BIODIVERSITAS
Volume 24, Number 3, March 2023
Pages: 1878-1885

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d240364

Yield quality of *Setaria italica* accessions originated from Numfor Island, Papua, Indonesia

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Manuscript received: 21 October 2022. Revision accepted: 29 March 2023.

Abstract. *Karamang S, Ariffin, Widaryanto E, Aini N. 2023. Yield quality of* Setaria italica *accessions originated from Numfor Island, Papua, Indonesia. Biodiversitas 24: 1878-1885.* Pokem (*Setaria italica* L. Beauv) is among the various germplasms of food plant diversity in Papua, especially in Numfor Island along with its traditional cultivation. Huge attention is needed in sustaining plant development due to its high nutritional value. Therefore, the study aims to (i) search for *S. italica* accessions with the highest yields and nutrient content in ex-situ cultivation, and (ii) *S. italica* gain accessions from the island of Numfor which contains phytochemical and antioxidant activity compounds. This study was carried out at the Experimental Garden of the Faculty of Agriculture, the University of Papua in Amban Manokwari. The plant materials used were 15 accessions of *S. italica* grains derived from existing cultivated locations of Numfor Island, Papua. The experiment was carried out using Randomized Block Design (RBD) with 4 replications. Yield component characters, nutritional content, total flavonoid and phenolic content, as well as antioxidant activity were observed. The results revealed that accession Sub Manggunsi 3 (SM3) had the highest grain yield. Based on nutrient contents, the highest recorded by Namber 2 (NM 2) accession for carbohydrate content, followed by Sub Manggunsi 2/SM2 (raw fiber), Kansai 3/KN3 and Sub Manggunsi 3/SM3 (protein content), Sub Manggunsi 1/SM1 (water content), Kameri 3/KM3 and Rimba Raya2/RR2 (fat content), Namber 3/NM3 (ash content); while Kameri 1 (KM1) accession, Rimba Raya 2 (RR2) and Kansai 1 (KM3) accession performed high content of total flavonoid, total phenol and antioxidant activity.

Keywords: Accession, nutritional content, phytochemicals compounds, *Setaria italica* grains, yield quality

INTRODUCTION

Pokem or foxtail millet (*Setaria italica* L. Beauv) is a cereal plant potentially developed in Indonesia and Papua in particular because of its widely growing adaptation. The grains can be processed into consumable millet cakes, wine, and seasonings that are served in ritual feasts and special occasions such as harvest festivals and weddings (Kuo et al. 2018; Regina et al. 2016). The grains are also processed into *S. italica* flour to be traded outside the region. Other advantages of the plant are (1) they can grow on marginal land and dry climates, (2) short lifespan (80-90 days), (3) high crop production, (4) easy to cultivate, (5) has a variety of uses, both as raw material for food and animal feed, (6) containing sufficient carbohydrates and protein (Sher 2021).

In tropical climates, *S. italica* can grow fast with fairly high efficiency of water use and the ability to produce in marginal soil. Furthermore, it can be used as a second plant in plant rotation activities. Due to its fast growth rate, the plant can grow to vary from lowland up to an altitude of 2000 m above sea level with less rainfall (Saxena et al. 2018; Ramlah et al. 2020). Purnomo et al. (2014) stated that the *S. italica* planted ex-situ with a spacing of jajar legowo 1:2 gave the highest yield of 1.53 tons ha^{-1} at a dose of chicken manure 23.4 tons ha^{-1}. This indicated that the *S. italica*'s yields can be increased when it was cultivated properly, starting from land preparation, and planting to harvesting.

Food crops, especially *Setaria italica* grains, contain many phytochemical compounds such as polyphenols and flavonoids by antioxidant activity (Suma and Urooj 2012; Liang and Liang 2019). The phytochemical compounds such as alkaloids, phenolics, reducing sugars, and flavonoids were only found in methanol and water extracts, while tannins and terpenoids were discovered in all solvent extracts of whole flour and bran from *Setaria italica* L. Beauv. This shows that *Setaria italica* contains phytochemical compounds that are important for health.

Considering that *S. italica* development is essential because the plant has high nutritional value, especially protein and minerals (Moharil et al. 2019). *S. italica* contains nutrients such as carbohydrates, protein, fat, crude fiber, and minerals Ca, and Fe (Tirajoh 2012). It also contains antioxidants protecting the body from free radicals and maintaining immunity from diseases. Another important phytochemical used to ward off free radicals is antioxidants, one of which is β-carotene. The content of β-carotene contained in *S. italica* is 54.1 ppb or 5.41 ug/100 g (Tirajoh et al. 2014). *S. italica* Jingu 41 from China contains lutein and zeaxanthin (Shen et al. 2015). These 2 compounds are the most abundant carotenoid components in cereal crops in addition to β-carotene and cryptoxanthin (Martinez et al. 2022).

Currently, *S. italica* plants in Numfor are still cultivated traditionally by relying on their local wisdom and are used as alternative food crops as well as traditional plants. The use is primarily based on information that people of Numfor Island cultivating these *S. italica* plants, the number of *S. italica* plants is decreasing. Based on its advantages and adaptability, *S. italica* is a prospective grain plant developed in Papua Island, although the yield is still low in Numfor Island and its benefit has not been used optimally. Therefore, this study aims to (i) find *S. italica* accessions with the highest yields and nutrient content in ex-situ cultivation, and (ii) *S. italica* gain accessions from the island of Numfor which contains phytochemical and antioxidant activity compounds.

MATERIALS AND METHODS

Plant materials

The plant materials used were 15 accessions of *S. italica* grains taken from villages Numfor Island, Papua. These include the villages of Kameri, Kansai, Namber, Rimba Raya, and Sub Manggunsi. The accessions consist of 1). Kameri 1/KM1 (black), 2). Kameri 2/KM2 (red), 3). Kameri 3/KM3 (yellow), 4). Kansai 1/KN1 (black), 5). Kansai 2/KN2 (red), 6). Kansai 3/KN3 (yellow); 7). Namber 1/NM1 (black), 8). Namber 2/NM2 (red), 9). Namber 3/NM3 (yellow), 10). Rimba Raya 1/RR1 (black), 11). Rimba Raya 2/RR2 (red), 12). Rimba Raya 3/RR3 (yellow), 13). Sub Manggunsi 1/SM1 (black), 14). Sub Manggunsi 2/SM2 (red), 15). Sub Manggunsi 3/SM3 (yellow).

Field experiment

This study was conducted from August to December 2018 in the experimental field of the Faculty of Agriculture, The University of Papua, Amban, Manokwari, West Papua Indonesia. The origin habitat of *S. italica* cultivation in Numfor Island that makes it different from Manokwari as an ex-situ cultivated area is the soil type. Numfor Island is rock type-dominated soil at 0-15 cm soil depth compared to Manokwari with 0-30 cm. The 15 accessions of *S. italica* grains were sown in the field using a Randomized Block Design (RBD) with 4 replications. Each experimental unit was a 2 x 1 m plot, with plant spacing of 20 x 20 cm. Chicken manure was applied to each experimental unit as basic fertilizer at a dosage of 4 kg per plot (20 tons ha^{-1}).

Observation variable

The yield component data observed were the number of tillers (8 wap), panicle number, panicle weight, 1.000 grain weight, grain weight per clump, yield per plot, yield (grains weight), and dry weight of stover (dry weight other than grains, including leaves, stalks and roots). Nutrient contents included water content, ash content, fat content, protein content, carbohydrate content, and raw fiber. The phytochemicals content, such as alkaloids, steroids, triterpenoids, saponins, flavonoids, and tannins were qualitatively analyzed (Harborne 1987). The total phenolics and flavonoids content, as well as antioxidant activity, were also observed in this study. Data on the level of strength of antioxidant activity were obtained by the DPPH method and classified according to the IC_{50} value (inhibitory concentration) (Molyneux 2004).

Data analysis

The data were statistically analyzed using analysis of variance (ANOVA) and to determine the differences among the mean values of accessions, the Duncan Multiple Range Test (DMRT) at the 5% level was used. Correlation analysis of yield component characters was performed using Pearson correlation. Phytochemical data and antioxidant activity obtained were analyzed using tabulation by interpreting laboratory data in the form of tables and graphs.

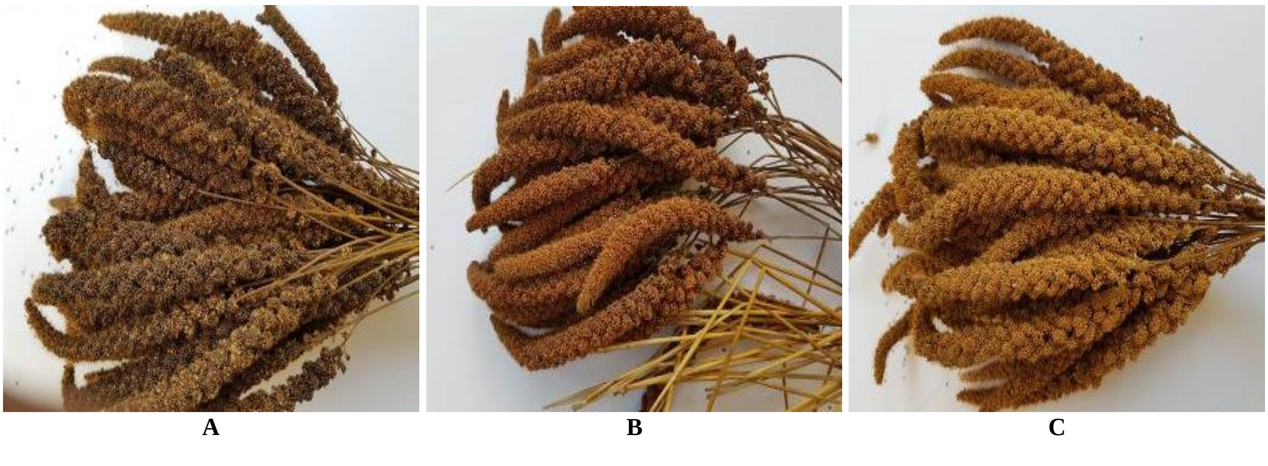


Figure 1. Variations on color differences of *Setaria italica* grains cultivated by local farmers in Numfor Island, Papua, Indonesia: A. black, B. Red, C. Yellow

RESULTS AND DISCUSSION

Yield components

Analysis of variance showed that the number of tillers and panicles per clump in various plant accessions were not significantly different (p>0.05), but significantly different in panicle weight per clump. The number of tillers per clump produced in this study ranged from 3.89 (NM2) - 5.08 (SM3), which is considerably lower compared to the previous studies. The number of basal tillers ranged from 3 to 6.2 was observed in fifty-one of India's elite foxtail millet accessions (Geethanjali and Jegadeeswaran 2016). Surprising results with very high tiller numbers ranging from 23.58 (without fertilization) to 24.03 (with 200 kg/ha SP-36 fertilizer) were produced in a study by Markoni et al. (2017). However, the number of tillers produced in this current study was higher compared to the study of Ridwan et al. (2018), using yellow and red seeds *S. italica* from Buru Island which yielded 2-3 tillers. The same results were also noticed in the foxtail millet accessions from Korea, producing only 1-2 tillers (Ghimire et al. 2019). These results indicate a high genetic variability of foxtail millet in the tiller number character, although it was not observed in the *S. italica* accessions used in this study since the number of tillers per clump in the 15 accessions from Numfor Island was not significantly different. Based on the variance analysis results, the largest panicle weight produced in SM3 accessions was significantly different from all accessions. The SM3 also had the highest number of tillers per clump and the number of panicles per clump. In addition, the accession having the lowest panicle weight (NM2) also showed the smallest number of panicles and the number of tillers per clump. Based on the correlation analysis results, the panicle weight has a very significant positive correlation with the number of tillers (0.910) and panicles per clump (0.926) (Table 2). Therefore, the greater number of tillers and panicles per clump, the greater the panicle weight per clump will be.

The panicle weights produced from *S. italica* in this study had a value between 15.81-19.43 g. This result was higher than that of *S. italica* grown with various nitrogen sources, which was 10.75-11.47 g (Juhaeti 2019) and also higher than the treatment of several shading intensities, namely 2.79-6.86 (Juhaeti et al. 2021). In this study, no anorganic fertilizer was applied; however *S. italica* still can grow well in the ex-situ cultivated area (Manokwari). The *S. italica* accession used in this study originated from Numfor Island, which is dominated by rock soil type having 0-15 cm soil depth compared to Manokwari with 0-30 cm. This showing that the adaptability of *S. italica* is quite extensive. *S. italica* is one of the cereal crops that can adapt well to nutrient-poor or land without fertilization (Wei et al. 2018; Diao et al. 2014).

The analysis of variance results on other yield components showed that the weight of 1,000 grains, grain weight per plot, yield, and dry weight of stover were not significantly different in all *S. italica* accessions (p> 0.05), but gave a significantly different response on grain weight per plot (Table 2). SM3 accession showed the best results in the weight of 1,000 grains, grains per clump and per plot, yield, as well as dry weight of stover parameters.

The lowest yield in grain weight per plot, yield, and dry weight were shown by NM2 accession. Meanwhile, the lowest yield in the weight of 1,000 grains was shown by SM2 accession and that of grain weight per clump was shown by RR2 (Table 1). The weight of 1,000 *S. italica* grains in this study was lower (0.99-1.18 g) compared to studies reported by Ghimire et al. (2019) with values between 1.44-2.91 g, by Randall et al. (2016) with values between 1.62-1.81, and Ning et al. (2015), who obtained 2.80-3.32 g. The difference was caused by variations in the genetic characteristics of each accession, which had shape, size, number, and endosperm content differences.

The 15 accessions from Numfor Island showed a significant difference in the weight of grains per clump. The grain weight was influenced by the weight of 1,000 grains and the density of grains in each panicle of *S. italica* accessions tested (Randall et al. 2016). Grain weight per plot was not significantly different in all accessions but had the best weight in SM3, which produced 404.79 g m^{-2}. This is higher than that of the Tenamude accession which produced 520.87 g in an area of 1 m x 5 m with a spacing of 75 cm x 20 cm (Suriani et al. (2021). The difference in *S. italica* productivity was influenced by variations in locations and genetic differences in each accession used.

According to Norman et al. (1995), the superior cultivar *S. italica* produced 3.1 tons ha^{-1} with 132 kg N fertilization, 28 kg P, 65 kg K, and 56 kg Ca ha^{-1} respectively. In this study, the highest yield of SM3 accession (2.023 tons ha^{-1}) was still lower than that of Norman et al. (1995) because the sole fertilizer used was organic fertilizer (chicken coop) at a dose of 20 tons ha^{-1}. Fertilization and environmental stress factors have been proven to cause a decrease in yield, which can be prevented by cultivating high-yielding *S. italica* (Mapikasari et al. 2017; Ning et al. 2015).

The yield of *S. italica* was also determined by the number of tillers, number of panicles and panicle weight which were indicated by a very significant positive correlation between the three variables and the yield of seed production from each accession (Table 2). The number of tillers had a significant positive correlation to the weight of 1000 seeds and a very significant positive correlation to the panicle weight per clump, seed weight per clump, seed weight per plot, stover dry weight, number of panicles per clump and production component. This designates that an increase in the number of tillers can lead to an increase in all production components (Herrera and Doust 2016). This statement was confirmed by Ravindranadh et al. (2019), that the highest number of tillers produced the highest yield.

Table 1. Yield component of *Setaria italica* accessions from Numfor Island, Papua, Indonesia

Accessions	NTC	NPC	PWC (g)	W1000 (g)	WGC (g per clump)	WG (g m^{-2})	Yi (kg ha^{-1})	DW (g m^{-2})
KM1	4.65	4.58	18.59 ab	1.16	17.68 ab	390.16	1950.81	140.00
KM2	4.34	4.33	16.75 efg	1.09	15.62 ef	365.54	1827.69	130.50
KM3	4.68	4.48	17.67 cd	1.13	16.66 cd	385.64	1928.20	137.38
KN1	4.50	4.40	17.05 de	1.11	16.15 cde	377.53	1887.63	136.63
KN2	4.48	4.38	18.05 bc	1.09	16.92 bc	387.37	1936.85	137.50
KN3	4.16	4.10	16.34 efg	1.18	15.26 ef	356.20	1781.02	124.63
NM1	4.16	4.03	15.91 fg	1.15	14.79 f	347.76	1738.81	117.50
NM2	3.89	3.78	15.81 g	1.03	14.89 f	347.69	1738.45	119.75
NM3	4.27	4.20	16.45 efg	1.09	15.32 ef	360.58	1802.87	129.63
RR1	4.31	4.28	16.79 ef	1.11	15.69 def	366.07	1830.37	132.63
RR2	4.35	4.25	16.36 efg	1.09	15.24 ef	356.79	1783.99	128.38
RR3	4.56	4.35	16.54 efg	1.09	15.35 ef	360.83	1804.16	131.75
SM1	4.83	4.68	18.65 ab	1.25	17.71 ab	391.71	1958.55	142.13
SM2	4.16	4.08	16.25 efg	0.99	15.17 ef	354.27	1771.35	124.38
SM3	5.08	4.93	19.43 a	1.18	18.26 a	404.79	2023.93	151.00
CV	10.68	12.48	3.35	14.17	4.02	13.19	13.19	15.91

Note: The numbers followed by different letters in the same parameter showed significant differences in the 0.05 DMRT test; NTC: Number of tillers per clump (8 wap); NPC: Number of Panicles per clump (12 wap); PWC: Panicle weight per clump (12 wap); W1000: Weight of 1000 Grains (12 wap); WGC: Weight of grains per clump (12 wap); WG: Weight of Grains (12 wap); Yi: Yield; DW: Dry weight (12 wap); wap: week after planting; KM1: Kameri 1, KM2: Kameri 2, KM3: Kameri 3, KN1: Kansai 1, KN2: Kansai 2, KN3: Kansai 3, NM1: Namber 1, NM2: Namber 2, NM3: Namber 3, RR1: Rimba Raya 1, RR2: Rimba Raya 2, RR3: Rimba Raya 3, SM1: Sub Manggunsi 1, SM2: Sub Manggunsi 2, SM3: Sub Manggunsi 3; CV: Coefficient of variance

Table 2. Pearson correlation of yield component characters of *Setaria italica* accessions from Numfor Island, Papua, Indonesia

Characters	NTC	NPC	PWC	W1000	WGC	WG	Yi	DW
NTC	1							
NPC	.985**	1						
PWC	.910**	.926**	1					
W1000	.616*	.629**	.617*	1				
WGC	.893**	.908**	.996**	.620*	1			
WG	.914**	.927**	.981**	.575*	.980**	1		
Yi	.914**	.927**	.981**	.575*	.980**	1.000**	1	
DW	.944**	.962**	.944**	.525*	.935**	.965**	.965**	1

Note: NTC: Number of tillers per clump; NPC: Number of Panicles per clump; PWC: Panicle weight per clump; W1000: Weight of 1000 Grains; WGC: Weight of grains per clump; WG: Weight of Grains; Yi: Yield; DW: Dry weight;** Correlation significant at the 0.01 level (2-tailed); * Correlation significant at the 0.05 level (2-tailed); Positive value (+): same direction; Negative value (-): opposite direction; *r:* 0.00-0.25 (no correlation/weak); 0.26-0.50 (moderate); 0.51-0.75 (strong); dan 0.76-1.00 (very strong)

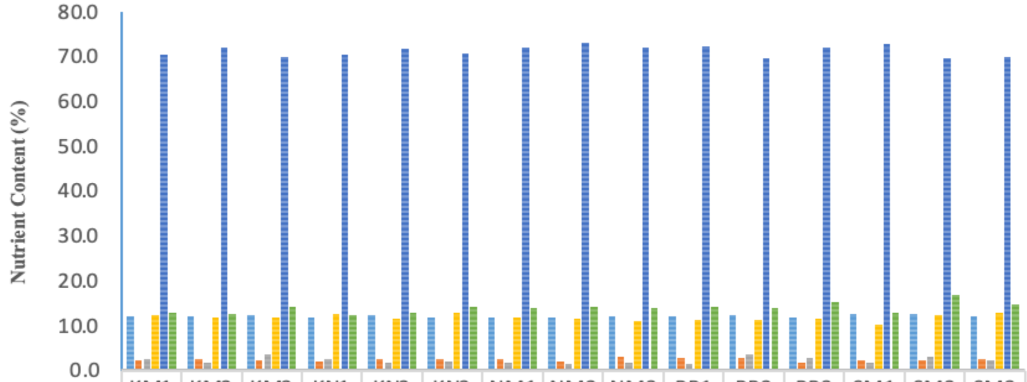
Nutrient contents

The nutritional content of the *S. italica* seeds tested in this study differed among each accession, in water content, ash content, fat content, protein content, carbohydrate content and crude fiber content (Figure 2). *S. italica* accessions that were cultivated in-situ (in Numfor Island) or ex-situ (in the current field experiment in Manokwari, West Papua Indonesia) also showed different nutrient content. Some *S. italica* accessions from Numfor Island that were cultivated ex-situ had the highest nutrient content, namely carbohydrates with values between 69.6%-73.1%. The results showed that the NM2 accession had the highest carbohydrate content of 73.1% and the SM2 had 69.6%. The carbohydrate content of *S. italica* in this study was lower compared to the studies of Tirajoh et al. (2012), Juhaeti et al. (2019), Kamatar et al. (2015) who reported that the carbohydrate contents of *S. italica* from Papua, Buru (Indonesia) and India were 83.99%, 84.2%, and 75.54%, respectively. Compared to other cereal crops, the carbohydrate content of *S. italica* in this study was not much different from white rice (75.63%), brown rice (67.97%), and job's tears rice (hanjeli) (76.88%) (Juhaeti et al. 2019). The differences are caused by variations in the place of growth and the climate of each of the *S. italica* planting sites.

The results showed that the nutritional content of *S. italica*, which has a higher nutritional value than rice is in the protein content of 10.3%-13.0%. Muthamilarasan et al. (2016) also reported that *S. italica* protein content is higher at 12.3% while rice is only 6.8%. In this study, the highest protein content was produced by KN3 and SM3 accessions at 13.0%, while the lowest protein content was produced by accessions of SM1 of 10.3%. The protein content of *S. italica* from Numfor Island was higher than some germplasms *S. italica* from India, which was 12.63% (Kamatar et al. 2015). Furthermore, another nutritional content higher than rice as a staple food is fat with a value of 1.5%-3.0%, while rice is 0.7 only. The *S. italica* plant from Numfor Island has the opportunity to continue to be developed as an energy-sourced plant for human needs and as an alternative food for the Papua and West Papua regions.

Phytochemical analysis

Phytochemical identification aims to determine the active compounds or secondary metabolites that are beneficial to health in *S. italica* seeds. The qualitative test analysis of the phytochemical compounds showed that *S. italica* from Numfor Island contains alkaloids, saponins, tannins, phenolics, flavonoids, triterpenoids, steroids, and glycosides (Table 3). There are also several similarities in the test results of phytochemical compounds in all accession grains of *S. italica* from Numfor Island. In all accessions that tested positive (+), there were alkaloids, saponins, phenolics, triterpenoids, and glycosides. There were no (-) tannin and steroid compounds in all of the accessions cultivated ex-situ within the experiment.



	KM1	KM2	KM3	KN1	KN2	KN3	NM1	NM2	NM3	RR1	RR2	RR3	SM1	SM2	SM3
Water Content	12.0	12.0	12.4	12.0	12.5	11.8	12.0	11.8	12.1	12.2	12.5	11.8	12.8	12.6	12.1
Ash Content	2.4	2.5	2.2	2.1	2.5	2.6	2.5	2.1	3.1	2.7	2.9	1.8	2.3	2.4	2.5
Fat Content	2.6	1.7	3.6	2.7	1.8	2.0	1.7	1.5	1.7	1.6	3.6	2.8	1.9	3.0	2.4
Protein Content	12.5	11.8	11.9	12.8	11.5	13.0	11.8	11.6	11.2	11.3	11.3	11.6	10.3	12.4	13.0
Carbohydrate Content	70.6	72.0	70.0	70.5	71.7	70.6	72.0	73.1	71.9	72.3	69.7	72.0	72.8	69.6	70.0
Raw Fiber	12.8	12.6	14.3	12.3	13.0	14.4	13.9	14.2	14.0	14.4	14.0	15.3	12.9	17.0	14.8

Accessions

Figure 2. Nutrient content of grains of various *Setaria italica* accessions after being cultivated ex-situ at the age of 12 wap. Note: The numbers followed by different letters in the same component showed significant differences in the 0.05 DMRT test; wap: week after planting; KM1: Kameri 1, KM2: Kameri 2, KM3: Kameri 3, KN1: Kansai 1, KN2: Kansai 2, KN3: Kansai 3, NM1: Namber 1, NM2: Namber 2, NM3: Namber 3, RR1: Rimba Raya 1, RR2: Rimba Raya 2, RR3: Rimba Raya 3, SM1: Sub Manggunsi 1, SM2: Sub Manggunsi 2, SM3: Sub Manggunsi 3

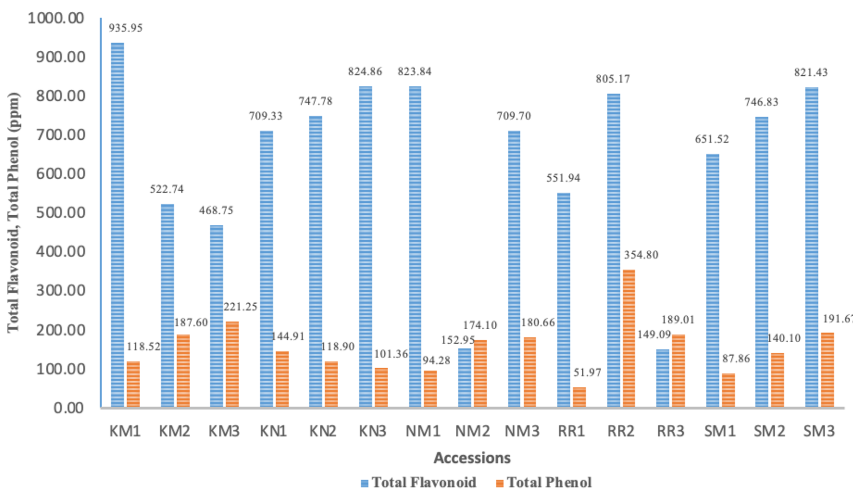


Figure 3. Total flavonoid content, total phenol of *Setaria italica* plant grains. Note: KM1: Kameri 1, KM2: Kameri 2, KM3: Kameri 3, KN1: Kansai 1, KN2: Kansai 2, KN3: Kansai 3, NM1: Namber 1, NM2: Namber 2, NM3: Namber 3, RR1: Rimba Raya1, RR2: Rimba Raya 2, RR3: Rimba Raya 3, SM1: Sub Manggunsi 1, SM2: Sub Manggunsi 2, SM3: Sub Manggunsi 3

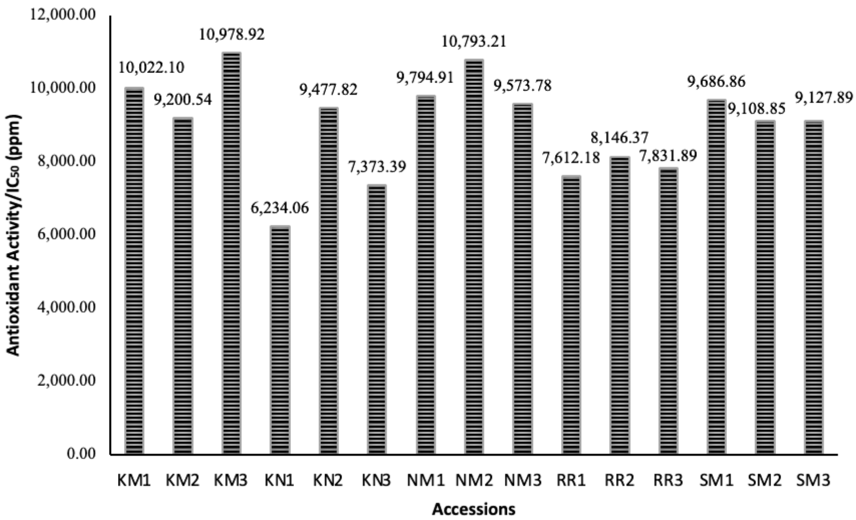


Figure 4. The antioxidant activity of *Setaria italica* plant grains. Note: KM1: Kameri 1, KM2: Kameri 2, KM3: Kameri 3, KN1: Kansai 1, KN2: Kansai 2, KN3: Kansai 3, NM1: Namber 1, NM2: Namber 2, NM3: Namber 3, RR1: Rimba Raya1, RR2: Rimba Raya 2, RR3: Rimba Raya 3, SM1: Sub Manggunsi 1, SM2: Sub Manggunsi 2, SM3: Sub Manggunsi 3

Table 3. The qualitative content of phytochemical *S. italica* plants in their natural habitat (Numfor Island) and ex-situ cultivated area

Origin	Qualitative content of phytochemical								
	Alk	**Sap**	**Tan**	**Fen**	**Flav**	**Tri**	**Ster**	**Glyc**	**Total**
Original habitat (Numfor Island, Papua)									
KM1	+	+	-	+	+	+	-	+	6+
KM2	+	+	-	+	+	-	+	+	6+
KM3	+	+	-	+	+	+	-	+	6+
KN1	+	+	-	+	+	+	-	+	6+
KN2	+	+	-	+	+	+	-	+	6+
KN3	+	+	+	+	+	+	+	+	8+
NM1	+	+	+	+	+	+	+	+	8+
NM2	+	+	+	+	+	+	+	+	8+
NM3	+	+	+	+	+	+	+	+	8+
RR1	+	+	+	+	+	+	-	+	7+
RR2	+	+	+	+	+	+	+	+	8+
RR3	+	+	+	+	+	+	+	+	8+
SM1	+	+	+	+	+	+	+	+	8+
SM2	+	+	+	+	+	+	+	+	8+
SM3	+	+	+	+	+	+	+	+	8+
Ex-situ cultivated (Manokwari, West Papua)									
KM1	+	+	-	+	+	+	-	+	6+
KM2	+	+	-	+	+	+	-	+	6+
KM3	+	+	-	+	+	+	-	+	6+
KN1	+	+	-	+	+	+	-	+	6+
KN2	+	+	-	+	+	+	-	+	6+
KN3	+	+	-	+	+	+	-	+	6+
NM1	+	+	-	+	+	+	-	+	6+
NM2	+	+	-	+	+	+	-	+	6+
NM3	+	+	-	+	+	+	-	+	6+
RR1	+	+	-	+	+	+	-	+	6+
RR2	+	+	-	+	+	+	-	+	6+
RR3	+	+	-	+	+	+	-	+	6+
SM1	+	+	-	+	+	+	-	+	6+
SM2	+	+	-	+	+	+	-	+	6+
SM3	+	+	-	+	+	+	-	+	6+

Note: Alk: alkaloids; Sap: saponins; Tan: tannins; Fen: phenolics; Flav: flavonoids; Tri: triterpenoids; Ster: steroids; Glyc: glycosides; +: positive/detected; -: not detected; KM1: Kameri 1, KM2: Kameri 2, KM3: Kameri 3, KN1: Kansai 1, KN2: Kansai 2, KN3: Kansai 3, NM1: Namber 1, NM2: Namber 2, NM3: Namber 3, RR1: Rimba Raya1, RR2: Rimba Raya 2, RR3: Rimba Raya 3, SM1: Sub Manggunsi 1, SM2: Sub Manggunsi 2, SM3: Sub Manggunsi 3

The *S. italica* accession grown in ex-situ experiment in Manokwari District revealed that tannins and steroids were not found in all accessions due to environmental changes. In their natural habitat at Numfor Island, *S. italica* plants were grown in soil dominated by rock with a depth of 0-15, whereas in Manokwari District they were planted in a soil solum depth of 0-30 without rocks. According to Ajithkumar and Ibadapbiangshylla (2017), changes in environmental conditions or environmental stress can cause a fluctuation in phytochemical compounds.

However, there are also unchanging ingredients, namely alkaloids, saponins, phenolics, flavonoids, and glycosides of *S. italica* accession grown in ex-situ. Overall, ex-situ cultivation reduces the qualitative phytochemical content. According to Sangma et al. (2019), the results of phytochemical screening showed that tannin and steroid compounds were not found in ungerminated *S. italica* grains. The difference in the results of the analysis of *S. italica* grains from the habitat of Numfor island and *S. italica* grains planted outside the island was caused by variations in environmental conditions.

Total flavonoid and phenolic content

Setaria italica, in its development as an alternative and functional food, requires to have one or more bioactive components for human health benefits (Hutabarat and Bowie 2022). Shahidi et al. (2015), Tungmunnithum et al. (2018), Mutha et al. (2021) reported that compounds such as phenolic acids and flavonoids are not only antioxidant compounds but are also safe to consume as dietary supplements.

Setaria italica grains vary and contain different total flavonoid content in each accession with values ranging from 51.97 ppm to 935.95 ppm (Figure 3). Similarly, the total phenol content in cultivated *S. italica* grains was 51.97 ppm-354.80 ppm. The highest total flavonoid and phenol contents were produced by KM1 accession of 935.95 ppm and RR2 accession of 354.80 ppm, respectively. Meanwhile, the lowest content of total flavonoid and phenol contents were produced by RR3 accession of 149.09 ppm and RR1 of 51.97 ppm, respectively. Tungmunnithum et al. (2018) stated that the content of phenolic or flavonoids as secondary metabolites scattered in plants is known to play a major role in antioxidant activity. The greater the content of phenol group compounds, the greater the antioxidant activity. These results are lower compared to the previous study reported that *S. italica* grains had a total flavonoid of 28,1 mg $g^{-1} \approx$ 28.100 ppm, and total phenol of 33.17 mg $g^{-1} \approx$ 33.170 ppm (Sharma et al. 2015). Ghimire et al. (2019) stated that since *S. italica* has a wide geographical range, affecting variations in nutritional value, biological activity, phytochemical composition, and agro-morphological properties. Millet or *S. italica* grains are a rich source of non-nutritive, especially the content of phenolic compounds. Phenolic compounds can act as antioxidants in the human body to protect against stress and inflammation caused by airborne particulate matter, in addition to a range of anti-inflammatory, anticancer, anti-aging, antibacterial, as well as treat allergy-related diseases (Rahman et al. 2022; Zhang and Liu 2015).

Antioxidant activity

Antioxidants play an important part as a protector from the effects of a free-radical compound, as excessive amounts of this compound will cause oxidative stress. DPPH analysis which was carried out to determine the antioxidant activity of each accession of cultivated *S. italica* grains showed different IC_{50} values between 6,234.06 ppm-10,978.92 ppm as presented in Figure 4. The IC_{50} value of *S. italica* grains according to Molyneux (2004) is classified as a very weak antioxidant as it has a value of > 200 ppm. This weak value of antioxidant activity in each accession of cultivated *S. italica* grains is due to the low content of total phenol in each grain. Similarly, Ghimire et al. (2019), Kumari et al. (2017), Zhang and Liu (2015) correlated variations in antioxidant activity with differences in the concentration of phenolic compounds where *S. italica* grain accessions with a low phenolic compound content had the least variation in antioxidants or weak antioxidant properties. When compared with other alternative staple foods, the antioxidant activity of the *S. italica* accessions from Numfor Island is still lower than that of corn and wheat, which have IC50 values of 10,270 ppm and 15,560 ppm, respectively (Forsido et al. 2013).

In conclusion, *S. italica* can be used as an alternative staple food since it contains nutrient content, a phytochemical and antioxidant activity which is good for health. In addition, *S. italica* contains higher protein content compared to rice. Among all of the 15 accessions from Numfor Island, the SM3 accession provided the highest grain yield, RR2 had the highest fat content and total phenol, the NM2 had the highest carbohydrate content, while KM1 and KN1 had the highest content of total flavonoids and the best antioxidant, respectively.

ACKNOWLEDGEMENTS

The authors are grateful to the Indonesia Endowment Fund for Education (LPDP) of the Ministry of Finance of the Republic of Indonesia for funding this study.

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