



Does antioxidant potential of traditional rice varieties vary with processing?

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ABSTRACT

Antioxidants protect cells and tissues from free radical damage and therefore, are important in the prevention and management of a variety of chronic diseases. Bran of pigmented rice are potent sources of naturally occurring antioxidants. Rice being the staple diet of Sri Lankans and traditional rice gaining more attention at present, investigating the effect of processing and cooking on total phenol content and antioxidant potentials of selected traditional rice varieties were the aims of this study. Differently processed (raw undermilled, raw polished [4%] and parboiled undermilled) six rice varieties, namely, Godaheeni, Batapola el, Dik wee, Dahanala, Unakola samba and, Hangimuththan were used in the study. The antioxidant properties of rice flour extracted with phosphate buffer solution (PBS) were determined by 2,2'-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) radical scavenging activity, 1,1-diphenyl-2-picrylhydrazine (DPPH) radical scavenging activity and, ferric reducing antioxidant power (FRAP) assays. Moreover, the total polyphenolic content (TPC) of differently processed rice was analysed. Mean TPC of both uncooked and cooked, raw polished rice was the least (4.9-6.1 mg GAE/g) followed by parboiled (4.9-6.1 mg GAE/g). The highest TPC was in raw (5.3-6.7 mg GAE/g) rice. Mean ABTS activity of raw polished rice (0.8-1.9 mg TE/g) was the least followed by parboiled (1.2- 2.3 mg TE/g) and raw rice (1.3-2.1 mg TE/g). Mean DPPH scavenging and FRAP activities followed the same pattern with raw rice having the highest (4.5-6.2 mg AE/100g; 4.6-14.4 mg AE/100g) followed by parboiled (4.4-5.1 mg AE/100g); 5.0-15.2 mg AE/100g) and the least in raw polished (4.0-4.6 mg AE/100g; 5.1-18.5 mg AE/100g) respectively. Phenolic compounds and antioxidant potential increased in the order of raw polished, parboiled, and raw rice flour in both cooked and uncooked rice. Rice grains with red coloured bran produced higher antioxidant activity compared to varieties with white bran. However, cooking reduced the antioxidant potentials in all differently processed varieties.

KEYWORDS: *Total phenol contents, Antioxidant capacities, Traditional rice, Parboiling, Milling, Polishing*

1 INTRODUCTION

Rice the staple food of Sri Lankans, plays a major role in the nutritional status of the whole population (Rambukwella & Priyankara 2016). With increasing awareness, people are more concerned about nutritional quality and health benefits of foods. Therefore, traditional rice has considerable demand in local as well as in the global market (Rebeira et al. 2014) since past decade. However, consumption of these traditional rice in raw under-milled form is popular among Sri Lankans. Past studies have proven that parboiled rice is nutritionally more beneficial and has been recommended for diabetes (Hettiarachchi et al. 2014; Nisanka & Ekanayake 2016; Pathiraje et al. 2011). A meta-analysis on whole and refined grain intake *reported* a 32% risk reduction in type 2 diabetes with high whole-grain intake including under-milled rice (3 servings daily), while refined white rice was associated with an increased risk of diabetes (Aune et al. 2013).

Antioxidants protect cells and tissues from free radical damage and therefore, are important in the prevention and management of chronic diseases (Rahman et al. 2012) such as diabetes, cardiovascular diseases etc. Free radicals formed inside living cells are neutralized through various pathways and the radical concentration is maintained below harmful levels. However, when the production of free radicals exceeds its neutralization process, it leads to oxidative stress (Birben et al. 2012). Oxidative stress causes damage to cellular macromolecules leading to a variety of chronic diseases (Krishnaiah, Sarbatly & Nithyanandam

2011). Research findings have shown that naturally occurring antioxidants in plant foods are safe, cheap and, better alternatives to many synthetic antioxidants (Pandey & Rizvi 2009). Bran of pigmented rice are potent sources of naturally occurring antioxidants (Laokuldilok et al. 2011; Muntana & Prasong 2010; Zhang et al. 2010). In addition, as the portion of staple rice consumed is relatively large, the contribution to cellular antioxidant capacity would be high by such varieties. Furthermore, phenolic compounds are known to have an effect on starch functional properties of rice flour (Zhu et al. 2008) which is an important ingredient in many of traditional foods prepared in Asia (Gunaratne et al. 2011). However, limited studies have been conducted on antioxidant properties of Sri Lankan traditional rice and the effects of processing such as polishing and parboiling on antioxidant properties have not been reported yet. Therefore, we determined the total phenol contents and antioxidant potentials of differently processed (milled only, milled and polished, parboiled) and cooked traditional rice varieties *Godaheenati*, *Batapola el*, *Dik wee*, *Dahanala*, *Unakola samba* and *Hangimuththan*.

2 MATERIALS AND METHODS

Traditional rice *Godaheenati*, *Batapola el*, *Dik wee*, *Dahanala*, *Unakola samba* and *Hangimuththan* varieties harvested during *Yala* season (2017), were collected from an authentic rice supplier (Mr. Gurusinghe, “Paramparika Goviurumayan Rekime *Wyaparaya*”, No 273 B, Circular Rd, Homagama). Paddy samples were collected into polythene bags, sealed,

labelled and transported on the same day to the laboratory and stored under temperature-controlled conditions until processed.

2.1 Processing of paddy samples

Raw paddy was dehulled (Satake THU 35B) and a portion was polished (4% polishing level) (Satake TM 05). Another portion was parboiled by immersing paddy in boiling water and heating until the paddy grains split open and sun dried. Parboiled paddy was dehulled without polishing.

2.2 Preparation of uncooked rice flour

Rice samples were washed and oven dried (Memmert, Germany) at 40°C for 5-6 hours and milled using the analytical mill (IKA ® A11 basic, New Zealand) and sieved (100 mesh sieve). The flour obtained from each rice sample was stored (-20 °C) in tightly closed containers. Stored uncooked flour was subjected to the below mentioned analyses.

2.3 Preparation of cooked rice flour

Rice samples were washed and cooked for 30 to 60 minutes with known amount of water as required for each rice variety. The cooked rice samples were oven dried at 55 °C for 3-4 days. Dried samples were milled using the analytical mill and sieved (100 mesh sieve). The flour obtained from each rice sample was stored (-20 °C) in tightly closed containers. Stored rice flour was also subjected to the following analyses.

2.4 Sample extract preparation for antioxidant assays

Rice flour (2.50g) was extracted with phosphate buffer solution (PBS) (pH=7.0, 30 mL) using the magnetic stirrer (Remi Equipments, India) for 30 minutes. The extract was filtered (Whatman No.1) and freshly prepared filtrate was used in antioxidant assays.

2.5 Total phenol contents

Total phenol content (TPC) of differently processed rice varieties was determined by using Folin-ciocalteu method (Singleton et al. 1999). Sample extracts and standard Gallic acid (Sigma-Aldrich, Germany) solutions were reacted with Folin-ciocalteu reagent. Results were expressed as percentage of Gallic acid equivalents (GAE) per gram weight of rice sample.

2.6 2,2'-Azinobis-3-ethylbenzothiazoline-6-sulphonic acid (ABTS.⁺) decolorization assay

The antioxidant activity of differently processed rice varieties was measured using the radical cation (ABTS.⁺ (Sigma-Aldrich, Canada)) decolorization assay (Keesey 1987). Total antioxidant activity was quantified against Trolox (Sigma-Aldrich, Germany) standard calibration curve. Results were expressed as percentage of Trolox equivalents (TEAC) per gram weight of rice sample.

2.7 1,1- Diphenyl-2-picrylhydrazyl (DPPH) colorimetric assay

The antioxidant activity of differently processed rice varieties was measured by DPPH (Sigma-Aldrich, Germany) colorimetric assay (Blois 1958). Results were expressed as percentage of ascorbic

acid equivalents (AE) per gram weight of rice sample.

2.8 Ferric reducing antioxidant power (FRAP) assay

The antioxidant activity of differently processed rice varieties was measured by FRAP assay according to the method described by Benzie & Szeto (1999). Total antioxidant activity was quantified against Gallic acid (Sigma-Aldrich, Germany) standard calibration curve. Results were expressed as percentage of Gallic acid equivalents (GAE) per gram weight of rice sample.

2.9 Statistical analysis

Data were presented as mean \pm SD. Data were analysed by SPSS 25.0 statistical software (IBM SPSS statistics). Descriptive statistics and ANOVA Tukey's posthoc test at 95% confidence interval was used to find the significances.

3 RESULTS AND DISCUSSION

Total phenol contents (TPC) of differently processed uncooked and cooked rice are stated in Table 1. The highest TPC was in raw rice (uncooked 5.8- 6.7 mg GAE/g and cooked 5.3- 6.2 mg GAE/g). The least TPC was found in raw polished rice varieties (uncooked - 5.1- 6.1 mg GAE/g and cooked - 4.9- 5 mg GAE/g) followed by parboiled rice (uncooked 5.2- 6.1 mg GAE/g and cooked 4.9- 6.0 mg GAE/g). Cooking has reduced the TPC content significantly ($P \leq 0.05$) of differently processed rice except for parboiled *Batapola el*. Raw polished varieties had significantly lower ($P \leq 0.05$) TPC content compared to raw varieties and non-

significantly ($P \geq 0.05$) lower TPC compared parboiled varieties. Raw white rice varieties, *Unakola samba* and *Hangimuththan* had significantly ($P \leq 0.05$) low TPC compared to raw red varieties. Same observation ($P \leq 0.05$) was made with uncooked parboiled white and red varieties.

Among the parboiled rice varieties, *Batapola el* and *Dahanala* had significantly ($P \leq 0.05$) higher TPC whereas among raw polished varieties *Dahanala* had significantly high ($P \leq 0.05$) TPC. When considering the effect of processing, the TPC contents of uncooked raw polished and parboiled rice varieties have reduced by 7-21% and 8-17% compared to uncooked raw varieties respectively.

A similar pattern to the present study was observed where uncooked polished rice had significantly low TPC content (25-64 mg GEA/100g) compared to parboiled rice (35- 635 mg GEA/100g) and raw rice (65- 944 mg GEA/100g) (Walter et al. 2013). However, the bran of uncooked traditional rice contained higher TPC (12-30 mg GAE/g) compared to improved varieties (0.2-18 mg GAE/g) (Abeysekera et al. 2017; Abeysekera & Premakumara 2017). The distribution of polyphenols in differently processed rice grains varied in the range 62- 97% in the pericarp of the rice grain (Walter et al. 2013). According to Zhou et al. (2004) and Hu et al. (2017), the rice bran accounted for 70 to 90% of the phenolic acids and anthocyanins. Therefore, polishing, which removes the external layers of the grain, significantly reduces the concentration of TPC which could be the reason for lower TPC in raw polished rice of the present study. The

reduction in the concentration of polyphenols in the parboiled rice is related to the loss of phenolics in the water during parboiling, thermal decomposition or interactions with other components of the grains (Walter et al. 2013). The effect of parboiling temperature on polyphenols should be considered as parboiling is a thermal process.

In the present study, in addition to processing, cooking which had not been studied for Sri Lankan traditional rice demonstrated reductions in TPC content of differently processed rice significantly except for parboiled *Batapola el*. When the effect of cooking of differently processed rice is considered, the scavenging activity of cooked raw polished and parboiled reduced by 4-20% and 0-20% respectively compared to raw cooked varieties. Thus, cooking has reduced the scavenging activity of all differently processed (raw, raw polished and parboiled) rice by 6-15%, 4-14% and 2-14% when compared to uncooked raw, raw polished and parboiled rice respectively. Several studies have demonstrated that phenolic compounds from different foods undergo decomposition under high temperatures, and this effect depends on the temperature, time of processing, type of compounds in the sample and other conditions (Larrauri et al. 1997; Piga et al. 2003). This decomposition results in reduction of the polyphenol concentration, as observed in the present study for cooked rice. The

effect of cooking on reduction of TPC content was also reported by Pérez-Jiménez & Saura-Calixto (2005).

Abeysekera & Premakumara (2017) revealed that mean TPC of brans of red rice were 10-fold higher than the bran of white rice. Colouration of rice is derived from accumulation of anthocyanins (Furukawa et al. 2007). Thus, it is proven by the present study data that not only rice bran but when rice is cooked, the white rice have lower TPC contents compared to red varieties.

Raw uncooked and cooked and parboiled uncooked *Unakola samba* and *Hangimuththan* had significantly lower TPC contents compared to other red varieties.

Mean ABTS scavenging activity of raw polished rice was the least followed by parboiled and raw rice in both cooked and uncooked rice as with TPC content (Table 2) where raw polished varieties had significantly lower scavenging activity compared to raw varieties and parboiled varieties ($P \geq 0.05$). However, cooking has reduced the scavenging activity significantly ($P \leq 0.05$) in raw *Batapola el*, *Dahanala*, *Unakola samba* and *Hangimuththan* and raw polished *Batapola el* and *Dik wee*. Specifically, in all parboiled varieties, no significant difference in scavenging activity was observed due to cooking.

Table 01: Total phenol content of differently processed rice flour on dry weight basis

| Variety | TPC / (mg GAE/g) | | | | | |
|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| | Raw | | Raw polished | | Parboiled | |
| | Uncooked | Cooked | Uncooked | Cooked | Uncooked | Cooked |
| <i>Godaheenati</i> | 6.7±0.0 ^a | 5.7±0.1 ^P | 5.7±0.0 ^b | 4.9±0.0 ^q | 5.8±0.1 ^b | 5.4±0.1 ^r |
| <i>Batapola el</i> | 6.6±0.1 ^a | 6.0±0.1 ^P | 5.2±0.0 ^b | 5.0±0.1 ^q | 6.1±0.0 ^c | 6.0±0.0 ^r |
| <i>Dik wee</i> | 6.6±0.1 ^a | 6.2±0.1 ^P | 5.7±0.0 ^b | 4.9±0.1 ^q | 5.5±0.0 ^b | 4.9±0.1 ^q |
| <i>Dahanala</i> | 6.6±0.0 ^a | 6.2±0.1 ^P | 6.1±0.1 ^b | 5.8±0.1 ^q | 6.1±0.0 ^b | 5.8±0.1 ^q |
| <i>Unakola samba</i> | 5.8±0.0 ^a | 5.3±0.1 ^P | 5.4±0.1 ^b | 5.1±0.1 ^q | 5.3±0.0 ^b | 5.1±0.0 ^q |
| <i>Hangimuththan</i> | 5.9±0.1 ^a | 5.5±0.1 ^P | 5.1±0.0 ^b | 5.0±0.0 ^q | 5.2±0.0 ^b | 5.0±0.1 ^q |

n=5; Values are represented in dry weight as mean±SD; in mg gallic acid equivalent per gram of rice flour; SD: Standard Deviation; a, b and c superscripts along a row indicate significances among differently processed uncooked varieties and p, q and r indicate significances among differently processed cooked varieties at 95% confidence interval

Furthermore, raw and parboiled *Unakola samba* and *Hangimuththan* which are white in colour showed significantly low ($P \leq 0.05$) scavenging activity compared to

other red varieties. Similarly, cooked raw polished white varieties had significantly lower ($P \leq 0.05$) scavenging activity compared to other red varieties.

Table 02: ABTS scavenging activity of differently processed rice flour in dry weight

| Variety | ABTS scavenging activity/ (mg TE/ g) | | | | | |
|----------------------|--------------------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| | Raw | | Raw polished | | Parboiled | |
| | Uncooked | Cooked | Uncooked | Cooked | Uncooked | Cooked |
| <i>Godaheenati</i> | 2.3±0.1 ^a | 2.1±0.1 ^P | 1.9±0.1 ^b | 1.7±0.1 ^q | 2.1±0.1 ^a | 2.0±0.1 ^P |
| <i>Batapola el</i> | 2.3±0.0 ^a | 2.0±0.1 ^P | 1.6±0.0 ^b | 1.5±0.0 ^q | 2.1±0.0 ^a | 2.0±0.1 ^P |
| <i>Dik wee</i> | 2.2±0.0 ^a | 2.1±0.0 ^P | 1.2±0.1 ^b | 1.0±0.0 ^q | 2.0±0.1 ^a | 1.8±0.1 ^r |
| <i>Dahanala</i> | 2.3±0.1 ^a | 2.0±0.1 ^P | 1.6±0.1 ^b | 1.4±0.1 ^q | 2.0±0.1 ^a | 1.9±0.0 ^P |
| <i>Unakola samba</i> | 1.7±0.1 ^a | 1.2±0.1 ^P | 1.0±0.1 ^b | 0.8±0.1 ^q | 1.5±0.0 ^a | 1.3±0.1 ^P |
| <i>Hangimuththan</i> | 1.9±0.1 ^a | 1.7±0.0 ^P | 1.0±0.1 ^b | 0.9±0.0 ^q | 1.6±0.1 ^c | 1.5±0.1 ^P |

n=5; Values are represented in dry weight as mean±SD in mg Trolox equivalent per gram of rice flour; SD: Standard Deviation; a, b and c superscripts along a row indicate significances among differently processed uncooked varieties and p, q and r indicate significances among differently processed cooked varieties at 95% confidence interval

Thus, polishing and parboiling have contributed to reduce the scavenging activity of uncooked raw rice by 17- 47% and 9-16% respectively. The loss of scavenging of raw rice due to polishing was much higher than that of parboiling. Germinated and parboiled red rice varieties have shown scavenging activity in a range of 25- 75 µM TE/100g where parboiled rice had lower scavenging activity (Hu et al. 2017). Rice bran had higher activity (8.7- 14.2 mmol/TE 100g

bran) as rice bran contains more phenolic compounds (Abeysekera et al. 2017). When compared to raw varieties, the scavenging activity of cooked raw polished and parboiled had decreased by 19-52% and 0-14% respectively. A higher reduction was observed in raw polished rice. Cooking has reduced the scavenging activity of raw, raw polished and parboiled by 4- 29%, 6- 20% and 5- 13% when compared to uncooked rice of raw, raw polished and parboiled respectively.

Table 03: DPPH scavenging activity of differently processed rice flour on dry weight basis

| Variety | DPPH/ (mg AE/100g) | | | | | |
|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| | Raw | | Raw polished | | Parboiled | |
| | Uncooked | Cooked | Uncooked | Cooked | Uncooked | Cooked |
| <i>Godaheenati</i> | 6.2±0.0 ^a | 6.0±0.1 ^p | 4.6±0.0 ^b | 4.4±0.0 ^q | 5.0±0.1 ^c | 4.9±0.0 ^r |
| <i>Batapola el</i> | 5.5±0.1 ^a | 5.0±0.1 ^p | 4.6±0.1 ^b | 4.5±0.0 ^q | 5.0±0.1 ^c | 4.8±0.1 ^p |
| <i>Dik wee</i> | 5.6±0.1 ^a | 5.5±0.1 ^p | 4.6±0.1 ^b | 4.5±0.1 ^q | 5.1±0.1 ^c | 5.0±0.1 ^r |
| <i>Dahanala</i> | 5.4±0.1 ^a | 5.2±0.0 ^p | 4.6±0.1 ^b | 4.4±0.0 ^q | 5.1±0.1 ^a | 5.0±0.0 ^r |
| <i>Unakola samba</i> | 4.9±0.1 ^a | 5.0±0.1 ^p | 4.2±0.0 ^b | 4.0±0.0 ^q | 4.7±0.0 ^a | 4.5±0.1 ^r |
| <i>Hangimuththan</i> | 4.7±0.1 ^a | 4.5±0.1 ^p | 4.3±0.1 ^b | 4.1±0.0 ^q | 4.5±0.2 ^a | 4.4±0.1 ^p |

n=5; Values are represented in dry weight as mean±SD in mg ascorbic acid equivalent per 100 gram of rice flour; SD: Standard Deviation; a, b and c superscripts along a row indicate significances among differently processed uncooked varieties and p, q and r indicate significances among differently processed cooked varieties at 95% confidence interval

As for ABTS, the mean DPPH scavenging activity of raw rice was the highest (4.7- 6.2 mg AE/100g and 4.5- 6.0 mg AE/100g)

followed by parboiled rice (4.5- 5.1 mg AE/100g and 4.4- 5.0 mg AE/100g) and least ($P \leq 0.05$) raw polished rice (4.2- 4.6

and 4.0- 4.5 mg AE/100g (Table 3) in uncooked and cooked rice respectively. However, cooking has reduced the scavenging activity significantly ($P \leq 0.05$) in majority of raw and raw polished varieties and in parboiled *Unakola samba*. Furthermore, except for cooked raw *Unakola samba*, all other differently processed *Unakola samba* and *Hangimuththan* which are white in colour showed significantly low ($P \leq 0.05$) scavenging activity compared to other red varieties. Among raw, significantly higher ($P \leq 0.05$) DPPH activity was present in *Godaheenati*. Polishing and parboiling of raw uncooked rice has reduced the scavenging activity of uncooked raw polished and parboiled by 9-26% and 4-19% respectively with a higher decline in polished rice. The mean DPPH scavenging activity of bran of traditional rice varieties was found to be higher (5- 68 % inhibition at 25 μ g/mL) compared to improved varieties (4- 61 % inhibition at 25 μ g/mL (Abeysekera & Premakumara 2017). Rice varieties having different pericarp colours have shown scavenging activity in a wide range as light brown (4.7), red (37- 69) and black (60) mmol TE/g grain (Walter et al. 2013).

Similar to TPC and ABTS scavenging activity, the DPPH scavenging activity of cooked raw polished and parboiled had reduced by 9-26% and 4-18% respectively compared to raw varieties. Further, cooking has reduced the scavenging activity of raw, raw polished and parboiled by 2-9%, 4-11% and 2-4% respectively with a higher decline in raw polished.

The raw polished rice varieties had shown the least FRAP scavenging activity

followed by parboiled and with highest activity in raw rice (Table 4). Except for cooked and uncooked *Unakola samba* and cooked *Hangimuththan*, both uncooked and cooked raw polished varieties had significantly lower ($P \leq 0.05$) scavenging activity compared to raw and parboiled varieties. Similar to other assays, cooking has reduced the scavenging activity in all the rice varieties where raw polished *Godaheenati*, *Batapola el* and *Unakola samba* showed significantly ($P \leq 0.05$) reduced values. Variety *Dahanala* irrespective of processing or cooking had significantly high FRAP activity. Among raw significantly higher ($P \leq 0.05$) FRAP activities were present in *Batapola el* and *Dahanala*. Among raw polished rice, both uncooked and cooked *Dahanala* and uncooked *Godaheenati* had significantly higher ($P \leq 0.05$) activity. Similarly, both uncooked and cooked parboiled *Dahanala* had significantly higher ($P \leq 0.05$) FRAP activities. When considering the differently processed, *Unakola samba* and *Hangimuththan* (white) showed significantly low ($P \leq 0.05$) scavenging activity in both uncooked and cooked forms compared to red varieties. The FRAP activity of differently processed cooked or uncooked *Unakola samba* varieties was not significantly different.

The scavenging activity of uncooked raw polished and parboiled had reduced by 2-26% and 1- 14% respectively compared to raw varieties. When comparing the effect of cooking on differently processed rice against raw rice, polished (10-55%) and parboiled rice (2-30%) had reduced scavenging activity. Cooking has reduced the scavenging activity of raw, raw polished and parboiled by 3-26%, 3- 28%

and 3-23% respectively when compared to uncooked raw, raw polished and parboiled rice. Traditional rice varieties, *Suduheenati*, *Masuran*, *Godaheenati* and *Dikwee* showed the scavenging activity in

the range of 8-11 mmol FeSO₄/ 100g bran (Abeysekera & Premakumara 2017).

Table 04: FRAP scavenging activity of differently processed rice flour in dry weight

| Variety | FRAP/ (mg AE/100g) | | | | | |
|----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | Raw | | Raw polished | | Parboiled | |
| | Uncooked | Cooked | Uncooked | Cooked | Uncooked | Cooked |
| <i>Godaheenati</i> | 15.6±1.1 ^a | 14.0±1.1 ^p | 12.6±0.8 ^b | 10.5±0.5 ^q | 13.2±0.5 ^b | 12.0±1.0 ^p |
| <i>Batapola el</i> | 18.5±1.1 ^a | 16.2±1.0 ^p | 10.0±0.6 ^b | 7.2±0.5 ^q | 11.6±0.6 ^c | 11.2±0.4 ^r |
| <i>Dik wee</i> | 13.7±0.7 ^a | 12.7±0.5 ^p | 10.3±1.0 ^b | 9.0±1.0 ^q | 10.8±0.4 ^b | 9.8±0.6 ^q |
| <i>Dahanala</i> | 18.5±1.2 ^a | 18.0±1.0 ^p | 14.4±1.2 ^b | 14.0±0.3 ^q | 15.2±1.0 ^b | 14.5±0.5 ^q |
| <i>Unakola samba</i> | 9.3±1.2 ^a | 7.2±1.0 ^p | 7.8±0.7 ^a | 6.1±0.6 ^p | 6.7±0.5 ^a | 5.1±0.8 ^p |
| <i>Hangimuththan</i> | 6.9±1.3 ^a | 5.1±1.2 ^p | 5.1±0.6 ^b | 4.6±0.5 ^p | 5.9±0.4 ^b | 5.0±0.4 ^p |

n=5; Values are represented in dry weight as mean±SD in mg ascorbic acid equivalent per 100 gram of rice flour; SD: Standard Deviation; a, b and c superscripts along a row indicate significances among differently processed uncooked varieties and p, q and r indicate significances among differently processed cooked varieties at 95% confidence interval

Antioxidant activities of differently processed rice flour varied in the order of raw > parboiled > raw polished. Cooking reduced the scavenging activities (ABTS, DPPH and FRAP) of all differently processed rice varieties. However, the reduction in scavenging activities of parboiled rice following cooking was lesser compared to raw and raw polished varieties as those grains had already been through a hydrothermal process (parboiling) before cooking with the loss of part of the phenolic compounds (Walter et al. 2013). Rice cooking directly affects the scavenging activity due to thermal

decomposition and interaction with other compounds such as proteins (Walter et al.2013). During cooking, damage occurs to the structure of starch granules and it undergoes gelatinization process. Somaratne et al. (2017) showed that antioxidant activity of cooked rice was reduced by about 55%. Moreover, the protein content of raw rice is higher in fresh weight compared to parboiled rice. The antioxidant properties of some proteins and peptides (Esfandi et al. 2019) contribute to the higher scavenging activity shown by raw rice compared to parboiled rice.

Least scavenging activity (ABTS, DPPH and FRAP) was shown by raw polished varieties. Raw rice contains increased amount of phenolic compounds in the bran layer compared to the polished rice similar to previous studies of Shobana et al. (2011) and Siriamornpun et al. (2008). Thus the low scavenging ability of polished rice could be due to the removal of bran layer during polishing which is rich in phenolic and antioxidant compounds (Walter et al. 2013).

In the present study two white varieties showed lesser scavenging activity (ABTS, DPPH and FRAP) compared to red varieties. Several phenolic compounds have already been identified in rice. In rice grains with light brown pericarp, the colour present mainly phenolic acids, especially ferulic and p-coumaric acids (Tian, Nakamura & Kayahara, 2004; Zhou et al. 2004), whereas in grains with red and black pericarp, the colour prevail due to compounds with higher molecular weight, mainly the anthocyanins.

4 CONCLUSIONS

Phenolic compounds and antioxidant potential increased in the order of raw polished, parboiled and raw rice flour. Rice grains with red coloured bran produced higher antioxidant activity compared to varieties with white bran. Cooking reduced the antioxidant potentials in all differently processed varieties where TPC, ABTS, DPPH and FRAP scavenging activities decreased by 2-15%, 4-29%, 2-11% and 3-28% respectively. It is concluded that irrespective of variety, raw undermilled, uncooked rice flour exhibit greater antioxidant properties compared to

parboiled and raw polished rice flour. Among cooked rice, raw unpolished rice has the highest antioxidant potential.

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