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Assessment of Proximate Chemical Composition of Cambodian Rice Varieties

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Abstract: *The present study aimed to assess the proximate chemical compositions of 16 rice varieties collected from Battambang, Takeo, and Prey Veng provinces in Cambodia. Proximate chemical compositions including moisture content, protein, total carbohydrates, fiber, ash, lipids, and amylose content were subjected to analysis. The results showed that all chemical compositions of the 16 rice varieties varied significantly (p <0.05). The carbohydrates and proteins were the main compositions in rice grain, ranging from 79 to 84% w/w, and 6 to 9% w/w, respectively. Moisture contents were reported from 6 to 12% w/w, while the fat contents were in the range of 0.1 to 0.5% w/w. For the minor composition, fiber and ash contents varied from 0.2 to 5% w/w, and 0.2 to 0.6 % w/w, respectively. The amylose content in the samples varied from 22 to 39%. Among the 16 collected rice varieties, the cultivated variety. 'Srov Atung' showed the lowest value of moisture content (6.7%) but it contained the highest value of carbohydrates (84.1%) and fat content (0.5%). The cv. 'Krohorm Tgon' showed the highest value of protein (8.05%) while the cv. 'Phka Romdoul Takeo' had the highest content of crude fiber (3.58%). The highest energy content (374.50 ± 2.03 Kcal/100g) was found in cv. 'Srov Atung', whereas, cv. 'Neang Minh' contained the least amount of energy (350.22 ± 3.85 Kcal/100g). In addition, cv. 'Srov Vear' contained the highest percentage of amylose (39.15%) and the lowest value was found in cv. 'IR66' (22.14%). Overall, the current study revealed the variation of chemical composition of rice grain from one variety to variety. The findings of this study could be used as database of local rice varieties and help the food processors to select suitable rice varieties for food product development, particularly for rice-based products.*

Keywords: Cambodian rice; chemical composition; amylose content.

1. INTRODUCTION

Rice (*Oryza* L.), a member of the grass family called Poaceae, comprises more than 20 species with AA genome clade of wild species–[1]. *Oryza sativa* spp., the most dominant cultivated rice in the world, is divided into two main sub-species, *indica*, and *japonica*. Sub-species *indica* is the most common sup-species cultivated in South and Southeast Asia, as well as in most regions of the People's Republic of China, while the *japonica* cultivar is generally planted in the temperate region including the lower Yangtze Valley of China, Taiwan, Korea, Japan, some part of Australia, some part of America, Europe, and Egypt [2]. Rice plant or *Oryza sativa* spp. is one of the most important cereal crops in human nutrition and nearly 760 million tons of rice paddy were produced in more than 100 nations, particularly, China (approximately 210 million tons) and India (about 175 million tons) accounting for more than half of the world rice production, followed by eight of the top 10 rice-producing countries in 2020 including Indonesia, Bangladesh, Vietnam, Thailand, Myanmar, Philippines, Pakistan, and Cambodia [3,4]. In 2020, more than 10 million tons of rice paddy were produced over around 3 million hectares in Cambodia, and the rice production was increased to approximately 12 million tons in 2021 [5-6] Additionally, rice has been widely used as a raw material by Cambodians for producing many kinds of Khmer traditional food and drink such as noodles, wine, snack, and dessert [7].

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Rice is commonly consumed as a whole grain after milling and cooking almost exclusively by humans, supplying 20% of daily calories for the world population and at least 65% for most Cambodian energy intake [8]. Chemical compositions of rice grain including carbohydrates, proteins, moisture, crude fat, crude fiber, and ash are considered to be the major components. There were approximately 85%, 8%, and 10% of carbohydrate, protein, and moisture content, correspondingly, while, amylose content of non-waxy rice ranged around 12 to 29% and only 1 to 2% of crude fat, crude fiber, and ash contained in milled rice [9,10]. Moreover, the evaluation of rice quality has been prioritized since it was reported that various physicochemical characteristics could determine consumers' preferences, cooking behavior as well as cooked rice texture [11]. The appropriate information on the rice quality is necessarily important for farmers, millers, as well as health-conscious consumers with respect to various applications of rice. More importantly, even rice was widely used to make many traditional foods by local people, but there was very limited information about the chemical composition of different rice Cambodian varieties in Cambodia. Therefore, the current study aimed to analyze the proximate chemical compositions of local rice varieties collected from provinces in the country.

2. METHODOLOGY

2.1 Sample collection and preparation

Battambang, Takeo and Prey Veng provinces represent the highest domestic rice production in the country based on an annual cultivation report of the Ministry of Agriculture, Forestry and Fisheries in 2020 [5].

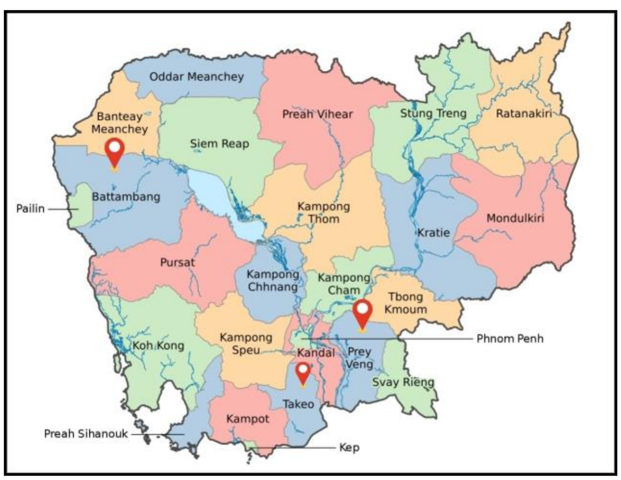

Fig.1. Map of sampling locations

Therefore, 16 milled rice samples of different varieties (listed in Table 1) were collected in the early of the year (in 2022) after harvesting season. The rice samples were packed in zip-lock bags and transported to the laboratory. The milled rice samples were then ground to obtain rice flour and stored in plastic contained at a room temperature (around 25 °C) prior to further analysis of chemical compositions.

Table 1. List of rice samples and its origin

Sample origin	Rice sample
Battambang	Phka Mlis (ផ្កាម្លិះ), Neang Khon (នាងខុន), Neang Minh (នាងមិញ), Phka Rumduol Battambang (ផ្ការំដួលបាត់ដំបង), Phka Khnhei (ផ្កាខ្ញី), Bonla Pdao (បន្លាផ្តៅ), Srov Vear (ស្រូវវារ),
Takeo	Krohorm Tgon (ក្រហមធ្ងន់), OM (អូអឹម), Phka Romdoul Takeo (ផ្ការំដួលតាកែវ), Krohorm Chin (ក្រហមចិន), Srov Sor (ស្រូវស)
Prey Veng	IR66 (អ៊ីអ៊ែរ៦៦), Srov Atung (ស្រូវអាទុង), Nam Bung (ណាំបួង), and Krosaing Teap (ក្រសាំងទៀប)

2.2. Chemicals and reagents

Chemicals used in the analysis including 37% of hydrochloric acid (Merck, Germany), sodium hydroxide (Merck, Germany), 99% of n-hexane (Scharlau, Spain), phosphate buffer (Sigma-Aldrich, Germany), protease enzyme (Sigma-Aldrich, Germany), amyloglucosidase (Sigma-Aldrich, Germany), α-amylase (Sigma-Aldrich, Germany), 100% of acetic acid (Merck, Germany), 99.7% of ethanol (Labscan, Thailand), iodine (Merck, Germany), and 98% purity of potato amylose (Merck, USA) were analytical grade.

2.3. Determination of moisture content

The moisture content in each collected sample was determined by drying around 2 g of sample in a hot air oven (Memmert, Germany) at 105℃ for 3 hours as described in AOAC Official Method 925.10 (AOAC, 2012).

$$\%M = [(m_1 - m_2) / m] \times 100 \qquad \text{(Eq. 1)}$$

where:

%M = percentage of moisture content (%w/w)
m = weight of wet sample (g)
m_1 = weight of sample and aluminum before drying (g)
m_2 = weight of sample and aluminum after drying (g)

2.4. Ash content analysis

The ash content in each rice flour sample was determined by putting 2 g of sample in a muffle furnace (Nabertherm, Germany) at a temperature 550℃ for 3 hours as described in AOAC Official Method 923.03 (AOAC, 2012).

$$\% \text{ Ash} = [(m_2 - m_1) / m] \times 100 \quad \text{(Eq. 2)}$$

where:
%Ash = percentage of ash content (%w/w)
m = weight of sample (g)
m_1 = weight of empty crucible (g)
m_2 = weight of sample and crucible after ashing (g)

2.5. Determination of protein content

The nitrogen content in rice flour samples was analyzed by following Kjeldahl method as described in AOAC Official Method 960.52 [12]. Shortly, 1g of sample, 3.6 g of potassium sulphate, 0.2 g of copper sulphate and 2.7 mL of sulphuric acid were weighed and transferred into a 250 ml Kjeldahl flask for digestion. After cooling down, some amount of distilled water, saturated boric acid, and 40 % sodium hydroxide solution were added into the flask for distillation. Finally, 20 mL of sample was pumped for titrating with 0.02 M of HCl until the pink color appeared. The percentage of total nitrogen was calculated using Eq. 3 and the percentage of protein was calculated by multiplying with a conversion factor (Eq. 4).

$$N = [(V_s - V_b) \times M_{acid} \times F \times 14 \times 100] / m \quad \text{(Eq. 3)}$$

$$\%P = \%N \times 6.25 \quad \text{(Eq. 4)}$$

where:
N = percentage of nitrogen (%w/w)
V_s = volume of HCl required to titrate sample (ml)
V_b = volume of HCl required to titrate blank (ml)
M_{acid} = molarity of HCl (0.02M)
m = weight of sample (mg)
F = correction factor of HCl
%P = percentage of protein content (%w/w)

2.6. Determination of fat content

The fat content was determined by following AOAC method with slight modification [12]. Briefly, 5 grams of sample and empty extraction beaker were weighed and fitted with Soxhlet apparatus (Velp Scientifica, Italy) using n-Hexane as a solvent. It was then run for around 2 hours and the beaker was dried at 105℃ until obtaining constant weight approximately 2 hours. Finally, the beaker containing extracted fat was weighed and calculated by using Eq. 5.

$$\%\text{Fat} = [(m_2 - m_1) / m] \times 100 \quad \text{(Eq. 5)}$$

where:
%Fat = percentage by wet weight of fat content (%w/w)
m = weight of sample (g)
m_1 = weight of empty beaker (g)
m_2 = weight of extracted oil and beaker (g)

2.7. Determination of fiber content

The fiber content was determined by following AOAC Official Method 985.29 with slight modification. Briefly, 1 g of sample was accurately weighed into a beaker with addition of 50 ml phosphate buffer to adjust pH to 6.0 ± 0.1. The beaker was then added with 50 µL of the heat-stable α-amylase solution, and incubated at around 100℃ for 15 minutes. Next, 10 ml of NaOH (0.275N) and 100 µL of protease enzyme were poured into the beaker with agitation in an incubator at 60℃ for 30 minutes. Afterward, it was cooled, and added 10 ml of HCl (0.325N), 200 µL of amyloglucosidase, and 280 ml of ethanol (95%) to form precipitate which were filtered and washed with ethanol (95%) and acetone. The precipitate was finally transferred to a weighed crucible, dried in 105℃ hot-air oven and re-weighed.

$$\%\text{Fiber} = [(m_3 - m_2 - m_1) / m] \times 100 \quad \text{(Eq. 6)}$$

where:
%Fiber = percentage by weight of fiber content (%w/w)
m = weight of flour sample (g)
m_1 = weight of ash residue (g)
m_2 = weight of protein residue (g)
m_3 = weight of sample residue (g)

2.8. Determination of carbohydrate content

The determination of the percentage of carbohydrate in the rice sample was reported by Devi et al. [9] . This method involved adding the total values (%) of crude protein, lipid, crude fiber, moisture and ash constituents of the sample and subtracting it from 100% as shown in an equation below.

Thus, %Carbohydrate = 100 – (%moisture + %fiber + %protein + %fat + %ash) (Eq. 7)

2.9. Determination of energy content

The energy content is an important value in foods, which was calculated by following Eq.3.8 (Verma and Srivastav, 2017).

$$\text{Energy (Kcal/100g)} = (\%P \times 4) + (\%\text{Fat} \times 9) + (\%\text{CHO} \times 4) \quad \text{(Eq. 8)}$$

Where:
%CHO = percentage by of total carbohydrate (%wb)
%Fat = percentage by of fat (%wb)
%P = percentage of by of protein (%wb)

2.10. Determination of amylose content

Amylose content of rice samples were determined based on iodine-binding procedure as reported by Abeysundara et al. [13] with slight modification. Briefly, 100 mg of sample was weighed and 9 ml of NaOH (1N) and 1 ml of ethanol (95%) were added in a 100 ml volumetric flask. The mixture was then heated on a boiling water for 15 minutes to gelatinize the starch. Then, the gelatinized starch was cooled and made up to 100 ml with distilled water. A volume of 5 ml of the solution was poured into another 100 ml volumetric flask. Afterward, 1 ml of 1N acetic acid and 2 ml of 0.2% iodine solution were added into the flask and made up to 100 ml with distilled water and the solution was kept in a dark place for 20 minutes and measured in Cary 60 UV-Visible spectrophotometer (Agilent, USA) at 620 nm. The amylose contents in samples were determined by referring to the standard curve as shown in Fig.1.

Standard curve was prepared using pure potato amylose. Initially, 40 mg of potato amylose was accurately weighed in a 100 ml volumetric flask. Then, 9 ml of NaOH (1N) and 1 ml of ethanol (95%) were added in the volumetric flask and the mixed solution was boiled on a boiling water for 15 minutes. The solution was cooled and made up to 100 ml with distilled water. After being diluted, 1 ml, 2 ml, 3 ml, 4 ml, and 5 ml of the solution were poured into 5 different volumetric flasks with the addition 0.2 ml, 0.4 ml, 0.6 ml, 0.8 ml, and 1 ml of acetic acid (1N) respectively. Afterward, 2 ml of iodine solution (0.2%) was added to the 5 flasks, topped up to 100ml with distilled water and kept in a dark box for 20 minutes, then, the absorbances of all standard solutions were measured at the wavelength 620 nm using Cary 60 UV-Visible spectrophotometer (Agilent, USA).

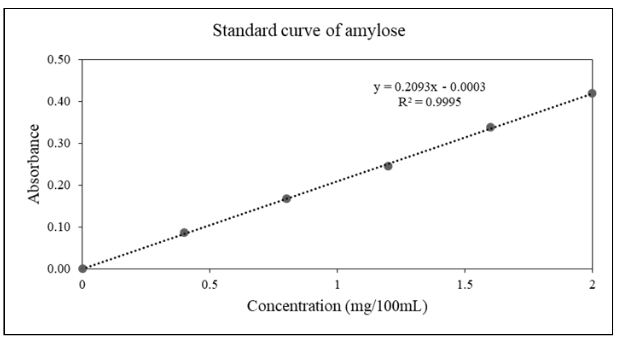

Fig.2. Standard curve of amylose

2.11. Data analysis

Analysis of all samples were performed in triplicates. The data obtained were expressed as mean ± standard deviation and subjected to analysis of variance (ANOVA) using statistical software (SPSS version 26.0). The significant differences were determined at $p < 0.05$.

3. RESULTS AND DISCUSSION

The proximate chemical compositions of different rice varieties are summarized in Table 1. The contents of moisture, protein, fat, fiber, ash, carbohydrates, energy, and amylose were found significantly different ($p<0.05$) among the 16 rice varieties.

3.1. Moisture and ash contents

Moisture content is an important parameter in determining the stability of rice during storage. It ranged from 6% to 12% in this study with the highest percentage of moisture (12.42%) was reported in cv. '*Neang Minh*', followed by *Phka Khnhei* (12.14%), *Phka Mlis* (12.14%), *Bonla Pdao* (12.01%), *Phka Romdoul* Battambang (11.93%), *Neang Khon* (11.70%), while cv. '*Srov Atung*' showed the lowest value of moisture content (6.74%). The results of this study showed a high variation of moisture content between varieties of rice. However, these variations were similar to the study by Devi et al. (2015) who reported the ranging value of moisture in rice varied from 7 to 11%, illustrating that cv. '*Srov Atung*' may have a longer shelf-life among rice varieties in the present study because of its lower moisture content. It was reported that the differences of moisture content among rice cultivars may be dependent on climatic conditions during planting as well as genetic makeup (Devi et al., 2015). Furthermore, the water content is also affected by drying condition including drying temperature and time since removal of the excess moisture could be quickly and safely as the temperature is increased [2].

Ash, one of the minor composition, is a crucial parameter in assessing quantities of minerals in rice. Based on Table 1, the ash content ranged from 0.2% in cv. '*Krohorm Chin*' to 0.60% in cv.'*Srov Atung*' followed by 0.48% in cv. '*Phka Khnhei*', 0.45% in cv. '*Krohorm Tgon'* and '*OM*', 0.42% and 0.40% in cv. '*Srov Sor*' and cv. '*Phka Romdoul* Takeo', respectively The results in this study are in accordance with the results of ash content in different Indian rice varieties (0.1 to 1.2%) (Devi et al., 2015). Furthermore, significant variations of ash content were found in Pakistani rice cultivars with different polishing levels (0.54 to 1.42%) and different rice varieties in Ghana (0.86 to 2.48%) indicating that differences in genetic structure as well as milling fractions were significant factors affecting total minerals of rice [14,15].

3.2. Protein and fat contents

Protein is a second major component influencing the eating and nutritional quality of rice. It is very beneficial for the human body as these levels of protein in rice contain essential amino acids which could repair cells and tissue in the body [15]. According to Table 1, the protein contents in 16 rice varieties were found significantly different which varied between 6 to 8% with an overall mean value and standard deviation of 7.08 ± 0.11. cv. Among these cultivars, cv. '*Bonla Pdao*' contained the lowest level of protein (6.05 ± 0.03), while the highest protein content of 8.05 ± 0.03 was found in cv. '*Krohorm Tgon*' followed by the second highest of 7.77 ± 0.13 was observed in cv. '*Krosaing Teap*'. These findings are in agreement with the previous research of rice in India which reported the range of protein between 5.3 to 10.8% (Devi et al., 2015). It is also similar to the protein of rice cultivated in Ghana which was ranged from 6% to around 8% (Mbatchou & Dawda, 2013). In addition, Muttagi & Ravindra (2020) also reported a wide range of protein content varying from 4 to 15%, illustrating that the levels of protein in rice could be due to some environmental conditions or technical issues including location, fertilization, crop season, drying temperature, drying time, and storage methods.

Rice lipid, a good source of essential fatty acids particularly linoleic acid, plays a vital role in determining rice quality. In this study, the highest percentage of fat (0.52%) was found in cv. '*Srov Atung*' followed by '*Krosaing Teap*' (shown in Table 1), while the lowest fat content (0.13%) was observed in cv. '*Srov Vear*'. Overall, the amount of fat in this finding was low compared to Mexican rice cultivars that varied from 0.47 to 1.22%. These variations could be caused by varietal differences and growing conditions [11]. Additionally, Devi et al. [9] illustrated that degree of milling could also affect the lipid content due to the removal of the bran layer of rice grain which contains a high amount of fat. According to earlier researches of Verma & Srivastav [16], high-fat rice tended to be better taste compared to low-fat rice. In this regards, it could indicate that cv. '*Srov Atung*' was tastier compared to the other cultivars in our study. However, yellowness and redness of this cultivar could also be higher than its lightness which may cause a negative impact on white rice noodle [17].

3.3. Fiber and carbohydrate contents

Fiber is a necessary nutrient among minor components which may help consumers in reducing risk of chronic diseases. In this study, a wide range of crude fiber content was obtained around 0.2 to 5.0%. The uppermost level was recorded in cv. '*Phka Romdoul* Takeo' (5.0%), followed by '*Srov Sor*' (3.58%), while the least amount of fiber was found in cv. '*Phka Mlis*' (0.24%). The ranging value of fiber in the present research was considerably higher than the fiber content in Indian rice cultivars (0.1% to 3.1%) and these variations could be due to the higher degree of milling via removing rice bran [9, 11].

Rice is a starchy food crop with high content of carbohydrates. In this study, all rice varieties were reported with more than 70% of carbohydrates (Table 1). The lowest content of carbohydrates (78.20%) was found in cv. '*Phka Romdoul* Takeo', whereas, the highest value was obtained in cv. '*Srov Atung*' (84.13%). The high carbohydrate contents recorded in this study are in agreement with previous findings which indicated a well-known source of the carbohydrate contents in rice varied from around 73 to 84% [9,11]. Additionally, rice which had a low value of carbohydrate, could be related to the water content of those cultivar and further environmental factors (Oko et al., 2012).

3.4. Energy content

Food energy content is a parameter, that is significant for the human body. The energy content of milled rice samples in this study were found significantly different at $p < 0.05$ as reported in Table 1. The highest amount of energy was found in cv. '*Srov Atung*' (374.50 ± 2.03 Kcal/100g) followed by cv. '*Krohorm Chin*' (366.06 ± 0.53 Kcal/100g), while, the least amount of energy was 350.22 ± 3.85 Kcal in 100g of milled rice found in cv. '*Neang Minh*'. The results of energy in this study are in agreement to a previous research obtained by Devi et al. (2015), who reported that the energy value had a strong positive correlation with carbohydrate content since a high amount of energy was observed in the high percentage of carbohydrate in rice. Furthermore, the negative correlation between energy and percentage of fat, fiber, and protein were also observed by Devi et al. (2015). In addition, the energy values among 16 milled rice samples found in the present study were similar to the food energy values obtained by Verma & Srivastav [17].

Table 2. Proximate chemical compositions of 16 rice varieties

Rice varieties	Proximate compositions						Energy content (Kcal/100g)
	%Moisture	%Ash	%Protein	%Fat	%Fiber	% carbohydrates	
Phka Mlis	12.14 ± 0.66^{a}	0.34 ± 0.03^{d}	6.84 ± 0.13^{fg}	0.27 ± 0.02^{fgh}	0.24 ± 0.04^{i}	80.18 ± 0.71^{ef}	351.43 ± 2.74^{g}
Neang Khon	11.70 ± 0.12^{ab}	0.31 ± 0.04^{def}	6.46 ± 0.19^{h}	0.22 ± 0.02^{ij}	1.39 ± 0.19^{fgh}	79.92 ± 0.44^{ef}	353.04 ± 0.59^{fg}
Neang Minh	12.42 ± 0.93^{a}	0.34 ± 0.02^{de}	7.21 ± 0.17^{cd}	0.24 ± 0.02^{hij}	0.33 ± 0.03^{i}	79.46 ± 0.89^{fg}	350.22 ± 3.85^{g}
Phka Romdoul (Battambang)	11.93 ± 0.30^{a}	0.23 ± 0.02^{g}	7.13 ± 0.24^{cde}	0.25 ± 0.03^{hij}	0.34 ± 0.03^{i}	80.11 ± 0.09^{ef}	352.63 ± 1.27^{fg}
Phka Khnhei	12.14 ± 0.59^{a}	0.49 ± 0.05^{b}	6.72 ± 0.23^{g}	0.26 ± 0.07^{ghi}	0.26 ± 0.03^{i}	80.14 ± 0.62^{ef}	350.82 ± 2.67^{g}
Bonla Pdao	12.01 ± 0.09^{a}	0.29 ± 0.01^{ef}	6.05 ± 0.03^{i}	0.21 ± 0.01^{j}	1.29 ± 0.02^{h}	80.14 ± 0.12^{ef}	351.86 ± 0.45^{fg}
Srov Vear	11.09 ± 0.44^{b}	0.35 ± 0.04^{d}	7.15 ± 0.05^{cde}	0.13 ± 0.02^{k}	1.27 ± 0.01^{h}	80.01 ± 0.49^{ef}	354.85 ± 1.62^{f}
Phka Romdoul (Takeo)	9.09 ± 0.23^{def}	0.40 ± 0.04^{c}	6.93 ± 0.02^{efg}	0.38 ± 0.02^{cd}	5.00 ± 0.06^{a}	78.20 ± 0.21^{h}	363.91 ± 0.77^{bcd}
Krohorm Tgon	8.48 ± 0.23^{f}	0.45 ± 0.01^{bc}	8.05 ± 0.03^{a}	0.31 ± 0.02^{ef}	2.21 ± 0.12^{d}	80.49 ± 0.14^{de}	365.77 ± 1.01^{bc}
OM	9.25 ± 0.20^{de}	0.45 ± 0.02^{bc}	7.37 ± 1.18^{c}	0.34 ± 0.01^{de}	1.49 ± 0.06^{f}	81.11 ± 0.15^{cd}	362.90 ± 0.74^{cde}
Krohorm Chin	8.66 ± 0.15^{ef}	0.20 ± 0.02^{g}	6.46 ± 0.02^{h}	0.30 ± 0.01^{efg}	1.63 ± 0.05^{e}	82.76 ± 0.16^{b}	366.06 ± 0.53^{b}
Srov Sor	9.54 ± 0.11^{cd}	0.42 ± 0.02^{c}	7.15 ± 0.06^{cde}	0.27 ± 0.01^{fgh}	3.58 ± 0.09^{b}	79.04 ± 0.14^{g}	361.48 ± 0.40^{de}
Nam Bung	10.02 ± 0.26^{c}	0.32 ± 0.02^{def}	6.36 ± 0.09^{h}	0.42 ± 0.02^{bc}	2.69 ± 0.02^{c}	80.18 ± 0.34^{ef}	360.74 ± 0.99^{ab}
IR66	9.56 ± 0.08^{cd}	0.28 ± 0.03^{f}	6.97 ± 0.03^{ef}	0.40 ± 0.03^{bc}	1.41 ± 0.03^{fg}	81.38 ± 0.16^{c}	362.67 ± 0.39^{de}
Srov Atung	6.74 ± 0.54^{g}	0.29 ± 0.02^{f}	7.03 ± 0.06^{def}	0.52 ± 0.06^{a}	1.29 ± 0.07^{gh}	84.13 ± 0.55^{a}	374.50 ± 2.03^{a}
Krosaing Teap	9.48 ± 0.22^{cd}	0.60 ± 0.02^{a}	7.77 ± 0.13^{b}	0.43 ± 0.04^{b}	1.64 ± 0.05^{e}	80.08 ± 0.27^{ef}	361.85 ± 1.06^{de}

Values presented as mean ± standard deviation, expressed as percentage of wet basis (%wb).
Means with different superscripts along the same column are significantly different (*p<0.05*).

3.4. Amylose content

Amylose content plays a crucial role in the evaluation of the cooking and pasting characteristics of rice. The amylose content is the second major constituent in rice starch that can be differentiated into 5 categories comprising high amylose rice variety (>25%), intermediate rice (20-25%), low (12-20%), very low (2-12%), and waxy rice (0-2% amylose) (Chatterjee & Das, 2018). The experimental results in Fig.2 illustrated a wide range of amylose content among the milled rice samples. The amylose content varied from 22.14 ± 0.78% in cv. 'IR66' to 39.15 ± 0.93% in cv. Srov Vear'. Based on the classification reported by Chatterjee & Das [19], cv. '*IR66*, *OM*, *Phka Romdoul* Battambang, *Phka Romdoul* Takeo, *Phka Khnhei*, and *Phka Mlis*' could be classified as intermediate rice varieties due to the medium level of amylose. It could be noted that these cultivars might be preferable for consumption as grains because of their moistness and softness after cooking. Furthermore, cv. '*Srov Vear*' and cv. '*Nam Bung*' contained greater amylose than high amylose rice varieties reported by Thilakarathna et al. [20]. It is worth noting that different rice varieties, environmental factors during planting rice grain as well as the processing of milled rice are the main factors influencing the amylose content of rice [19]. Moreover, the high percentage of amylose in rice may also be caused by increasing levels of polishing rice grains because of a slight amount of starch in the outer layer and significantly higher starch in the endosperm layer [19]. High amylose rice cultivar could become best choice for the production of rice noodles since it plays an important role in forming strong network structures via hydrogen bonds [20]. In this regard, it could show that cv. '*Srov Vear*' is the best variety for food product development among the rice cultivars in the present experiment due to its highest amylose content.

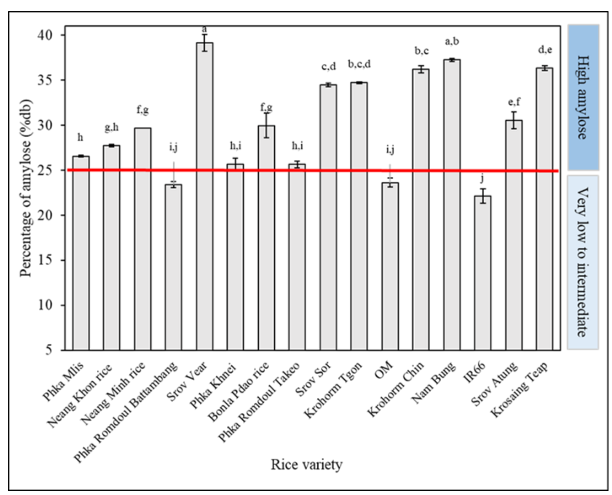

Fig.3. Amylose content of rice samples

3.5. Chemical compositions of cv. Phka Romdoul based on locations

As stated earlier, genotypic variation is not the only factor influencing the chemical compositions of rice, different planting area is also a feature which could differentiate the result of a rice variety [11]. The result in Fig.3 showed the chemical composition of one rice cv. *Phka Romdoul* collected from Battambang and Takeo provinces. It revealed significant differences among rice collected from the two locations based on Table 1. The study of Kaur et al. [21] also revealed variations in some compositions of rice planted in different Indian regions. However, the comparison in this study could not clearly demonstrate the alterations caused by different planting zone due to its limited data, hence, the effect of locations on the composition of rice (same variety) in Cambodia is necessary for further investigations.

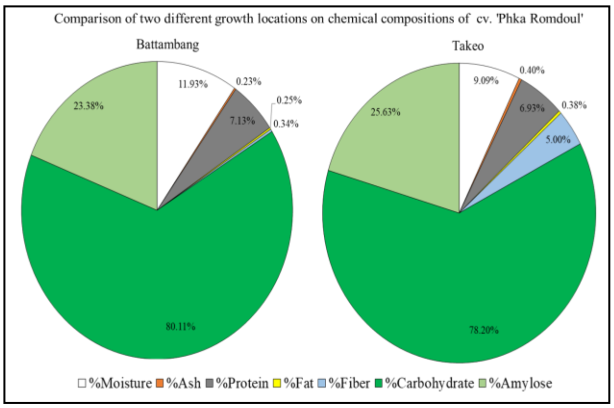

Fig.3. Comparison of different rice growing locations on chemical composition of cv. 'Phka Romdoul'.

4. CONCLUSION

The present work was carried out to examine proximate chemical composition of different rice varieties in Cambodia. The highest percentage of carbohydrates and fat were found in cv. '*Srov Atung*', while the lowest values were observed in cv. '*Phka Romdoul* Takeo' and '*Srov Vear*' correspondingly. The rice variety cv. '*Neang Minh*' showed the highest moisture content, while, cv. '*Srov Atung*' was reported the lowest value. The cv. '*Phka Romdoul* Takeo' contained the highest value of crude fiber followed by cv. '*Srov Sor*', whereas, the lowest value was observed in the cv. '*Phka Mlis*'. The highest amount of energy was found in cv. 'Srov Atung', when, the least amount of energy was observed in cv. '*Neang Minh*'. The highest value of ash and amylose content were observed in cv. '*Krosaing Teap*' and cv. '*Nam Bung*' when the lowest values were found in cv. '*Krohorm Chin*' and '*IR66*', respectively. Furthermore, this study also revealed slightly different of compositions caused by two growing areas with the same rice variety. Therefore, this current study could be beneficial for further research or for food processors to select rice varieties for their own purposes, mainly innovation of rice-based products. In the next research, a few rice cultivars among these 16 varieties will be selected for the study of rice vermicelli and puffed rice processing.

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REFERENCES

[1] Nair, K. P. (2018). Utilizing crop wild relatives to combat global warming. Advances in Agronomy.

[2] Bautista, R. C., & Counce, P. A. (2020). An Overview of Rice and Rice Quality. Cereal Foods World, 65.

[3] FAO. (2022). Crops and livestock products. Food and Agricultural Organization of the United Nations. Retrieved on 28 March 2022 from https://www.fao.org/faostat/en/#data/QCL.

[4] Subedi, U., Karki, R., Mishra, A., & Shrestha, M. A. N. B. (2016). Quality assessment of some rice varieties newly adopted in Nepal. Journal of Food Science and Technology Nepal. 9, 48–54.

[5] MAFF. (2021). Yearly report of Ministry of Agriculture, Forestry, Fisheries. Retrieved on 10 July 2022 from https://elibrary.maff.gov.kh/download/book/6098de874 7980.

[6] MAFF. (2022). Yearly report of Ministry of Agriculture, Forestry, Fisheries. Retrieved on 13 July 2022 from https://elibrary.maff.gov.kh/book/623933d233e7d.

[7] Sopheap, E., Inatsu, Y., Zaman, S., & Buntong, B. (2019). Assessment of microbiological quality and safety of fermented and non-fermented Khmer Rice Noodles in Cambodia. Bangladesh Journal of Microbiology, 35(2), 82–88.

[8] Ek, S., Setka, S., Mithona, A., Seiha, T., Thong, K., & Saio, K. (2018). Quality and safety of Cambodian rice. Food Science and Technology Research, 24, 829–838.

[9] Devi, G. N., Padmavathi, G., & Babu, V. R. (2015). Proximate nutritional evaluation of rice (Oryza Sativa L.). Journal of Rice Research, 8, 23–32.

[10] Wani, A. A., Singh, P., Shah, M. A., Schweiggert-Weisz, U., Gul, K., & Wani, I. A. (2012). Rice starch diversity: effects on structural, morphological, thermal, and physicochemical properties-A review. Comprehensive Reviews in Food Science and Food Safety, 11, 417–436

[11] Muttagi, G. C., & Ravindra, U. (2020). Chemical and nutritional composition of traditional rice varieties of Karnataka. Journal of Pharmacognosy and Phytochemistry. 9, 2300–2309.

[12] AOAC. (2012). AOAC Method. In Official Methods of Analysis of AOAC International.

[13] Abeysundara, A., Navaratne, S., Wickramasinghe, I., & Ekanayake, D. (2015). Determination of changes of amylose and amylopectin content of paddy during early storage. International Journal of Science and Research, 6, 2094–2097.
[14] Anjum, F. M., Pasha, I., Bugti, M. A., & Butt, M. S. (2007). Mineral composition of different rice varieties and their milling fractions. Pakistan Journal of Agricultural Science, 44, 332–336.
[15] Mbatchou, V. C., & Dawda, S. (2018). The nutritional composition of four rice varieties grown and used in different food preparations in Kassena-Nankana district, Ghana. International Journal of Research in Chemistry and Environment. 3, 308–315.
[16] Verma, D. K., & Srivastav, P. P. (2017). Proximate composition, mineral content and fatty acids analyses of aromatic and non-aromatic Indian rice. Rice Science, 24, 21–31.
[17] Kraithong, S., & Rawdkuen, S. (2021). Quality attributes and cooking properties of commercial Thai rice noodles. PeerJ, 9:e11113.
[18] Oko, A. O., Ubi, B. E., Efisue, A. A., & Dambaba, N. (2012). Comparative analysis of the chemical nutrient composition of selected local and newly introduced rice varieties grown in Ebonyi State of Nigeria. 2, 16–23.
[19] Chatterjee, L., & Das, P. (2018). Study on amylose content of ten rice varieties recommended for Assam. International Journal of Pure & Applied Bioscience, 6, 1230–1233.
[20] Thilakarathna, G. C., Navarathne, S. B., & Wickramasinghe, I. (2017). Identification of important physical properties and amylose content in commercially available improved and traditional rice varieties in Sri Lanka. International Journal of Advanced Engineering Research and Science, 4, 186–194.
[21] Kaur, P., Singh, N., Pal, P., & Kaur, A. (2018). Variation in composition, protein and pasting characteristics of different pigmented and non-pigmented rice (*Oryza sativa* L.) grown in Indian Himalayan region. Journal of Food Science and Technology, 55(9), 3809–3820.