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Research Article

Agronomic and Starch Content Studies of Local Adlay Accessions (*Coix lacrima jobi* - L.) from West Sumatra, Indonesia

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Abstract.
Indonesia has a high potential for diverse local food resources, one of which is the plant of adlay. Exploration activities aimed at collecting genetic resources of adlay have been successfully carried out in the province of West Sumatra, Indonesia, resulting in the collection of six local genotypes. The purpose of this research is to obtain information about the agronomic potential and starch content of several local adlay accessions. The study was conducted from April to September 2023 in Limau Manis, Padang City, West Sumatra. The six adlay accessions used in the study are PTA-1, KKD-3, PH-4, BTA-2, GT-2, and TJR-2. The experimental design employed was a completely randomized design with three replications. Based on the research findings, significant differences were observed in both agronomic aspects and starch content among the tested accessions. Adlay with the accession code PH-4 exhibited advantages in terms of harvest maturity and production. The starch content of adlay ranged from 56.64% to 61.26%, with the PH-4 accession having the highest amylopectin content (96.60%), while the highest amylose content was found in the GT-2, TJR-2, and KKD-3 accession (19.90%, 20.03%, and 20.48%). Accession PH-4 can be proposed as a candidate for Adlay variety assembly.

Keywords: agronomic, starch content, adlay accessions, *Coix lacrima jobi*

1. Introduction

Indonesia is an agrarian country, yet its dependency on imported food products is increasing, including a high reliance on wheat flour. Wheat is a processed product derived from wheat grains, and it is used in various food products, including instant noodles, leading to substantial domestic consumption. According to the statistic Indonesia [1], Indonesia imported 11.48 million tons of wheat in 2021. This figure increased by about 1.18 million tons compared to the previous year, raising concerns due to the very high dependence on imported products. Meanwhile, Indonesia possesses a diverse array of local potential food sources rich in carbohydrates and other nutrients. One of the plants with potential for development is adlay. This plant is known for its tolerance to drought and its wide adaptability to various environmental conditions [2-4].

There is limited information available about adlay, both at the national level and within the West Sumatra province. This commodity is not widely known, and its popularity lags far behind other cereal crops. The general public has little precise knowledge about the existence and uses of adlay, leading to the assumption that there is no profit in cultivating this commodity. Additionally, adlay is considered a minor and sporadic crop by local communities. It often grows without any care or cultivation techniques. People regard it as a wild plant or weed, leading to intensive control measures, both mechanical and chemical. However, some individuals are aware that adlay can be utilized as a food source, such as in the Agam district (Canduang, Sungai Pua, Banuhampu), Padang Pariaman district (Batang Anai), and Padang city (Pauh). Over time, however, local consumption of adlay has declined due to the current population's reliance on rice as a staple food [5].

Adlay is known to contain about 67 - 76% carbohydrates [6,7]. Koehler and Wieser [8]; Saleh et al. [9]; Inglett et al. [10] further mention that this cereal type contains over 50% starch and other macro and micronutrients essential for health, making it a valuable source of nutrition. Specifically, adlay and wheat contain beta-glucans that have health benefits. However, the full potential of this plant has not been harnessed, mainly due to a lack of knowledge about its capabilities, processing, and characterization of its components. Adlay is a gluten-free food source with a low glycemic index of 35, making it suitable for consumption by individuals with diabetes [11,12]. Andriana et al. [13] add that small-scale production of adlay-based flour is financially viable.

Based on the benefits of adlay that have been explained, it is essential to further explore the potential of this plant. Moreover, it is known that the West Sumatra province has a relatively high level of diversity for adlay plants. Exploration activities aimed at collecting genetic resources of adlay in West Sumatra have successfully gathered six accessions. One of the core activities in conserving germplasm, alongside exploration and selection, is evaluation. Evaluation is a process aimed at assessing the reactions of a genotype resulting from exploration or germplasm collection [14]. The development and utilization of adaptive adlay genotypes with various health-supporting compounds are crucial to safeguard against national food crises and malnutrition. Therefore, the evaluation of each accession is necessary, serving as foundational information about the potential of each accession. The purpose of this research is to obtain information about the agronomic potential and starch content of several local adlay accessions from the West Sumatra province. Generally, the biochemical properties of starch can provide guidance in selecting suitable commodity types for desired products. Researchers and other users can utilize the database as a reference material for further studies. Cultivators and industrial stakeholders can also select genotypes that align with their needs, based on adlay.

2. Materials and Method

This research was conducted from April to August 2023 in Limau Manis, Padang City, West Sumatra, Indonesia at an elevation of 206 meters above sea level. The location falls under the A1 rainfall classification according to the Oldeman classification. The six adlay accessions used in the study are PTA-1, KKD-3, PH-4, BTA-2, GT-2, and TJR-2. The locations where these accessions were found can be seen in Figure 1. The study employed an experiment using polybags measuring 40 x 50 cm. The soil order used was Ultisol, and the soil was amended with dolomite (5 tons/ha) and cattle manure (20 tons/ha) to reduce aluminum content and increase pH in the growing media.

The experimental design used in this study was a Completely Randomized Design with 3 replications, resulting in 18 experimental units. Compound fertilizer NPK (16:16:16) was applied at a rate of 150 kg/ha. The application of the compound fertilizer was divided into two instances: one-third of the dose was applied one week after planting, and two-thirds of the dose was applied at 8 weeks after planting. Planting was carried out by placing one seed per planting hole. When the plants entered the generative phase, the staminate flowers were isolated by covering them with plastic to prevent cross-pollination between accessions. Each experimental unit contained 10 plants, and 5 randomly selected plants were sampled for observations including plant height (1 - 12 weeks after planting), flowering age, harvest age, number of productive tillers, grain weight per tiller, and starch content (amylose and amylopectin). The observation data will be statistically analyzed using an F-test at a significance level of 5%. If the calculated F-value is greater than the tabulated F-value at 5%, a Duncan New Multiple Range Test (DNMRT) will be conducted at a significance level of 5%.

Figure 1: The locations where the six adlay accessions were found in West Sumatra Province, Indonesia.

3. Results and Discussion

3.1. Plant height

The plant height of adlay at 1 WAP (Weeks After Planting) appeared similar for each accession, ranging from 10.11 to 13.19 cm (Figure 2). Differences in the rate of plant height increase became more evident at 4 WAP, where the PH-4 accession exhibited a faster growth rate compared to the other accessions. Meanwhile, the GT-2 accession showed the lowest plant height, and this condition persisted throughout the observation period (12 WAP). Based on the analysis of variance, adlay with the PH-4 accession code displayed the tallest appearance at the 12 WAP observation (Table 1), while adlay with the PTA-1 and GT-2 accession codes had the lowest plant heights. Variations in plant height morphology among the studied accessions are attributed to genetic diversity within each accession. Research by Dwipa et al. [4] indicated that based on the similarity analysis of phenotypic characteristics, the tested accessions belonged to different subgroups, making it highly likely for morphological differences to occur among the accessions. Differences in growth appearance among adlay accessions are due to variations in growth rate, cell division, and cell proliferation. As stated by Gardner et al. [15], the influence of varieties on observation variables is attributed to genetic differences inherent in each variety and its adaptability to the environment.

These differences in plant height among the respective accessions are also supported by several research findings. For instance, Qosim et al. [16] mentioned that among four tested adlay genotypes, the range of plant heights was 114.83 - 253.67 cm. The Batu cultivar of adlay had a height of 139.9 cm, while the Pulut cultivar was shorter at 120.6 cm [17]. Aradilla [18] added that there were significant differences in harvested plant height among six adlay cultivars studied, ranging from 149 cm to 233 cm. Every genotype has a different level of adaptability in responding to environmental conditions.

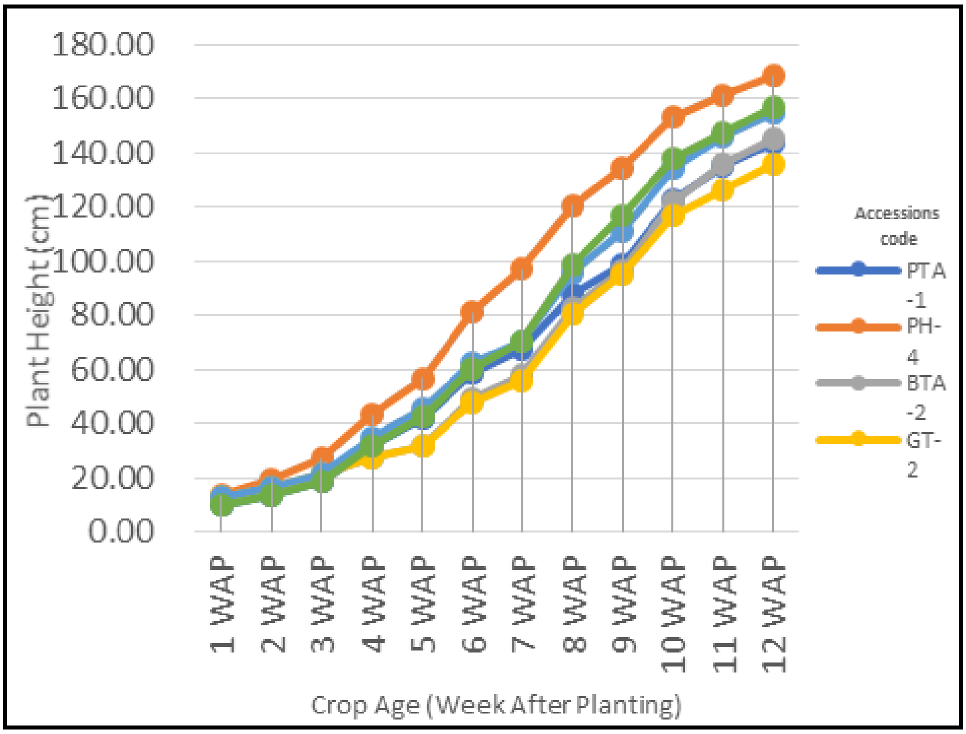

Figure 2: Plant height based on age increment in six local adlay accessions from West Sumatra.

3.2. Flowering and harvesting age

Regarding the flowering age variable, the BTA-2 and GT-2 accessions exhibited the longest durations (100.30 days and 99.53 days), while the fastest flowering occurred in the TJR-2 accession at 95.66 days. As for the harvesting age variable based on Table

TABLE 1: Plant height in six local adlay accessions from West Sumatra.

Accession Code	Plant Height at 12 WAP (cm)
PTA-1	143,68 b
PH-4	168,36 a
BTA-2	145,06 ab
GT-2	135,59 b
TJR-2	155,02 ab
KKD-3	156,68 ab

Note: Numbers followed by different letters in the same column are significantly different based on the post hoc Duncan's New Multiple Range Test (DNMRT) at the α 0.05 level.

2, the longest harvesting times were observed in the PTA-1 (172.68 days), KKD-3 (172.67 days), BTA-2 (171.34 days), and GT-2 (170.83 days) accessions, with the fastest harvesting time observed in the PH-4 accession (148.93 days).

The variations in timing among the accessions are likely due to genetic factors influencing flowering and harvesting ages. Consistent with the perspective of Darjanto and Satifah [19], the transition from the vegetative to the generative phase is partly determined by internal factors such as genetics and partly by external factors such as temperature and light intensity. The differences in flowering and harvesting times among the accessions are also supported by the findings of Handayani et al. [20], which reported morphological diversity among three adlay genotypes, with flowering ages ranging from 115 to 145 days and harvesting ages from 150 to 180 days. Qosim et al. [16] additionally noted that flowering ages in four Pulut adlay varieties ranged from 91 to 105 days, while harvesting ages ranged from 137 to 162 days.

TABLE 2: Flowering and harvesting age in six local adlay accessions from West Sumatra.

Accession Code	Flowering Age (days)	Harvesting Age (days)
PTA-1	98.67 ab	172.68 a
PH-4	98.10 abc	148.93 c
BTA-2	100.30 a	171.34 a
GT-2	99.53 a	170.83 a
TJR-2	95.66 c	167.30 b
KKD-3	96.00 bc	172.67a

Note: Numbers followed by different letters in the same column are significantly different based on the post hoc Duncan's New Multiple Range Test (DNMRT) at the α 0.05 level.

3.3. Productive tillers

Not all adlay tillers that form are productive, productive adlay tillers are those that are capable of producing panicles. According to the Duncan's post hoc test, the observation of the number of productive tillers in the six adlay accessions showed a significant difference (Table 3). The accession with the highest number of productive tillers compared to the others is the adlay with the code KKD-3, with a value of 7.46 stems, while the least productive tillers were observed in the accession with the code GT-2 (5.02 stems). The range of productive tillers in this study, 5.02 - 7.46 stems, is lower compared to other adlay research findings. Handayani et al. [20] revealed that adlay had a range of 7 - 14 tillers, while Qosim et al. [16] characterized four adlay genotypes with a range of 10.08 - 17.25 tillers.

Table 3: Number of productive tillers in six local adlay accessions from West Sumatra.

Accession Code	**Productive tillers**
PTA-1	6.04 ab
PH-4	6.88 ab
BTA-2	5.17 ab
GT-2	5.02 b
TJR-2	6.94 ab
KKD-3	7.46 a

Note: Numbers followed by different letters in the same column are significantly different based on the post hoc Duncan's New Multiple Range Test (DNMRT) at the α 0.05 level.

Aradilla [18] added that the appearance of the six adlay varieties studied had 10 - 13 productive tillers. The lower number of productive tillers is likely due to the cultivation of plants in less-than-ideal conditions (utilization of land with Ultisol order), and the presence of limiting factors from both biotic and abiotic environments can affect tiller formation. Stress will affect all processes in plants, including germination, emergence, leaves, roots, and tiller development [21]. Productive adlay tillers under suboptimal environmental conditions are fewer compared to when planted in ideal conditions, where adlay can produce 17-19 tillers per stem [22].

3.4. Seed weight per clump and 100-Seeds weight

The differences in the planted accessions significantly influenced the observed outcomes, namely seed weight per clump and 100-seeds weight (Table 4). Variation in seed weight among accessions indicates seed quality (larger or plumper) due to differences in stored assimilates within the seeds. Jabereldar et al. [23] stated that the weight of 100 grains could be influenced by water stress and genotype. Based on the results obtained, the accession with the code PH-4 had the highest seed weight per clump at 126.25 g, but it also had one of the lowest 100-seed weights at 12.21 g. Consistent with the findings of Ruminta et al. [24], who mentioned that adlay cultivated in three locations with different climate types had seed weight per plant values ranging from 173.88 g to 286.33 g, and 100-seed weights ranging from 12.43 g to 13.07 g.

Although the PH-4 accession had a low 100-seed weight, it had the highest yield value at 62.97%. This is supported by the fact that the PH-4 accession has a thinner epicarp structure compared to other accessions, which typically have thicker and harder epicarps. Additionally, the PH-4 accession has a higher weight of dehulled seeds based on previous research Ramadhan [25]. It is known that yield is the percentage of milling weight to the weight of the material milled. Liu et al. [26] added that there are broadly two types of adlay: Coix lacryma-jobi L. and Coix aquatica Roxb., where C. aquatica is the oldest relative of var. puellarum, var. lacryma-jobi, and var. ma-yuen. Var. ma-yuen is commonly cultivated and its distinctive feature is its thin and easily breakable epicarp. On the other hand, C.l. var. lacryma-jobi is often referred to as Hanjeli batu due to its very hard and difficult-to-break epicarp.

Table 4: Seed weight per clump and 100-seed weight in six local adlay accessions from West Sumatra.

Accession Code	Seed Weight per Clump (g)	100 - Seeds Weight (g)	Rendement (%). Source : Ramadhan et al. [25]
PTA-1	88.29 b	16.18 d	19.01
PH-4	126.25 a	12.21 e	62.97
BTA-2	85.36 b	22.59 c	23.02
GT-2	94.17 b	12.82 e	27.56
TJR-2	100.30 b	25.44 b	25.16
KKD-3	100.16 b	29.77 a	20.06

Note: Numbers followed by different letters in the same column are significantly different based on the post hoc Duncan's New Multiple Range Test (DNMRT) at the α 0.05 level.

3.5. Starch content

Starch is one of the primary forms of carbohydrates present in a food material. Based on the analysis of starch content in the six studied adlay accessions, there is variability in the starch content present in each accession. The GT-2 accession has the highest starch content at 61.26%, while the lowest starch content is found in the BTA-2 and PH-4 accessions (56.64% and 56.77%) (Figure 3). The differences in starch content are indicated to be a result of different genetic factors for each accession. Chaplin [27] revealed that the form and size of starch granules differ depending on the plant source and are characteristic of each type of starch.

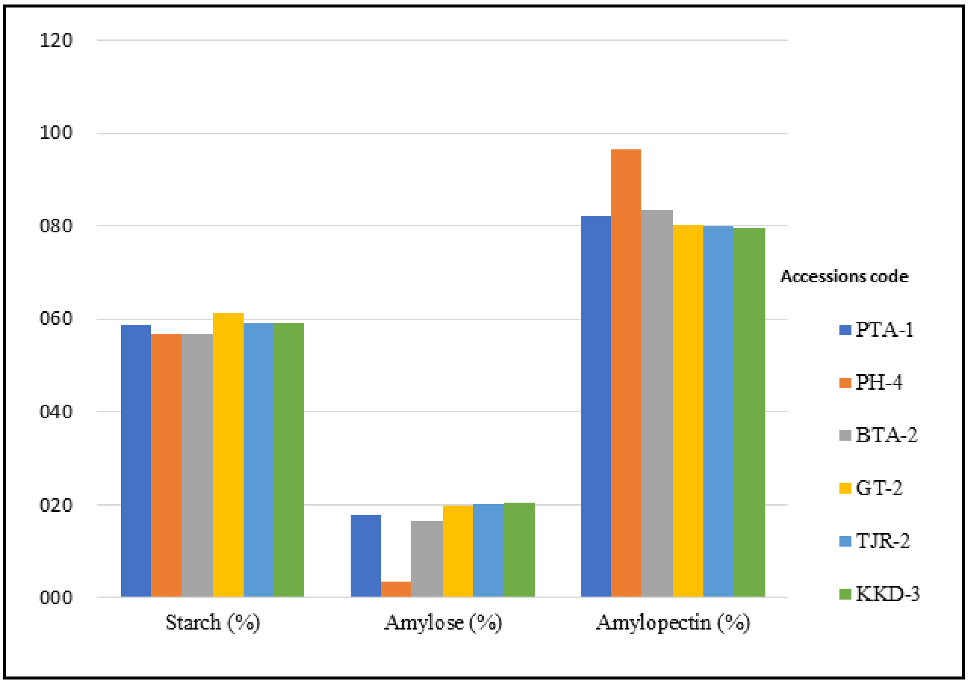

Figure 3: Starch, amylose and amylopectin in six local adlay accessions from West Sumatra.

In addition to the differences in starch content, the percentage of amylose and amylopectin values also show variations for each accession (Figure 3). Amylose and amylopectin play roles in determining the physical, chemical, and functional characteristics of starch. Based on the analysis of variance, the highest amylose content is found in the GT-2, TJR-2, and KKD-3 accessions (19.90%, 20.03%, and 20.48%), while the highest amylopectin content is present in the PH-4 accession (96.60%). Lopulalan et al. [28] stated that the proportion of amylose and amylopectin varies across different sources of starch, as well as the forms and sizes of the granules they constitute. Generally, starch has a much larger proportion of amylopectin compared to amylose. The amylose content in most sources of starch typically ranges between 20-30%, and amylopectin between 70-80%. The higher the amylopectin content, the starch tends to be more wet, sticky, and slightly water-absorbing. Conversely, if the amylose content is high, starch is dry, less sticky, and readily absorbs water (hygroscopic). Winarno [29] added that food materials with very high amylopectin content, such as glutinous rice (98-99%), will have much higher adhesiveness.

4. Conclusion

The conclusion of this study is that there are significant differences in both agronomic aspects and starch content among the tested accessions. The PH-4 accession of adlay stands out in terms of harvesting age and production. Adlay has a starch content ranging from 56.64% to 61.26%, with the PH-4 accession having the highest amylopectin content (96.60%), while the highest amylose content is present in the GT-2, TJR-2, and KKD-3 accessions (19.90%, 20.03%, and 20.48%). Accession PH-4 can be proposed as a candidate for Adlay variety assembly.

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