $2.04^{f}$ ±0.04 | 50.48 |
| Total | | | | 243.70±75.92 | | 3.10 ±0.71 | |
| F value | | | | 241.53 | | 377.80 | |
| CD value | | | | 20.60** | | 0.14** | |
| S.Em value | | | | 5.06 | | 0.03 | |

Values are expressed as mean ± standard deviation of three replications. Values in a column with different superscripts are significantly different (p<0.01). CD: Critical difference, S.Em: Standard error of mean.

**Effect of processing on the antioxidant property of browntop millet**

The effect of processing on the antioxidant property in terms of tannin content was expressed in Table 2. The tannin content of unprocessed browntop millet flour was recorded as 2.12 ±0.00 mg/g while it ranged from 1.96±0.01 to 1.00±0.01mg/g in processed browntop millet flours (BTM1 to BTM8). The results demonstrated that processing had significantly (P<0.01) affected the tannin content of browntop millet as there was a decrease in the amount by 52.83% in BTM8 when compared to UPBTM. As the hours of soaking increased from 12 to 24 and germination from 12 to 48 there was a significant (P<0.01) decrease in tannin content of browntop millet.

Tannins are classified as antinutrients as well as antioxidants. As antinutrients, they can promote protein precipitation, block digestive enzymes and hinder vitamin and mineral bioavailability. As antioxidants, they bind to Fe(II) and impede the Fenton reaction through which oxidation is retarted. Furthermore, they also inhibit cyclooxygenase thereby inhibiting lipid peroxidation [20].

Leaching into the water during soaking itself could have resulted in tannin losses [21]. Besides, the decrease could also be due to the increased activity of polyphenol oxidase and other hydrolysing enzymes [22]. An identical trend of a decrease in tannin content with an increase in germination period in five millets namely finger millet (2.07 to 0.55 mg/g), foxtail millet (1.97 to 1.23 mg/g), Kodo millet (1.42 to 0.52 mg/g) little millet (1.22 to 0.34 mg/g) and pearl millet (1.86 to 0.53 mg/g) was observed in research conducted by [23].

***Table 2: Effect of processing on the tannin content of browntop millet***

| Treatment | Soaking (hrs) | Germination (hrs) | Pressure cooking (min) | Tannins (mg/g) | Tannin reduction (%) |
|---|---|---|---|---|---|
| UPBTM | - | - | - | $2.12^{a}$ ±0.00 | - |
| BTM1 | 12 | 12 | 10 | $1.96^{b}$ ±0.01 | 7.54 |
| BTM2 | 12 | 24 | 10 | $1.75^{d}$ ±0.01 | 17.45 |
| BTM3 | 12 | 36 | 10 | $1.45^{f}$ ±0.01 | 31.6 |
| BTM4 | 12 | 48 | 10 | $1.26^{h}$ ±0.00 | 40.56 |
| BTM5 | 24 | 12 | 10 | $1.81^{c}$ ±0.01 | 14.62 |
| BTM6 | 24 | 24 | 10 | $1.67^{e}$ ±0.05 | 21.22 |
| BTM7 | 24 | 36 | 10 | $1.37^{g}$ ±0.05 | 35.37 |
| BTM8 | 24 | 48 | 10 | $1.00^{i}$ ±0.01 | 52.83 |
| Total | | | | 1.60 ±0.34 | |
| F value | | | | 4126.95 | |
| CD value | | | | 0.10** | |
| S.Em value | | | | 0.02 | |

Values are expressed as mean ± standard deviation of three replications. Values in a column with different superscripts are significantly different (p<0.01). CD: Critical difference, S.Em: Standard error of mean.

### 3.3 Effect of processing on carbohydrate quality of browntop millet

#### 3.3.1 *In vitro* starch digestibility (IVSD) and predicted glycaemic index (pGI) of browntop millet

As the hours of soaking increased from 12 to 24 and germination from 12 to 48 there was a significant (P<0.01) increase in the starch digestibility from 68.22±0.28 to 78.04±0.57 at 120min of digestion as shown in Table 3. Therefore, it was observed that soaking and germination time was directly proportional to the digestibility of starch.

The unprocessed brown top millet had an initial pGI of 48.15±0.23 which had significantly increased by 24.65% to 60.02±0.40 after the application of processing techniques like soaking and germination for different periods as shown in Table 3. The increase in pGI was directly proportional to the soaking and germination time.

The improved starch digestibility of soaked and germinated brown top millet may be attributed to the breakdown of starch molecules into oligosaccharides [24]. Moreover, as a result of hydrothermal treatment like pressure cooking used in the present study could have resulted in the expansion and rupture of starch granules which had allowed α-amylase to initiate starch hydrolysis in a more stochastic pattern [25]. A similar increase of 112.8% in starch digestibility of pearl millet was found in a study performed by [25]. Similar findings were observed in research conducted by [26] showed that longer sprouting periods 20, 60 and 24 hours had significantly increased IVSD in mungbean, chickpea and cowpea than shorter ones.

According to [27] and [28], a similar range of predicted glycemic index of different millets was found. It ranged from 41.43 in kodo millet to 54.15 in pearl millet. The predicted glycemic index of proso millet increased from 46.5 to 60.8 upon 96h of germination as reported by [29]. As a result of soaking and germination, starch had undergone constant hydrolysis, which made it more permeable for digestion. Food is categorised as low GI only if its value is 55 or lower. Due to soaking and germination, BTM8 had transformed into a medium GI meal. Increased starch digestibility as seen earlier caused the samples' glucose levels to rise rapidly as germination time rose, making absorption easier. This breakdown led the pGI values to rise quickly.

***Table 3: Effect of processing on in vitro starch digestibility (IVSD) and predicted glycemic index of browntop millet.***

| Treatment | Soaking (hrs) | Germination (hrs) | Pressure cooking (min) | IVSD (%) | % increase in IVSD | pGI | % increase in pGI |
|---|---|---|---|---|---|---|---|
| UPBTM | - | - | - | $68.22^{h}$±0.28 | - | $48.15^{g}$±0.23 | - |
| BTM1 | 12 | 12 | 10 | $68.90^{fg}$±0.28 | 0.99 | $50.28^{f}$±0.23 | 4.42 |
| BTM2 | 12 | 24 | 10 | $70.25^{e}$±0.28 | 2.97 | $52.15^{e}$±0.23 | 8.30 |
| BTM3 | 12 | 36 | 10 | $73.64^{c}$±0.49 | 7.94 | $52.55^{de}$±0.46 | 9.13 |
| BTM4 | 12 | 48 | 10 | $74.82^{b}$±0.28 | 9.67 | $56.28^{b}$±0.46 | 16.88 |
| BTM5 | 24 | 12 | 10 | $69.75^{ef}$±0.28 | 2.24 | $51.08^{f}$±0.23 | 6.08 |
| BTM6 | 24 | 24 | 10 | $71.27^{d}$±0.75 | 4.47 | $53.35^{cd}$±0.46 | 10.79 |
| BTM7 | 24 | 36 | 10 | $75.67^{b}$±0.49 | 10.92 | $53.75^{c}$±0.23 | 11.63 |
| BTM8 | 24 | 48 | 10 | $78.04^{a}$±0.57 | 14.39 | $60.02^{a}$±0.40 | 24.65 |
| Total | | | | 72.28±3.28 | | 53.07±3.43 | |
| F value | | | | 190.14 | | 304.250 | |
| CD value | | | | 1.00** | | 0.81** | |
| S.Em value | | | | 0.24 | | 0.19 | |

Values are expressed as mean ± standard deviation of three replications. Values in a column with different superscripts are significantly different (p<0.01). CD: Critical difference, S.Em: Standard error of mean.

**Effect of processing on types of starch of browntop millet**

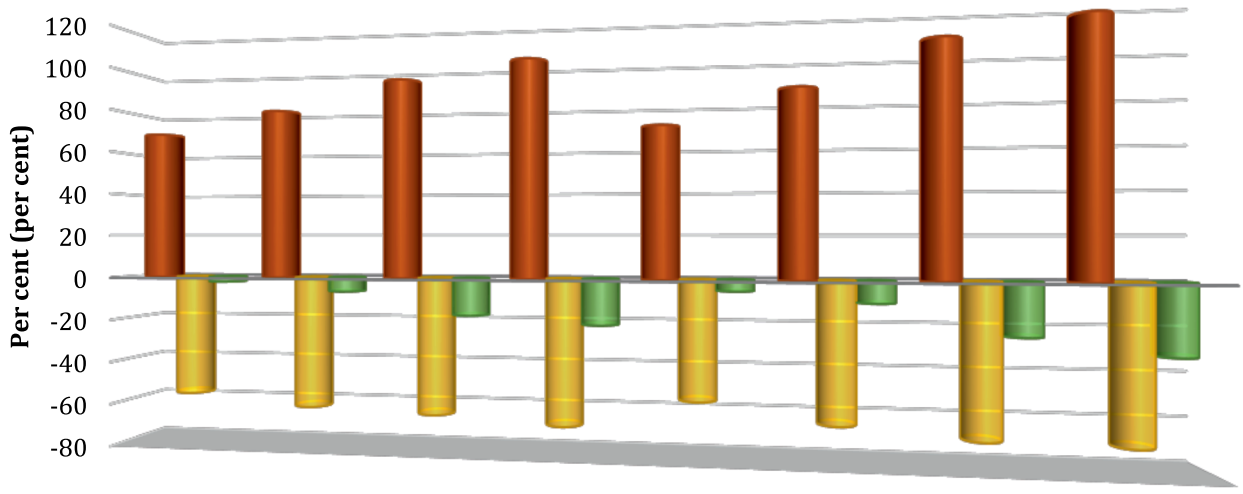
The rapidly digestible starch (RDS), slowly digestible starch (SDS) and residual starch (RES) of unprocessed brown top millet flour were 31.14±0.29. 37.07±0.50 and 31.77 0.29% respectively as shown in Table 4. There was a significant (P<0.01) increase in RDS of brown top millet flour with an increase in soaking and germination time when compared to unprocessed brown top millet flour while a significant (P<0.01) decrease in SDS and RES content was found with an increase in soaking and germination time. The per cent increase in RDS of processed brown top millet flour ranged from 69.04 to 114.19% when compared to unprocessed flour, while the per cent decrease in SDS and RES ranged from 56.16 to 69.40% and 2.14 to 30.90% respectively as depicted in Figure 1.

The starch that degrades quickly within the initial 30 minutes of digestion is known as rapidly digestible starch (RDS). The potential to affect blood glucose response increases with the amount of RDS in a food product. During the course of germination, the crystalline structure of the starch decreased and the hydrolysis of starch increased through the enhanced activity of amylase [29]. This led to an increase in RDS and a decrease in SDS and RES as much of these later portions are converted to RDS due to soaking and germination. A familiar pattern of increased RDS decreased SDS and RES upon germination of maize was found in research conducted by [30]. A bit of similar scenario was also seen in a study done by [29] in which 96h germinated proso millet sample had the highest RDS and lowest SDS and RES.

***Table 4: Effect of processing on types of starch of brown top millet***

| Treatments | Soaking period (h) | Germination period (h) | Pressure cooking (min) | (% of total starch) | | |
|---|---|---|---|---|---|---|
| | | | | RDS | SDS | RES |
| UPBTM (Control) | - | - | - | 31.14±0.29$^{h}$ | 37.07±0.50$^{a}$ | 31.77$^{a}$±0.29 |
| BTM1 | 12 | 12 | 10 | 52.64±0.29$^{g}$ | 16.25±0.50$^{b}$ | 31.09$^{ab}$±0.29 |
| BTM2 | 12 | 24 | 10 | 55.86±0.50$^{f}$ | 14.34±0.29$^{c}$ | 29.74$^{c}$±0.29 |
| BTM3 | 12 | 36 | 10 | 60.09±0.29$^{d}$ | 13.54±0.29$^{c}$ | 26.35$^{e}$±0.50 |
| BTM4 | 12 | 48 | 10 | 62.63±0.29$^{c}$ | 12.18±0.50$^{d}$ | 25.17$^{f}$±0.29 |
| BTM5 | 24 | 12 | 10 | 52.81±0.50$^{g}$ | 16.92±0.58$^{b}$ | 30.25$^{bc}$±0.29 |
| BTM6 | 24 | 24 | 10 | 57.72±0.29$^{e}$ | 13.54±0.58$^{c}$ | 28.72$^{d}$±0.77 |
| BTM7 | 24 | 36 | 10 | 63.99±0.50$^{b}$ | 11.68±0.00$^{d}$ | 24.32$^{f}$±0.50 |
| BTM8 | 24 | 48 | 10 | 66.70±0.29$^{a}$ | 11.34±0.29$^{d}$ | 21.95$^{g}$±0.29 |
| Total | | | | 55.95±10.08 | 16.32±7.70 | 27.71±3.28 |
| F value | | | | 2305.81 | 1008.12 | 192.01 |
| CD value | | | | 0.88** | 1.02** | 1.00** |
| S.Em value | | | | 0.21 | 0.25 | 0.24 |

Note: Values are expressed as mean ± standard deviation of three replications. Values in a column with different superscripts are significantly different (p<0.01) and with the same superscripts are non-significant. CD: Critical difference, S.Em: Standard error ofmean. **significant at 1per cent level, *significant at 5per cent level.




| | BTM 1 | BTM 2 | BTM 3 | BTM 4 | BTM 5 | BTM 6 | BTM 7 | BTM 8 |
|---|---|---|---|---|---|---|---|---|
| RDS | 69.04 | 79.38 | 92.96 | 101.12 | 69.58 | 85.35 | 105.49 | 114.19 |
| SDS | -56.16 | -61.31 | -63.47 | -67.14 | -54.35 | -63.47 | -68.49 | -69.4 |
| RS | -2.14 | -6.38 | -17.06 | -20.77 | -4.78 | -9.6 | -23.44 | -30.9 |

***Figure 1: Per cent change in the types of starch of soaked, germinated and pressure cooked (10min) browntop millet***

Note: RDS: Rapidly digestible starch, SDS: slowly digestible starch, RES: residual starch.

**Effect of processing on total starch, total sugars, reducing and non-reducing sugars of browntop millet**

The total starch present in unprocessed browntop millet flour was 56.43±0.49g/100g. In the processed browntop millet flours (BTM1 to BTM8) the starch content varied from 53.79±0.28 to 49.50±0.49 g/100g of sample with a per cent decrease from 4.68 to 12.20% (Table 5). As the hours of soaking increased from 12 to 24 and germination from 12 to 48 there was a significant (P<0.01) decrease in total starch of browntop millet.

The unprocessed browntop millet flour had 0.97±0.01 g/100g of total sugars, 0.49±0.02 g/100g of reducing sugars and 0.48±0.02 g/100g of non-reducing sugars. With an increase in the soaking and germination time, there was a significant (P<0.01) increase in all three parameters among all the treatments. The total, reducing and non-reducing sugars of processed browntop millet flours ranged

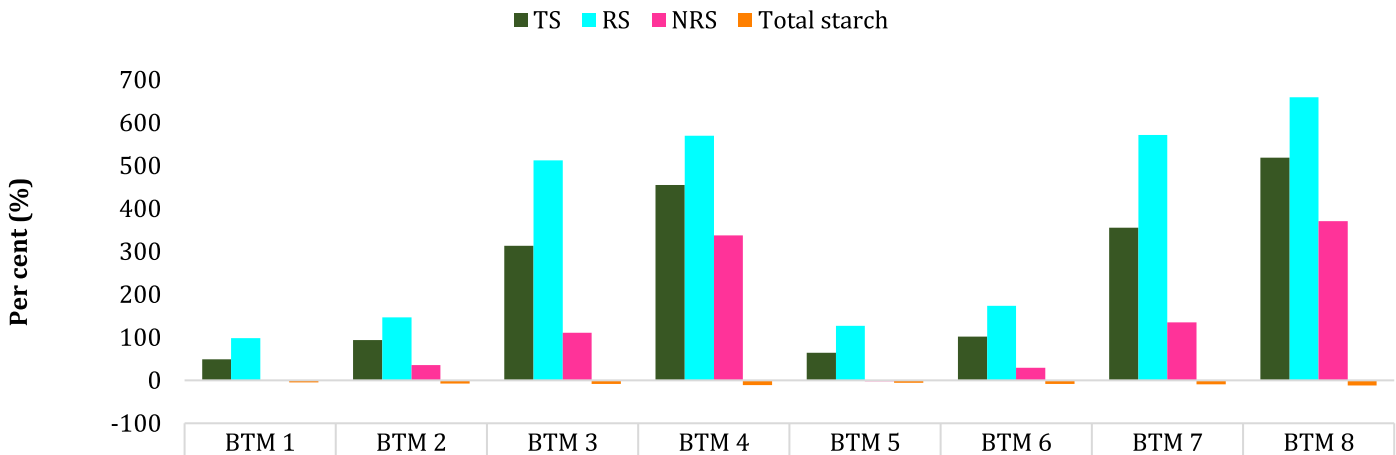
from 1.45±0.63 to 6.00±0.05 g/100g, 0.97±0.08 to 3.72±0.07 g/100g and 0.48±0.02 to 2.26±0.05 g/100g respectively. The per cent increase in total, reducing and non-reducing sugars ranged from 49.40 to 518.55, 97.95 to 659.18 and 35.41 to 370.83% respectively (Figure 2).

The conversion of starch into sugars during browntop millet germination caused the rise in sugars and fall in starch. Enzymatic hydrolysis degrades starch into sugars and other metabolites during the course of germination [31]. A similar decrease in starch content from 62.83 to 41.19% after 96h germination of finger millet, while reducing sugars increased from 0.86 to 10.54% was reported [32].

***Table 5: Effect of processing on total starch, total sugars, reducing and non-reducing sugars of browntop millet.***

| Treatment | Soaking (hrs) | Germination (hrs) | Pressure cooking (min) | Total starch (g/100g) | Total sugars (g/100g) | Reducing sugars (g/100g) | Non-reducing sugars (g/100g) |
|---|---|---|---|---|---|---|---|
| UPBTM | - | - | - | 56.43$^{a}$±0.49 | 0.97$^{h}$±0.01 | 0.49$^{g}$±0.02 | 0.48$^{e}$±0.02 |
| BTM1 | 12 | 12 | 10 | 53.79$^{b}$±0.28 | 1.45$^{g}$±0.63 | 0.97$^{f}$±0.08 | 0.48$^{e}$±0.02 |
| BTM2 | 12 | 24 | 10 | 52.14$^{cd}$±0.75 | 1.88$^{e}$±0.02 | 1.21$^{de}$±0.07 | 0.65$^{d}$±0.10 |
| BTM3 | 12 | 36 | 10 | 51.48$^{d}$±0.49 | 4.01$^{d}$±0.02 | 3.00$^{c}$±0.02 | 1.01$^{c}$±0.02 |
| BTM4 | 12 | 48 | 10 | 50.16$^{ef}$±0.28 | 5.38$^{b}$±0.08 | 3.28$^{b}$±0.05 | 2.10$^{b}$±0.13 |
| BTM5 | 24 | 12 | 10 | 53.13$^{bc}$±0.57 | 1.59$^{f}$±0.05 | 1.11$^{e}$±0.02 | 0.47$^{e}$±0.02 |
| BTM6 | 24 | 24 | 10 | 51.81$^{d}$±0.28 | 1.96$^{e}$±0.02 | 1.34$^{d}$±0.02 | 0.62$^{d}$±0.00 |
| BTM7 | 24 | 36 | 10 | 50.98$^{de}$±0.49 | 4.42$^{c}$±0.02 | 3.29$^{b}$±0.07 | 1.13$^{c}$±0.05 |
| BTM8 | 24 | 48 | 10 | 49.50$^{f}$±0.49 | 6.00$^{a}$±0.05 | 3.72$^{a}$±0.07 | 2.26$^{a}$±0.05 |
| Total | | | | 52.16±2.04 | 3.07±1.81 | 2.04±1.19 | 1.02±0.67 |
| F value | | | | 55.28 | 4830.63 | 1361.41 | 362.46 |
| CD value | | | | 1.14** | 0.10** | 0.12** | 0.14** |
| S.Em value | | | | 0.28 | 0.02 | 0.03 | 0.03 |

Values are expressed as mean ± standard deviation of three replications. Values in a column with different superscripts are significantly different ($p<0.01$). CD: Critical difference, S.Em: Standard error of mean.




| | BTM 1 | BTM 2 | BTM 3 | BTM 4 | BTM 5 | BTM 6 | BTM 7 | BTM 8 |
|---|---|---|---|---|---|---|---|---|
| TS | 49.4 | 93.81 | 313.4 | 454.63 | 63.91 | 102.06 | 355.67 | 518.55 |
| RS | 97.95 | 146.93 | 512.24 | 569.38 | 126.53 | 173.46 | 571.42 | 659.18 |
| NRS | 0 | 35.41 | 110.41 | 337.5 | -2.08 | 29.16 | 135.41 | 370.83 |
| Total starch | -4.67 | -7.6 | -8.77 | -11.11 | -5.84 | -8.18 | -9.65 | -12.2 |

***Figure 2: Per cent change in total starch, total sugars, reducing and non-reducing sugars of browntop millet flour after processing***

Note: TS: Total starch, RS: reducing sugars, NRS: Non reducing sugars.

## CONCLUSION

Browntop millet is a powerhouse of nutrients. The grain is of superior quality containing good amounts of Fe, Ca, K, Mg, Zn and P along with B complex vitamins [33]. It has 12.5% fibre content which is comparatively higher than other millets [2]. As a result, this millet can be explored for its potential to manage or prevent diabetes, its complications and other lifestyle disorders. However, the presence of antinutritional components in millet reduces minerals' bioavailability, decreasing their wholesomeness. Thus, processing techniques like soaking, germination and pressure cooking were applied, reducing the anti-nutritional components and making it more digestible. The results showed that there was a significant decrease in phytates and oxalates with an increase in soaking and germination time. Nevertheless, an increase in the availability of RDS with 66.70% and a predicted glycaemic index of

60.02 were also found at 24h soaking and 48h germination of brown top millet which reduced its essence of being used as a diabetic food. Hence, it was concluded that soaking and germination reduced antinutritional components which were beneficial but increased the pGI of brown top millet at higher soaking and germination periods. Thus, BTM 7 (24h soaking and 36h germination) was found suitable as there was an adequate reduction in antinutrients alongside maintaining brown op millet in a low glycaemic index state.

## FUTURE SCOPE OF THE STUDY

- Development of low glycaemic value-added products for various health benefits like diabetes and other lifestyle disorders.
- Evaluation of shelf life of the value-added products from browntop millet
- In-depth nutritional analysis of browntop millet

## CONFLICT OF INTEREST

The authors declare no conflict of interest in preparing this article.

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