RESEARCH ARTICLE

ສຶກສາການປ່ຽນແປງອົງປະກອບທາງເຄມີ ແລະ ສານຕ້ານອະນຸມູນອິດສະຫຼະໃນລະຫວ່າງຊ່ວງການເຮັດຊາເຂົ້າຟ້າງ[1]

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ບົດຄັດຫຍໍ້

ການສຶກສາຄັ້ງນີ້ແມ່ນໄດ້ເລັ່ງໃສ່ໃນການກວດສອບຂອງການປ່ຽນແປງອົງປະກອບທາງດ້ານເຄມີ ແລະ ສານຕ້ານອະນຸມູນອິດສະຫຼະ ໃນລະຫວ່າງຊ່ວງການເຮັດຊາເຂົ້າຟ້າງ ຫຼື ຊາ Broomcorn millet, ເຊິ່ງນັບຕັ້ງແຕ່ ເມັດດິບ, ຊ່ວງແຊ່ເມັດ, ຊ່ວງໜຶ້ງເມັດ, ຊ່ວງອົບໃຫ້ເມັດແຫ້ງ ແລະ ຊ່ວງທີ່ຂົ້ວເມັດເພື່ອເຮັດຊາ, ເຊິ່ງໃນແຕ່ລະຊ່ວງແມ່ນຈະນຳຕົວຢ່າງໄປວິເຄາະຫາອົງປະກອບທາງເຄມີ ແລະ ສານຕ້ານອະນຸມູນອິດສະຫຼະ. ຈາກຜົນຂອງການວິເຄາະສະແດງໃຫ້ເຫັນວ່າ: ໃນຊ່ວງຂອງການແຊ່ເມັດ Broomcorn millets ແມ່ນມີການລຸດລົງປະລິມານຂອງສານ phenol, tannin, ແລະ ສານຕ້ານອະນຸມູນອິດສະຫຼະເມື່ອປຽບທຽບກັບເມັດດິບແມ່ນມີຄວາມແຕກຕ່າງທາງດ້ານສະຖິຕິ, ແຕ່ວ່າ ພັດມີການເພີ່ມຂຶ້ນປະລິມານຂອງບັນດາສານອາຊິດ phenolic. ໃນກໍລະນີດຽວກັນນີ້ຂອງຊ່ວງໜຶ້ງເມັດ Broomcorn millet ໄດ້ສະແດງໃຫ້ເຫັນວ່າ ມີການລຸດລົງຂອງປະລິມານສານ phenol, tannin, reducing power and metal chelating ໃນລະດັບຄວາມເຊື່ອຖືກ $p \leq 0.05$, ແຕ່ວ່າ ປະລິມານຂອງສານ Ferulic acid ພັດເພີ່ມຂຶ້ນ. ນອກຈາກນີ້, ໃນຊ່ວງຂອງການເຮັດແຫ້ງ ແລະ ຂົ້ວເມັດ Broomcorn millet ເພື່ອເຮັດຊານັ້ນ ແມ່ນມີການລຸດລົງປະລິມານຂອງບັນດາສານ phenolic, ແຕ່ວ່າພັດມີການເພີ່ມຂຶ້ນຂອງປະລິມານສານ phenol, tannin, ແລະ ສານຕ້ານອະນຸມູນອິດສະຫຼະ ແລະ ເມື່ອປຽບທຽບກັບເມັດດິບແລ້ວແມ່ນມີຄວາມແຕກຕ່າງທາງດ້ານສະຖິຕິ, ສະນັ້ນ ອາດເວົ້າໄດ້ວ່າ ໃນແຕ່ລະຊ່ວງຂອງການເຮັດຊາ Broomcorn millet ໂດຍການໃຊ້ເມັດນີ້ແມ່ນເຮັດໃຫ້ມີການປ່ຽນແປງອົງປະກອບທາງເຄມີ ແລະ ສິ່ງຜົນເຮັດໃຫ້ສານຕ້ານອະນຸມູນອິດສະຫຼະເກີດມີການປ່ຽນແປງໄປທາງດຽວກັນ.

ຄຳສັບສຳຄັນ

ເຂົ້າຟ້າງ, ຊາ, ສານຕ້ານອະນຸມູນອິດສະຫຼະ, ສານປະກອບຟີນອນ (phenolic compounds)

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[1] **ການອ້າງອີງພາສາລາວ**

ພອນສະຫວັນ ພຸດທະໄຊ, ຕິມນ້ອຍ ສະລິດໄຊ, ດາວວ່ຽ ຈາທ່າວກ່າລໍ ແລະ Cheol Ho Park (2018). ສຶກສາການປ່ຽນແປງອົງປະກອບທາງເຄມີ ແລະ ສານຕ້ານອະນຸມູນອິດສະຫຼະໃນລະຫວ່າງຊ່ວງການເຮັດຊາເຂົ້າຟ້າງ, ວາລະສານວິທະຍາສາດ ມະຫາວິທະຍາໄລສຸພານຸວົງ, ສະບັບທີ 3 : ໜ້າ 125-135.

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RESEARCH ARTICLE

Change in phytochemical composition and antioxidant inhibitory activity during processing of Broomcorn millet tea.

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ABSTRACT

This study focused on the evaluation of changes in phytochemical compositions and antioxidant inhibitory activities during the processing of broomcorn millets tea. From the result was showed that Soak-treating of broomcorn millets significantly decreased all of total phenol and tannin contents, and antioxidant activity was compared with raw treatment at $p \leq 0.05$, but significantly increased the contents of phenolic acid. In the same case of the steaming treatment were exhibited the contents of total phenol, tannin, reducing power and metal chelating activity significantly decreased, whereas the content of Ferulic acid significantly increased. The process of drying and roasting significantly decrease the contents of total phenolic compounds. Whereas, significantly increased all of total phenol and tannin contents, and antioxidant activity was compared with raw treatment. The total phenolic content of collecting processed millets materials positively correlated with the antioxidant inhibition activities.

Keywords

Broomcorn millets, tea, antioxidant, phenolic compounds

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1. INTRODUCTION

Millets are small-seeded existent cereal crops belonging to the family Poaceae. Miller's play an important role in the economies of many developing countries. In Africa, East Asia and Indian subcontinent millets serve as staple diets for large populations of less chance groups (Chandrasekara, Naczk, & Shahidi, 2012). They have a divergent advantage of being drought resistant crops and hence act as the principle source of energy, protein, fat and minerals for people living in these regions. The nutritive value of millets is comparable to other main cereals like wheat and rice. (Klopfenstein & Hoseney, 1995). Beyond nutrients, millet grains have a diversity of particularly phenolic compounds and phytochemicals, (Shahidi & Chandrasekara, 2013). They are several reported to efficient health benefits of millets such as preventing cancer and cardiovascular diseases, lowering blood pressure have been attributed to these phenolic (Saleh, Zhang, Chen, & Shen, 2013).

Secondary metabolites in millet consisted phenolic compound are one of the most important groups, having anti-nutrient properties. However, these compounds act as antioxidants, singlet oxygen quenchers, metal chelators, reducing agents and inhibitors of digestive and regulatory enzymes, thus variety of different mechanisms were promoting human healthy (Truswell, 2002). Chandrasekara and Shahidi (2010) indicated a wide range of phenolic compound concentrations and anti- oxidant capacities in soluble as well as bound fractions of millets. In addition to antioxidant properties, poly-phenols of millets, particularly millets, possess other health benefits such as anticancer, antimicrobial, anti-inflamm-atory, antiviral, antiplatelet aggregation and inhibitory activities in cataract formation (Viswanath, Urooj, & Malleshi, 2009).

Several traditional processing methods are normally utilized in preparation of millet based foods, and it is known that processing induces significant changes in chemical composition that affect the bio accessibility and concentration of foods and health promoting phytochemicals (N'Dri et al., 2012; Pradeep & Guha, 2011). We were founded that physical and chemical properties of millet seeds and products were greatly affected by different processing conditions. For example, thermal processing via firing improved the total phenolic content, anti- oxidant activity and functionality of millet, which relation with (Randhir, Kwon, & Shetty, 2008) reported that thermal processing via autoclave antioxidant activity, total polyphenols and functionality of buckwheat. In addition, Shobana, Sreerama, and Malleshi (2009) exhibited that phenolic extracts from millet seed coat were responsible for inhibiting enzymes such as alpha-glucosidase, thus indicating their therapeutic potential for managing postprandial hyper- glycemia. Therefore, the nutritional value and health benefits of millets are dependent upon their metabolic profiles, including the types and amounts of natural phenolic compounds present.

Further studies on these phenolic com- pounds would enhance understanding of the biological activity of millet phenolic and their benefits to human health. Furthermore, the contributions of millet phenolic to the anti- oxidant properties and inhibitory activities against alpha-amylase and alpha-glucosidase were also evaluated. In addition, considering the limited information available in the literature on the suitability of processing conditions of the specific health beneficial components in these millets. Thus, the aim of this study was to investigate the

effect of processing methods on the phenolic profiles of broomcorn millet.

2. MATERIAL AND METHODS

2.1. Chemicals

Tannic acid (TA), 1.1-dipheny l-2-picryl hydrazyl (DPPH) and standard phenolic compounds were purchased from Sigma Chemical Co. (St. Louis, Mo). Folin Cio -calteu's reagent was purchased from Wako Pure Chemicals, Japan. All other chemicals and reagents used in the experiments were of laboratory grade.

2.2. Preparation of processing millet samples

Broomcorn millet grains without cover were purchased from local markets in Chuncheon city, Gangwon district, South Korea. All grains were cleaned for control and soaking with water 4 hours for different domestic processing samples in Fig.1, show a simplified flow diagram of millet tea preparation processing. Five of different Broomcorn millet tea materials of the processing were collected as follows: fraction 1: Raw seeds, fraction 2: soaked seeds, fraction 3 steamed seeds, fraction 4: dried seed and fraction 5: broomcorn millet tea (fired seeds), and samples at each processing point were collected tree time.

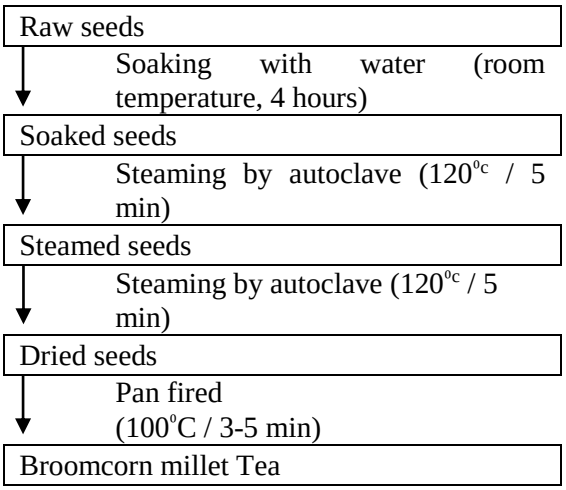


Fig 1. Simplified flow diagram of Broomcorn millet tea preparation procedures.

2.3. Extraction and quantification of total phenolic contents

The phenolic compounds were extracted by using grinder powder 5g each processing point sample were mixed with 100 ml of 70% methanol (v/v) solution in a glass and kept in incubate shaker under at 35^{0C}, 150 rpm for 24 hours. The extract solution was filtered through adventures 5B filter paper (Tokyo Roshi Kaissha Ltd, Japan) and dried using a vacuum rotatory evaporator (EYLA N-1000, Tokoy, Japan) in a 40^{0}C water bath. The dried samples were dissolved in 70% methanol and then stored at 4^{0}C until use.

The total phenolic content of the extracts was determined according to Folin-Cio- caltues method described by Singleton and Rossi (1965). In brief, a sample aliquot of 1 ml of extract was added to a test tube containing 0.2 ml of phenol reagent (1M). The volume was made up by adding 1.8 ml of distilled water and the solution was vortexed for 3min for the reaction. Incidentally, 0.4 ml of Na_2CO_3 (10% in water, v/v) was added and then increase total value to 4 ml by adding 0.6 ml of distilled water. The mix-tube was allowed to stand at room temperature for 1h and absorbance was measured at 725 nm in a spectrophotometer (Model UV-1800. Shi- madsu Corporation, Kyoto, Japan). The total phenolic content was calculated from a calibration curve (R^2 = 0.999) using tannic acid equivalent (TAE) per g dry weight (dw).

2.4. Determination of tannin contents

The tannins were determined by Folin and Ciocalteu method. In brief, 0.1 ml of the sample extract was added to test tubes and followed by 7.5 ml of distilled water, then adds 0.5 ml of Folin Phenol reagent and 35% sodium carbonate solution (1 ml) and increase

the total value to 10 ml was adjusted by distilled water. The mix-tube was vortexed nice mixture, kept at room temperature for 30 min and absorbance was measured at 725 nm. Blank was prepared with water instead of the sample. A set of standard solutions of tannic acid is treated in the same manner as described earlier and read against a blank. The results of tannins are expressed in terms of tannic acid mg/g of extract.

2.5. Determination of antioxidant properties

2.5.1. DPPH radical scavenging activity

The antioxidant activity of the treated samples was determined on the basis of the scavenging activity of stable 1.1-diphenyl-2-picrylhydrazyl (DPPH) free radical accor- ding to the method described by Braca et al. (2003) with slight modifications. Briefly, the phenolic extract solution 1 ml of the extract at different concentrations (6, 4 and 2 mg/ ml) was mixed with 3ml of DPPH solution (0.15 mM). The mixtures were shaken vigorously and left to stand at room temperature for 30 min in the dark before the absorbance was measured at 517 nm using a spectrophoto- meter and against a methanol blank. The scavenging activity was calculated using the following equation:

Radical scavenging activity (%) = $(1-A_{sample} / A_{control}) \times 100$

Where A_{sample} represents the absorbance of the experimental sample and $A_{control}$ represent the observance of the control.

2.5.2. Metal chelating assay

The phenolic extract samples were analyzed for the metal chelating activity, according to the procedure of Dinis et al. (1994) with modification. Briefly, 0.5 ml of sample extracts at different concentrations
(6, 4 and 2 mg/ml) was mixed with 0.1 ml of 1 mM FeCl2 followed by the addition of
0.2 ml of 5 mM ferrozine. The mixtures were vortexed and kept at room temperature for 10 min. For a blank, the sample extracts were replaced with 70% methanol. Finally, before measuring the absorbance with a spectrophotometer at 532 nm, the total volume was made up to 4 ml with the addition of 3.2 ml of 70% methanol. The ability of the extracts to chelate ferrous ions was calculated as follows:

Chelating effect (%) = $(A_0-A_1) / A_0 \times 100$

Where, A0 and A1 were the absorbance of the control and the test sample, respectively.

2.5.3. Reducing power

The reducing power was determined according to the method of Oyaizu (1986) with modifications. Samples (0.5 ml) were mixed with 0.5 ml of 0.2 M sodium phosphate buffer pH 6.6, and 0.5 ml of 1% potassium ferricyanide, and incubated at 50◦C for 20 min. After cooling at room temperature, 0.5 ml of 10% trichloro acetic acid was added. The solution mixed samples were taken to centrifuge at 2000 ppm for 15 min, upper layer 1 ml was added to tube content 1 ml of distilled water, and 0.2 ml of 0.1% ferric chloride (III) was added. The absorbance was measured at 700 nm against a blank of distilled water. The concentration of sample required to obtain 0.5 ml absorbance units (A.U.) was calculated from linear regression analysis.

2.5.4. Hydroxyl radical scavenging activity

The hydroxyl radical scavenging activity of the phenolic extract was

measured accor- ding to the method of Halliwell et al. (1987) with modification. Briefly, 0.1ml of various concentrations of the extract was added to test tubes consisted of 10 mM FeCl3, 10 mM EDTA, 10 mM H_2O_2, and 10 mM deoxyribose in potassium phosphate buffer (pH 7.4) (0.9 ml). The reaction mixture was incubated for 1 h at 37 °C, and boiling in water bath 95ºC for 15 min after added 0.5 ml of 10% (w/v) trichloroacetic acid and 0.5 ml of 1% (w/w) 2-thiobarbituric acid. The color development was measured of 532nm against a blank containing phosphate buffer.

2.6. HPLC analysis

The sample extract was analyzed by HPLC to obtain a profile of individual phenolic compounds (Court, 1977) using HPLC system (Agilent 1200 Series, Agilent Technologies Inc, Santa Clara, CA, USA) equipped with a Diode Array detector. HPLC analysis was carried out using C18 analytical column (250 x 4.6 nm; 5µm). The mobile phase consisted of 0.1% trifluoro acetic acid (solvent A) and 100% methanol solvent B). The flow rate was maintained at 1.0 ml/min for a total run time of 60 min with the gradient program as follows: 20-40% B in 40 min which was maintained for 10 min and then again to 20% B in next 5 min. There was 5 min of post-run for reconditioning. Sample (20µl) was injected and peaks were recorded simultaneously at 280 and 320 nm for the benzoic acid and cinnamic acid derivatives, respectively.

2.7 Statistical analysis

All experiments were processed in triplication and the average values are reported as mean values with standard deviation. The differences of mean values amongst millet processing were determined using one-way analysis of variance (ANOVA) at $p \leq 0.05$ significance level.

Table1. Yield and phenolic indexes of raw and processed millets

Samples	Yield	Total phenolic content (TPC)	Tannin content
Raw seed	4.12±0.21^{a}	63.17±0.32^{c}	18.41±1.13^{c}
Soaked	2.8±0.45^{c}	44.33±0.00^{e}	10.82±1.24^{d}
Steamed	4.01±0.71^{a}	57.59±0.79^{d}	14.82±0.68^{cd}
Dried	3.01±082^{b}	52.26±1.06^{de}	15.60±0.98^{cd}
Millet tea	3.28±0.65^{ab}	134.48±0.77^{a}	53.32±2.24^{a}

Results are mean of three determinations ± SD. Values with the same letters (a, b, c, d, e, within columns) are not significantly different at p < 0.05., The yield of methanol extracts expressed as g/100 g. TPC was expressed as mg of Tannic acid equivalents/100 g.

Table 2. Phenolic acid identified in raw and processed broomcorn millets samples

No	Phenolic acid	Concentration (µg/g)				
		Raw seed	Soaked	Steamed	Dried	Millet tea
1	*p*-hydroxybenzoic acid	nd	nd	nd	nd	nd
2	Vanillic acid	0.814	1.361	1.608	1.878	0.459
3	o-Cumaric acid	15.347	2.870	18.398	11.837	13.134
4	Syringic acid	nd	4.831	10.673	nd	65.483
5	Ferulic acid	nd	458.136	212.756	437.782	nd
6	3-hydroxybenzoic acid	1.657	1.028	2.496	1.498	0.166
7	Caffeic acid	nd	nd	Nd	nd	nd
8	Sinapic acid	12.724	6.330	9.521	5.269	0.863
9	*p*-Cumaric acid	0.250	0.260	1.456	1.095	11.532
10	Protocatechic cid	0.552	0.164	0.981	1.000	0.683

nd= no detection

3. RESULTS

The present work was aimed at assessing the phenolic contents and antioxidant properties of subsequent hydrothermal of millet grain processing. Phenolic extract of various processed broomcorn millet tea samples was analyzed for total phenol, tannins, antioxidant activity and phenolic profiles.

3.1. Total polyphenol and tannin contents

Total polyphenol and tannin contents of raw and processed broomcorn millets are presented in Table 1. Raw and broomcorn millet tea highest total polyphenol content (TPC) (63.17±0.32 and 134.48±0.77mgTAE /100g) respectively. And followed by Steamed (57.59±0.79 mg TAE/100g), Dried (52.26±1.06 mg TAE/100g), but total poly phenol was found to decrease significant variation ($p \leq 0.05$) in Soaked (44.33±0.001 mg TAE /100g), but highest TPC and tannin content was exhibited in millet tea. Thus, significant differences of TPC and tannin contents various processed of broomcorn millets observed in this study could be release of bound phenolic which compensated the losses experienced during thermal treatment. However, both soaked and streamed processing treatments resulted in significant.

3.2. HPLC profile of broomcorn millet polyphenols

The phenolic acid content of raw and processed millets on HPLC (Figure not shown) is presented in Table 2. The result showed that the content and type of phenolic acid varied dependent on the processing method of broomcorn millet. And revealed that 10 compounds were identified as proto catechic acid, *p*-hydroxybezoic acid, caffeic acid, syringic acid, *p*-coumaric acid, ferulic acid, sinapic acid, o-cumaric acid, 3-hydroxybezoic acid and vanillic acid. Amongst the phenolic acids, ferulic acids were the predominant phenolic acids detected in soaked, dried and steamed millet processing was highest (458.138 µg/g, 437.782 µg/g and 212.756 µg/g) respectively, and followed by syringic acid (65.483 µg/g) and *o*-curaric acid (15.347 µg/g) in millet tea and raw seed millets. Significant change were observed in the phenolic profiles of processed broomcorn millet samples. In comparison to the raw caused significant increase in ferulic, syrigic acids, and o-coumaric acid, but caused significant decrease in *p*-hydroxybenzoic, caffeic and *p*-coumaric acid contents in all the processed millets.

3.3.1. DPPH radical scavenging activity

The DPPH radical scavenging activity method had good repeatability and has been widely used to determine radical scavenging or anti-oxidation activity of purified phenolic compounds as well as natural plant extracts. The results were expressed in percentage of inhibition of DPPH. Table 3 shows the free radical scavenging ability of Raw and pro- cessing treatment of broomcorn millet samples. The sample of phenolic extracts of broomcorn millet (mg/ml) was found that all the extracts exhibited concentration depen- dent on radical scavenging and all the samples extract possessed potent and distinct DPPH radical scavenging activities with each variation in the mg/ml values between the processed samples. Among the samples, millet tea exhibited strong inhibition of DPPH (80.81%), followed by raw (40.80%) and dried (35.53%) respectively. The radical scavenging activity of millet tea was significantly ($p \leq 0.05$) higher than soaked and steamed process treatment. But in both soaked and steamed treatment results were found not significant inhibition of DPPH radical scavenging activity.

3.3.2. Reducing power

The reducing power of raw and processed millet is shown in Table 3. It is observed that the results followed a similar trend to the DPPH free radical scavenging activity. The millet tea extract showed 70.19% increase in the absorbance spectra as compared to the raw sample. And steamed, dried and soaked millet extracts exhibited an increase in the absorbance value by 7.89%, 10.26% and 30%, respectively, when compared to raw millet extract was exhibited a higher reducing power indicating greater antioxidant property, which is desirable for use as a base material in health food formulations.

3.3.3. Hydroxyl radical scavenging activity

Hydroxyl radical by phenolic extract of samples may be attributed to their phenolic, which can donate electrons to OH thus neutralizing it to water. All the extract were capable of scavenging hydroxyl in a concen- tration dependent manner (Table 3). The phenolic extract of the broomcorn millet tea sample at 6mg/ml concentration showed the strongest effect by scavenging (80%) followed by raw millet (70%) of hydroxyl. On other soaked, steamed and dried samples also highest of hydroxyl by 63.44%, 60.65% and 68.14% respectively. Similar to the DPPH radical scavenging activity, broom corn millet tea was had the highest levels of TPC and tannin content exhibited high OH radical scavenging activity than their corresponding raw, soaked, steamed and dried processed treatment millets. However, both soaked and steamed treatments resulted in lower OH radical scavenging activity in all the five processed millet treatments. These results suggest that soaked and steamed of millet grains invariably affect the antiradical activity owing to the compositional changes occurring in mechanical and hydrothermal processes involved.

3.3.4. Metal chelating property

The chelating effect of samples phenolic extracts on ferrous ions. Ferrozine can make complexes with ferrous ions that produce red color. In the presence of other chelating agents, the complex formation is interrupted; as a result, the redness of the complex decreases. Thus, the chelating effect of the coexisting chelator can be determined by measuring the rate of color reduction (Senevirathene et al., 2006). In this assay, phenolic extract of millets interfered with the formation of the ferrozine-$FeCl_2$ complex was exhibited that the chelating effects increase with increased concentration of phenolic extract of each samples in the table 3. The broomcorn millet tea treatment showed highest metal chelating activity than other millet processed treatments with 65.48% at 6mg/ml of concentration, and followed by streamed, dried and soaked (64.35%, 62.112% and 61.37%). However, raw and soaked treatments resulted in the reduction of metal-chelating activity compared to millet tea treatment. From this data, it is suggested that the metal chelating activity of phenolic extract of millet processed treatment is depending on the thermal processing.

Table 3. Antioxidant properties of raw and processed millets

Samples	DPPH (%)	Metal chelating (%)	Hydroxyl (%)	Reducing power (700nm)
Raw seed	40.80±2.52^{b}	55.62±0.00^{b}	71.21±0.54^{b}	0.35±0.00^{c}
Soaked	24.66±2.83^{d}	61.37±0.72^{ab}	63.44±1.22^{c}	0.50±0.04^{b}
Steamed	25.35±1.48^{d}	64.35±0.08^{a}	60.65±0.27^{c}	0.38±0.02^{c}
Dried	32.53±3.01^{c}	62.12±0.26^{ab}	68.14±1.09^{b}	0.39±0.02^{c}
Millet tea	80.81±1.66^{a}	65.48±1.74^{a}	80.33±0.41^{a}	1.18±0.05^{a}

Results are mean of three determinations ± SD. Values with the same letters (a, b, c, d, e, within columns) are not significantly different at p < 0.05.

4. DISCUSSION

These results are in agreement with other studies reported in the literature where in Bryngelsson et al (2002) showed that various hydrothermal processes such as steaming and autoclaving of oats were effective in increasing the assay able phenolic contents, particularly ferulic and *p*-coumaric acids which could be released from their bound forms. According to Zielinski et al. (2006) extrusion of buckwheat seeds increased the phenolic acids content primarily due to the increased release of phenolic from their matrix.

However, Bryngelsson et al. (2002) also demonstrated that drum drying of oats decreased the phenolic compounds such as those of ferulic acid, *p*-coumaric acid and vanillin, possibly due to their oxidation under the processing conditions employed. In addition, both soaked and streamed processing treatments resulted in significant reduction of tannin content, similar decreases in the proanthocyanidin content of pinto and black beans after steam treatment was reported by Xu and Chang (2009). On another hand, the levels of these phenolic acids observed in the present study were not higher than the reported values for foxtail and proso millets (Chandrasekara & Shahidi, 2011). The differences could be attributed to the differences of extraction methods. Never- theless, these results are in agreement with the data compiled by Shahidi and Naczk (1995), wherein, it was found that most of the cereals and cereal products are rich in hydroxyl cinnamic acids such as ferulic and *p*-coumaric acids.

5. CONCLUSIONS

The results of this study indicated that raw and processed treatment of millets significantly affected the total phenolic, individual phenolic acid, antioxidant activity and α-glucosidase inhibitory properties of millets. Thermal processing affected not only the content of phenolic compounds in millets but also affected their beneficial biological effects. Evaluation of the effects of different processing treatments on the phenolic profiles, determination of their contents. Antioxidant activities and inhibitory properties against enzymes associated with thermal has contributed to the understanding of these under-utilized cereals and proper processing methods to enrich their biological activity. These results have provided useful information for effective utilization of millets as functional food ingredients for promoting health.

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