Characterization And Rejuvination Of Upland Red Rice In North Sumatra

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Abstract: This Paddy (Oryza sativa L.) or rice as the main staple food, is very important food crop for the people of Indonesia. Germplasm or genetic resources (GR) is very important biodiversity and the basic capital needed in development agricultural industry including new varieties inventionin order to increase productionto support food security and sustainable agriculture. One type among upland rices in North Sumatra that widely planted by the farmersare the upland red rices. In order to conserve the extinction of these GR and to empower their cultivation, it is necessary to takeaction in more dynamic way of conservation such as in situ conservation (onfarm conservation) and ex situ conservation. The purpose of this study was to obtain information and data; agronomic, morphological, and production characteristics such as: plant height, harvest age, production per ha, weight of 1000 grains, shape, size, and color of unhulled grain and the hulled one (rice). The research was initiated with exploration activities in several districts in North Sumatra from January 2015 to April 2016 which included literature study, interviews and direct visit to farmer fields. Collection and storage for consolidation and characterization of upland red rice was conducted at Experimental Field and Screen House of Faculty of Agriculture UISU Medan. Results obtained; (1) Acquired 12 uplandred rice cultivars and most cultivars were found in areas of medium to high altitude, with flat topography, plateau tohilly;(2). All upland red rice cultivars showed good diversity in terms of agronomy, harvest age and production (2). Grain (lemma/palea) and seed (caryopsis) obtained were found to be variated in the shape, size, and color.

Index Terms: biodiversity, characterization, food security, red rice, sustainable agriculture

1 Introduction

Indonesia is a tropical country with a huge potential and belongs to the second largest country on biodiversity. The high level of biodiversity of germplasm or genetic resources (GR) is because Indonesia has a vast landscape with the spread and condition of geographic areas that vary [1]. Germplasm or GR is one of the most important natural resources and is the basic capital needed to develop the agricultural industry. Genetic Resources management is considered successful if it has been able to provide access to GR as a source of donor genes in breeding programs, and plant breeding is considered to be successful if it has utilized the genetic properties available in GR collections [2]. Local cultivars are seen as a very valuable asset and need to be well managed. Local rice (landrace) is an GR that has a certain genetic advantage, has been cultivated for generations so that the genotype has adapted well to the various land conditions and specific climate in the area development. In addition, local rice is naturally resistant to pests and diseases, tolerant to abiotic stress, and has a good quality of rice and generally has a taste and aroma favored by the people [3,4,5] Paddy (Oryza sativa L.) or rice is the main staple food for the people of Indonesia, and an important component in the national food security system [6]. In addition, rice is also one of raw material of various foods, such as cakes flour, noodles, and baby food (brown rice). Indonesian rice consumption is 135 kgs/capita/year. Out of the 39.7 million hectares of Indonesian mainland, 20.5% is planted with rice. In 2013, harvested area of Indonesia's rice was 13.83 million hectares resulting the productivity of 5.15 t/ha and total production of 71.28 million tons [7].

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The national productivity of upland rice in the country remains low at 3.35 t/ha [8]. Rice cultivation in upland areas worldwide accounts for about 13 million hectares and contributes about 4% of the total rice production in the world [9]. In Indonesia, upland rice production covers about 1.15 million hectares and contributes about 5% of the national rice production [8]. Indonesian upland rice area is mainly cultivated in marginal areas, which comprise diverse geographical areas from low to high altitude. Rice production increased from 52 million tons in 2000 to about 66 million tons in 2010, or an increase of 2.68% per annum as combination of 1.24% increase in harvested area and 1.41% annual increase in productivity. The lowness increase in harvested area shows that to increase rice production has been more difficult especially in Java, Sumatera and Nusa tenggara [8,10]. The exploration and conservation of GR has become a global concern, by forming an international body of the International Plant Genetic Resource Institute (IPGRI) based in Rome, which plays a role in the management of germplasm for some particular commodities [11]. Exploration is an activity to seek, find, and collect certain GR to secure them from extinction. In order for the GR to be more efficiently secured it is necessary to conduct more dynamic conservation such as in situ conservation or on-farm conservation. Breeding to improve rice varieties for upland areas has been established in Indonesia since 1970s with the main target areas were upland rice in low altitude. In contrast, improvement of upland rice varieties for high altitude in the country was just initiated in 2011. It is estimated that 2.07 million ha of upland areas in high altitude has the potential for food crop production including rice [12]. However, in the high-altitude areas, farmers still cultivate traditional rice varieties mainly due to the absence of improved varieties specifically released for the areas. One type of upland rice in North Sumatra which widely still being planted by farmers is red upland rice. Rice also contains proteins, and some minerals, including Fe and Zn. Rice accounts 60-65% of total energy consumption [13]. Red (brown) rice has the advantage of both its tenderness and benefit for the human body. Brown rice is known to be very beneficial to health, as well as staple foods, among others, to prevent food and nutrition shortages and cure diseases. The content of anthocyanin in brown rice is believed to prevent various diseases such as cancer, cholesterol, and coronary heart [14]. The specific purpose of this research is to explore and characterize the various local rice characters of North Sumatra red rice, and followed by characters improvement of North Sumatran red rice upland landraces through further in the breeding activities. Characters that will be improved primarily. are the age of plants, posture, and production. While the specific objectives of the study are as follows:

1. Getting, and collecting and consolidating the upland red rice in North Sumatra as a first step in conservation.
2. Characterization of morphology, especially morphology of rice grain of red rice from exploration results
3. Knowing the genetic kinship of local upland red rice in the North Sumatra.

MATERIAL AND METHOD

The research was conducted in eight districts in North Sumatra Province from January 2015 until April 2016. The method included the study of literature, interviews to the relevant agencies, the Department of Agriculture, Ministry of Agriculture, Indonesian Center for Rice Research, Agricultural Extension, the Village Head, and Farmer Groups, as well as visits and interviews directly to the Farmers fields in the District which are regional producer of rice and have the potential existence of local upland red rice. The research was conducted on several stages of research activities, namely: 1) exploration and rice collection of upland red rice in North Sumatra, and 2) characterization of morphology of upland red rice in North Sumatera results of exploration activities. Data collected in this study were primary and secondary data. Primary data collected directly through interviews with respondents using a questionnaire to determine the existence and identify the red rice geographic, agricultural systems, farmers' character, agronomic characters, morphology, and production coverance, plant height, date of harvest, production per hectare, 1000 grain weight, grain shape, and color of grain. Secondary data related to this study were obtained through the agencies associated with this research.

1. Exploration and Collection of Red Rice of North Sumatra

Local GR rice exploration activities were carried out in several regencies in North Sumatra Province. Each of these districts was eligible for exploration activities because it stores the diversity of paddy GR which was preserved for years to come. Prior to the initial exploration preliminary survey was conducted, for data collection that contains about the existence of local upland rice species or even wild relatives in the area. Visited and interviewed directly to the fields Farmers in the District which were regional producers of rice and had the potential of the existence of local upland red rice. Data collection included name of cultivar, number and origin of collection, based on predefined sampling method. The paddy seeds were then collected and stored in appropriate places and temperatures for the purpose of collecting GR and for characterization purposes.

2. Evaluation and Rejuvenation (Consolidation)

The cultivars that had been collected from the farmers' fields were collected and stored in cold storage, and some are planted for consolidation and rejuvenation by ex situ or in situ. For rejuvenation, acquired rice cultivars were planted in experimental field of The Faculty of Agriculture UISU Medan. Furthermore, identification was done. The data taken were morphological character and production component. Data observed were still limited to the initial character including plant height, number of productive tillers, panicle length, flowering age, 1000 grain, grain shape, and grain color.

3. Characterization of Grain Morphology

Cultivars collected from farmers' fields, then identified (characterization) and stored. A total of 12 cultivars, were planted in the experimental field and the green house of Faculty of Agriculture UISU Medan, for evaluation, stabilization, and characterization. Stages of observation of red rice character was done by observing grain quantitatively and qualitatively. All quantitative data was determined by measuring all grain characteristics in accordance with the rice descriptor issued by IRRI and WARDA [15]. Observations consisted of quantitative and qualitative observation. Quantitative quantities consisting of grain length, grain width, grain thickness, and grain length as measured by using digital slurry in mm, and weight of 100 grains as measured by analytical scales in grams. While qualitative observations consisted of grain color surface color, rice color, and shape of rice. The data of morphological characterization (phenotypic data) were then used for the analysis of diversity and kinship.

1. Upland GR Data in Location Collection Field Visit

From the exploration result in 5 regencies, there were 12 cultivars of upland red rice, and agronomic data obtained (Table 1).

Table 1. *Upland Red rice from exploration in Province of North of District*

Number (Genotipe Code)	Local Name (Accession)	Sub District / District	Plant height (cm) / Age production (day)	Production (ton)	High area (masl)	Class
1.(BM01)	Gara Geduk	STM Hulu/ Deli Serdang	180 / 180	1,0 – 1,5	500- 1000	Indica (Cere)
2.(BM02)	Belacan TM	STM Hulu/ Deli Serdang	180 / 170	1,0 – 1,5	500- 1000	Indica (Cere)
3.(BM03)	SiPote	Bintang Bayu/ Serdang Bedagai	160 / 165	1,5 – 2,0	500 - 800	Japonica
4.(BM04)	SiPala	Raya/Simalungun	180 / 170	2,0 – 2,5	500 - 800	Indica (Cere)
5.(BM05)	SiGambiri SM	Seribu Dolok/ Simalungun	180 /170	2,5 – 3,0	750- 1300	Indica (Cere)
6.(BM06)	Pagai Gara	STM Hulu/ Deli Serdang	180 / 170	1,0 – 1,5	500- 1000	Indica (Cere)
7.(BM07)	SiPenuh	Barus Jahe/ Tanah Karo	170 / 170	1,5 – 2,0	750- 1000	Indica (Cere)
8.(BM08)	Belacan TB	STM Hulu/ Deli Serdang	160 / 170	1,0 – 1,5	500- 1000	Indica (Cere)
9.(BM09)	SiBuah	Raya/Simalungun	180 / 170	2,5 – 3,0	500 - 800	Indica (Cere)
10.(BM 10)	Condong	Barus Jahe/ Tanah Karo	150 /160	2,0 – 2,5	750- 1000	Indica (Cere)
11.(BM 11)	Kabanjahe	Brampu/Dairi	180 / 165	2,5 – 3,0	750- 1200	Indica (Cere)
12.(BM 12)	SiKembiri	Dolat Rayat/ Tanah Karo	180 / 175	1,5 – 2,0	750- 1000	Indica (Cere)

Source: Farmer's information and visits field visits and observations in the field

Results From Table 1 it can be explained the exploration results that in the 5 visited districts were obtained 12 upland rice cultivars of red rice. Deli Serdang, Simalungun, and Tanah Karo districts had the largest number and varieties of upland red rice, compared to other districts, especially in the area around medium to high altitude, where until now upland red rice cultivation still maintained for generations due to local culture. These 5 District (1) Deli Serdang); (2); Simalungun (3) Tanah Karo; (4) Serdang Bedagai; and (5) Dairi; planting areas were situated in different ecosystems with varying altitudes from medium to high plains with flat, uneven to hilly topography. The farming or cultivation system was still relatively simple and upland rice was planted as intercropping plants with some annual crops such as rubber, palm oil, and coffee. Its also intercropped with horticultural plants, such as bananas, and oranges. Then the planting sites were always altered depend on the condition of the land or could be said as shifting cultivation. From this data it can be seen that the cultivation of upland rice was still an unimportant crop, although it generally proven to have high adaptation and tolerance to pests and diseases while the land was still available. This was because the field priority of farmers to plant rice, which they would choose irrigated rice fields first, followed by rain fed lowland (gogo rancah), and the last option was dry land for upland rice cultivation. For farmers who did not have wetland or where rice field was limited, then dry land was chosen to cultivate upland rice. In the other words, the cultivation of upland rice was more directed by the interests to fulfill farmers household consumption. Harvest age was long (>145 days), ranging from 150.00 to 180.00 days after seed (DAS), and production was still low to moderate (1.0 - 3.5 t / ha). All of harvest ages of cultivars could be categorized in the age of the deep category. This age of harvest could be affected by the altitude of the place and climatic conditions. This was because the collection area was situated on medium to highland which was above >400 m-asl. Low productivity of lowland rice was mainly caused by environmental stresses, both biotic and abiotic [16.17], varying climatic and soil conditions, the application of cultivation technology that had not been optimum, especially in the use of improved varieties, fertilization and blast disease control (Toha, 2005). The higher the place was planted, the appearance of harvest age would tend to be longer than the plants grown on the lowlands. Farmers tent to choose high potentially yielding cultivars, and moderate to low plant height characters. This was done by farmers to avoid the risk of crop failure due to lodging in the rainy season. The low productivity of rice in upland areas might be caused by the dominant utilization of local varieties that were tolerant of low temperatures and low soil fertility in most of the land belonging to podzolic soil type. Low temperatures in the highlands could inhibit the growth of seedlings and saplings, causing leaf discoloration (yellowing leaves), slow down the flowering time, exerted abnormal panicles, increased panicle sterility, irregular tassel maturation, which resulted to declining of production. The productivity of upland rice were lower primarily due to climatic and soil conditions variations, un optimal cultivation technology, especially in the use of high yielding varieties, fertilizing and controlling blast disease [17], also due to various environmental stress both biotic and abiotic [16]. In addition, the decline in production was also caused by the sloping increase in the potential yield of existing rice cultivars. This was due to the narrowness of the genetic diversity of existing rice cultivars as a result of releasing many rice cultivars that were related one to each other. As a result, rice diversity was reduced and the potential yields were no different[18]. This caused the existence of local rice both wetland and upland rice, currently increasingly abandoned farmers and threatened extinction [17]. Although there had been a lot of upland rice varieties released by the Government, but no one had been able to adapt well in the highlands. High yielding varieties that had been released, such as Situ Patenggang, Towuti, Situ Bagendit, Batu Tegi, and Limboto that had relatively high yield potential (> 3.5 t/ha), but the level of adaptation was still limited appropriate only in the lowlands (< 500 mdpl) [19,20]. In general, farmers cultivated local varieties (Sunjaya, 2011) that tasted good, tolerant of marginal land, resistant to some kinds of pests and diseases, requiring low fertilizer inputs as well as easy and simple cultivation. However, it had low productivity [21]. Problems faced by farmers in upland rice cultivation, such as the lack of availability of superior varieties seed. Then, the development of upland rice planting should consider soil conservation, productivity levels, taste, also the resistance to pests and diseases through modeling approaches of integrated crop management and resource (ICM) in the area of specific locations, to achieve food security and sustainable agricultural systems [17]. The utilization of improved varieties is a reliable technology in increasing the production of food crops. This technology is considered safer and more environmentally friendly and cheaper for farmers. Therefore, attention to the effort obtaining superior varieties through breeding research needs to be given so that genetic quality of the local rice can be improved. Indonesian plant breeders successfully breeded 180-day-old rice with productivity of 2-3 tons / ha to 105 days old with 6-8 tons / ha productivity such as Aek Sibundong a local rice varieties of North Sumatra [22]. To support the sustainability of paddy production in the regions and the increasing of national rice production, varieties that are adaptive to environmental conditions in the country are needed [16].

2. Evaluation and Rejuvenation (Consolidation)
From the results of rejuvenation and observation of morphological character of upland rice from 5 regencies were obtained 12 cultivars of upland red rice from North Sumatera. From the observations both in the field and initial studies, could be obtained morphological characters and component resulted in Figure 1 and Table 2.

Figure 1. *Rejuvenation of 12 Red Rice Exploration Results (Direct seed planting)*

From the Figure 2 below, there were several variations of 12 cultivars of upland rice from 5 districts which were grown for further rejuvenation. Characterization of all important morphological and agronomic properties of GR exploration results was carried out on several morphological characters and agronomic characters (yield component) by IRRI standard, IBPGR (1980).

Table 2. *Morphology characteristics and results component (characteristic score) cultivated gogo rancah rice at 5 Districts of Sumatera Utara Province*

Code Number	Height of plant (cm)	Productive seed (caulis)	Long of seed (cm)	Shape/ Color of grain
BM01	137.33 b (7)	7,78 a (3)	21,7 (5)	Slim/Cream
BM02	146.33a (7)	7,56 b (3)	32,17 (7)	Slim/Red
BM03	140.00b (7)	6,78 b (3)	30,00 (7)	Slim/Cream
BM04	135.55b (7)	5,78 b (3)	31,67 (7)	Slim/Cream
BM05	160.78a (7)	8,78 b (3)	28,67 (5)	Fat/Yellow
BM06	154.78a (7)	8,11 b (3)	5,00 (7)	Slim/Cream
BM07	160.45a (7)	7,00 b (3)	28,00 (5)	Fat/Brown
BM08	155.11a (7)	5,78 b (3)	33,33 (7)	Slim/Red
BM09	139.78b (7)	7,39 b (3)	30,33 (7)	Rounded/Brown
BM10	143.11ab (7)	9,44 b (3)	31,67 (7)	Slim/Cream
BM11	148.00a (7)	6,00 ab (3)	24,33 (5)	Rounded/Cream
BM12	142.44b (7)	9,78 a (3)	26,33 (5)	Fat/Yellow

Source: Observation data of age 90 DAP rejuvenation

Note: The numbers followed by unequal letters in the same treatment group differ significantly at the 5% (lower case) level based on the DMRT Test. From Table 2 above, there are several variations of all cultivars of upland rice in 5 districts that are planted for rejuvenation and then identification (characterization). The data collected were as follows: Base on morphological character (phenotypic data) of 12 local red rice cultivars, there were variations of each cultivar as follows: Plant height was high > 125 cm (score 7) ranging from 135.55 - 160.78 cm. Productive tillers was classified as little < 10 (score 3) ranging from 5,78 - 9,78 tillers. Long panicle was medium with score 20 - 30 cm to long (31 - 40 cm) rangimg from 21.7 - 35 cm.

Character of Grain Morphology

a. Qualitative Character
From the exploration result in 5 regencies, 12 local rice cultivars of upland red rice from North Sumatra were obtained. Observations both in the field and by conducting initial studies then could be obtained some characters, both morphological and anatomical characters. Morphological and anatomical characteristics of 12 local upland red rice cultivars. Based on the observations obtained, the longest length of red rice grains are genotypes BM 01 and BM 06, while the shortest is genotype BM 15. IRRI and WARDA (2007) divide the length of grain in three classes, ie short (<7.5 mm), medium (7.5-12 mm), and long (> 12 mm). Based on the classification of [15], we obtained short, and medium red rice genotypes. The result of qualitative observation on red rice grain showed the variation between each genotype. Grain of red rice both unhealed and hulled had varying surface and shape colors. Based on the observation on the qualitative character, the color of the grain surface was generally colored yellow straw, brownish, and brownish red. According to [15], the colors of the grain surface were quite diverse, ie brownish yellow, brownish white, brownish orange, light brown, brownish red, and greenish brown. According to [23] (2010), the colors of the grain surface were quite diverse, namely brownish yellow, brownish white, brownish orange, light brown, brownish red, and greenish brown. Similarly, there are also variations on the color of the seed (caryopsis). Namely red, pink, blackish-red rice. According to [24], different rice colors were genetically regulated, due to differences in genes that regulate aleuron color, endosperm color, and starch composition in endosperm. The shape of rice also showed variations, which were round, semi-round, and oval. Most of the red rice form found to beoval followed by a semi-spherical shape and the smallest was round. Shape of grain form started from oval, round, and semi of round, brown grain color (brown), brown spots, and brown stripes. Caryopsis color obtained starting from red, red brown, and dark red. From the colors of these seeds could be estimated the differences in nutritional content in brown rice. The color of the seeds of the 12 existing cultivars can be seen on the characterization of grain (lemma/palea and seeds (caryopsis). The result of qualitative observation on red rice grain showed the variation between each genotype. Grain of red rice both unhulled and hulled had varying surface and shape colors (Table 2 and Figure 3). Based on the observation on qualitative character, the colors of the grain surface were generally yellow straw,

brownish, dark red, and red black. According to [15], the colors of the grain surface were quite diverse, namely brownish yellow, brownish white, brownish orange, light brown, brownish red, and greenish brown. According to Putra et al. (2010), the colors of the grain surface were quite diverse, namely brownish yellow, brownish white, brownish orange, light brown, brownish red, and greenish brown. Likewise there were also variations considering the colors of the seed (caryopsis). Most of the hulled grainswere dark red, pink, and blackish red. According to [24], different hulled grains colors were genetically regulated, due to differences in genes that regulate aleuron color, color of endosperm, and starch composition in endosperm. The shape of hulled grains also showed variations, namely round, semi-round, and oval. Most of the hulled red rice grains forms found to be oval, followed by semi-spherical, and the smallest is round.

b. Quantitative Character

The results of observation of the quantitative character of upland red rice grain can be seen in Table 2.

Table 2. *The quantitative character of upland red rice grain*

No.	Cultivar/ Genotype	Observation of Grain (G) and Rice (R) (Long (L), Width (W) Thick (T) = mm); Weight = g)						
		L (G)	W (G)	T (G)	L(R)	W	T (R)	Weight 100 (g)
1	1	8.66	2.28	1.66	8.64	2.24	1.63	2.72
2	2	8.75	2.02	1.54	8.73	2.00	1.52	2.42
3	3	**7.05**	2.39	1.62	6.72	2.22	1.69	**1.69**
4	4	9.00	2.35	1.62	8.99	2.33	1.60	2.10
5	5	7.96	**2.91**	1.89	7.91	2.87	1.88	3.34
6	6	8.71	2.18	1.64	8.67	2.16	1.62	2.42
7	7	8.09	2.78	1.93	8.03	2.78	1.92	3.23
8	8	8.85	**1.97**	1.57	8.86	1.95	1.57	2.43
9	9	7.21	2.25	1.61	7.19	2.23	1.59	2.27
10	10	**9.14**	2.21	**1.53**	9.13	2.19	**1.51**	2.62
11	11	7.75	2.69	1.77	7.73	2.67	1.74	2.75
12	12	7.77	2.74	**2.02**	7.76	2.72	2.00	3.32
	Average	**8.24**	**2.40**	**1.70**	**8.19**	**2.36**	**1.68**	**2.52**

In general, there was a difference in the characteristics of each of the red rice genotypes. The observation of quantitative variables on grain showed that the length of grain ranged from 7.05 - 9.14 mm. The width of grain ranged from 1.97 - 2.91 mm. Grain thickness ranged from 1.53 - 2.02 mm. The weight of 100 grain seeds ranged from 1.69 to 3.32 g. Based on observations obtained in Table 2., the longest length of red rice grass was Condong genotype (9,14 mm), while the shortest was SiPote genotype (7,05 mm). According to [15, 23], divided the length of grain in three classes, ie short (<7.5 mm), medium (7.5-12 mm), and length (> 12 mm). Based on the classification of [13,15], we obtained 1 short size red rice genotype while the remaining were classified as short and medium size. Weight 1000 grains were between 20 - 30 g. The size of the percentage of similarity is influenced by the extent or narrowness of diversity (variability). According to [3,5], generally a high level of variability of morphological characters would complicate the limitation of taxon under the type. The level of kinship should be known to facilitate breeders in producing new varieties that have a wide or narrow diversity through crosses. To produce varieties with a narrow diversity varieties are used that close kinship level, while to produce a wide level of diversity crossing of varieties that have A distant kinship level. The further the kinship relationship, the recombinant will be more diverse. [5,7] states that to determine the proximity of kinship relationships between plant taxon can be done by determining the similarity between plant taxon using morphological properties because morphological properties can be used to recognize and describe kinship of type. In the characterization activities that had been done could be known the character of each cultivar to be used and developed in plant breeding activities in accordance with the purpose of superior varieties which wanted to be assembled. Given this variation, further selection activities could be performed because the selection would be successful if the plant populations that would be selected had variations or diversity.

CONCLUSIONS

From the results of research, the following conclusions such as:

1. Germplasm exploration / conservation plays an important role in avoiding the extinction of local / wild rice species due to the rapid growth of modern high yielding varieties, the opening of new land, the transition of rice cultivation to other crops, and the development of settlements.
2. Results of exploration in ten districts obtained 21 local rice genotypes of red rice in North Sumatra.
3. Rain morphology characterization results indicated the variations on quantitative and qualitative characters. The widest level of diversity was obtained from the long feather characters.
4. Correlation analysis results showed the correlation between some variables of morphology of grain and caryopsis.

It needs collaboration between government, farmers, businessmen, and colleges in the application of technology for the development of upland rice, including conservation and collection of local cultivars, therefore the next new varieties can be produced in order to support food security and sustainable agriculture, as well as the welfare of farmers.

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