



Characterization of Two New Varieties of Curly Chili (*Capsicum annuum* L.) for Quality Standard

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Abstract. Two commercial curly red chili varieties cv. Amro-99 and cv. Kencana was identified and analyzed. The purpose of this research is to recognize and describe the physical and chemical contents of the two potential chilies for sorting, welding, and packaging technology to meet consumer needs and export quality. Two hundred chili samples for each variety were obtained from farmers in Kawali District, Ciamis Regency. The results showed that the cv. Amro-99 had a larger size and was longer than the cv. Kencana. Physical characteristics of cv. Kencana and Amro-99 are almost the same except for the petal margins. The cv. Amro-99 has higher fat, water, protein, and vitamin C content than the cv. Kencana, but cv. Kencana has a spicier taste because it has a higher capsaicin content. According to Codex standards for spiciness, cv. Kencana and cv. Amro-99 is included in the medium category for the content of capsaicin. The results of this study can be used to map marketing strategies and the basis for considerations to engineer postharvest chili peppers. Through branding, products can be identified and converted into sales value. The most important chili characteristics are spiciness and red color. Therefore, branding can be done easily through variety, spiciness, and red color, which will help determine the target -of consumers' markets.

Keywords: Characterization · Chili · Physical · Chemical

1 Introduction

Chili (*Capsicum annuum*) is considered the most frequently used commercial spice. Indonesia's domestic demand for red chili range between 720,000–840,000 tons/year, with the national production, being 1,061,428 tons/year, from the harvest area of 126,790 ha [1]. Indonesia has immense potential to produce different types of chilies. Problems with chili in Indonesia are constrained by the standards determined by export destinations, such as weight, uniformity in size, color uniformity, and spiciness. Therefore, chili characterization needs to be done in terms of physical size, dimensions, weight, the shape of the petal margin, and fruit shape groups. Similarly, its chemical content characterization includes capsaicin, anthocyanin, moisture, ash, fat, protein, and vitamin C levels. Chili cv. Kencana and cv. Amro-99 as superior varieties that the Ministry of

Agriculture has released as fresh chili for export. There are no data on the physical and chemical characteristics that can be used as a standard in global trade.

Vegetable Research Institute (Balitsa) since 1980 has released six new superior varieties (VUB), namely Lingga variety, Tanjung-1, Tanjung-2, Ciko variety, Kencana, and Lembang-1. The two potential varieties of curly chilies in Indonesia are Kencana and Amro-99. The important parameter in the scheming of handling, grading, processing, and packaging systems of agricultural products, is its physical character. Some important physical characteristics in handling systems are volume, weight, projected area, and center of gravity [2]. For chili, the product length, width, and thickness are important parameters [2, 3]. The information of length, width, volume, surface area, and center location of mass may be utilized in the designing of sorting machinery. Before designing the sorting machinery, the surface area is needed to predict when applying chemicals. The shape factor (sphericity) and surface area of the yield is needed in the peeling operation [4].

This study was accomplished to define the geometric proportion, specific heat, and density of chili with different moisture content. This study aim to distinguish and characterize the chemical and physical characteristics of two potential cayenne chilies for use in the sorting, grading, and packaging process and quality management for product export.

2 Material and Methods

2.1 Materials

The study was conducted in February 2014. Two commercial varieties of chili used in this research were Kencana and Amro-99. Freshly harvested chilies of two varieties were obtained from three different field plantations in Kawali Sub District, Ciamis Regency. Chili harvesting is done by local farmers in the morning against several chilies with an aging level according to local market demand. Yields collected in warehouses are available, and chilies were stacked in the amount of harvest obtained. Furthermore, randomly taken as a sample for the study, approximately 200 chilies were selected with the same color, size, and no defects. The dimensions were determined by selecting randomly 200 fruits of each variety after fruit sorting from decay or abnormal shape.

2.2 Methods

2.2.1 Physical Analysis

Chili samples of each field plantation were selected randomly to record observations on fruit character including fruit length, weight, diameter, volume, and fruit color. The size of the chilies was determined by selecting chilies randomly and measuring the three diameters (major, medium, and minor).

Based on the chili character, the shape was expressed as sphericity, cylindricity, and roundness. This expression is then compared to the standard chart. It is defined as oblong when its horizontal diameter is smaller than the vertical diameter [5].

Samples of 200 chilies from each cultivar were randomly selected. The weight of 200 fruits was defined at the ambient temperature of 28.5 °C by counting 200 fruits randomly and weighing them by an electronic balance with an accuracy of 0.01 g. The average mass of 200 chilies was calculated. Three times replicated for each experiment were conducted for each moisture content.

Fruit length was measured using a flexible ruler meter from the base/bottom of the fruit to the apex. The fruit diameter was measured with a veneer caliper at the stem end, middle part, and fruit blossom end. The mass of each chili was measured at 0.01 g on a digital balance. The volume of chili was measured by displacement water. The chili was submerged into the known water volume, and the volume of water displaced was measured. Ten chili fruits from each cultivar were selected randomly. The number of seeds of each fruit was calculated, and the mean seed number per fruit was computed. The peduncle length of the chili was measured from the bottom of the peduncle to its top in centimeters. The skin color was measured directly on three zones of the chili skin. The average measurement of 200 chilies was calculated. The color was measured using a Minolta (CR-200 model) tristimulus colorimeter with illuminant C. The results are expressed in CIE L*, a*, b* values. Physical characteristics such as appearance, color, and shape were recorded by visual observations and compared to the standards of The International Plant Genetic Resources Institute/IPGRI [6].

2.2.2 Chemical Analysis

Chemical analyses were analyzed in triplicates for moisture, ash, fat, protein, vitamin A, C, E, anthocyanin, and capsaicin. The moisture content was calculated after drying in an oven at 105 °C till the constant weight was obtained. The calculation results are obtained from the differentiation between the accurately weighed samples before and after drying [7]. Ash was determined by weighing a sample of known weight (10 g) in a crucible in a muffle furnace for three hours at 600 °C and then cooled. The sample was then weighed and the difference in weight was expressed as the weight of the ash [8]. Fat content was analyzed by solvent extraction method by circulating petroleum ether over the sample in soxhlet apparatus for 14–16 h [8]. The vitamin C content was analyzed using the 2,6-dichlorophenol indophenol titration method (Association of Official Analytical Chemists) [7]. Protein, vitamin A, E, and anthocyanin were determined using the standard procedures. Estimation of capsaicin content was estimated by HPLC (condition: column C18 with the size of 150 × 4.6 mm × 3 μm; the mobile phase: H₂O/CH₃CN, 50:50 v/v, flow rate: 1 mL/min, UV detection at 222 nm, volume inject 20 μm). The three times replicates were conducted at each of the varieties. Descriptive analysis was used in this study.

3 Results and Discussions

Chili is significant as a food additive worldwide. It has great diversity in size, shape, skin color, pungency, flavor, and aroma. In Indonesia, chili peppers have broad utilization in most typical dishes, and consequent they play fundamental roles in culture and cuisine. The compounds that are synthesized and accumulated in chili pepper fruits are

capsaicin which is responsible for the pungent taste, vitamins A, vitamin C, vitamin E, and pigments (anthocyanins and carotenoids) [9, 10]. Generally, chili has a high concentration of vitamins A, C, and E the oxidative vitamins [9]. The presence of each of these compounds makes chili peppers commonly used in food, pharmaceutical, and cosmetic industries.

3.1 Physical Characteristics

There are some quality parameters such as length, width, skin thickness and pod, and seed ratio of chili [11]. The size and shape of chili are important in their electrostatic separation from unwanted materials. It is also important for the development of sizing and grading machinery. For analytical prediction of its drying behavior, the shape of chili is needed [12]. Physical characteristics of the chili cultivar showed that Amro-99 had a bigger size than Kencana (Table 1). The table showed that the whole fruit weight of Kencana is more varied with intervals of 2.09–6.12 g, but the average whole fruit weight of Amro-99 is higher than Kencana. The edible portion of Kencana is more varied, with intervals of 1.91–5.73 g. The whole fruit length, stem length, peduncle length, and fruit length of Amro-99 is more varied than Kencana, and the average fruit length of Amro-99 is higher than Kencana. The fruit diameter of Amro-99 is more varied and bigger than Kencana.

Table 1. Physical characteristics of chili CV. Kencana and CV. Amro-99 (mean \pm sd)*

Characters	Kencana	Amro-99
Whole fruit weight (g)	3.63 \pm 0.96	3.66 \pm 0.66
Edible portion (g)	3.37 \pm 0.88	3.53 \pm 0.66
Whole fruit length (cm)	15.00 \pm 1.94	16.99 \pm 1.87
Stem length (cm)	3.65 \pm 0.77	4.78 \pm 0.67
Peduncle length (cm)	0.71 \pm 0.18	0.78 \pm 0.15
Fruit length (cm)	10.64 \pm 1.67	11.43 \pm 1.45
Stem end diameter (cm)	0.73 \pm 0.09	0.81 \pm 0.09
Middle part of fruit diameter (cm)	0.74 \pm 0.08	0.71 \pm 0.06
Fruit blossom end diameter (cm)	2.80 \pm 0.62	3.09 \pm 0.45
Seed amount (seeds)	64.23 \pm 12.08	63.29 \pm 8.94
Fruit color (visual rating method)	3.65 \pm 0.91	4.92 \pm 0.28
Color (L*)	41.51 \pm 2.32	37.99 \pm 3.11
Color (a*)	41.65 \pm 2.64	41.08 \pm 2.01
Color (b*)	34.55 \pm 4.00	32.81 \pm 2.53
Volume	3.64 \pm 1.44	3.73 \pm 0.82
Fruit firmness (mm)	9.15 \pm 1.18	9.75 \pm 1.38

* Remarks: Data obtained from 200 chili with three replications

Table 2. Indonesian standard for fresh chili (SNI 01-4480-1998)

Character	Grade I	Grade II	Grade III
Fruit length (cm)	>12–17	10–<12	<10
Stem end diameter (cm)	>1.3–1.5	1.0–<1.3	<1.0

According to variety description [13], Kencana have 10.7–16.8 cm length, 3.0–3.9 g whole fruit weight, and 0.7–0.8 cm width. Based on those characters, Kencana characters in this study were in range with that variety of descriptions. According to the variety description for Amro-99 [14], it has a 15.0–16.0 cm fruit length, a diameter of 0.8–0.9 cm, and a whole fruit weight of 5–6 g. Based on those characters, the Amro-99 character has a relatively low value than the variety description.

The fruit weight was significantly correlated with an amount of seeds per fruit. This indicated that the seeds may be contributing significantly to weight, or affecting the higher growth of mesocarp. This impact has been reported for *Capsicum annum*, and pomegranate [15, 16]. Leaf and fruit color were measured using a standard color chart. This method for measuring the color of fruits such as cherries has been reported [17].

The Indonesian Standard for Fresh Chili (SNI 01-4480-1998) [18] described three grades of standards for fresh chili. But the standard only describes fruit length and stem end diameter for physical characteristics of fresh chili, as shown in Table 2. Compared with the SNI for fresh chili, the fruit length of Kencana and Amro-99 fit the Grade II, and the stem end diameter of Kencana and Amro fit to Grade III.

Adetula and Olekojo [18] research on the characteristic of “shombo” pepper showed that the average fruit length was 9.78 cm, average fruit weight was 34.40 g, and fruit peduncle was 3.24. And fruit blossom 1.23 cm. This showed that chili cultivar Kencana and Amro-99 had almost similar sizes to “shombo” pepper from Nigeria, but the “shombo” pepper was much heavier. Research on manzano hot pepper showed that the fruit diameter ranged from 1.1–1.3 cm, higher than Kencana and Amro-99 fruit diameter i.e.: 0.74–0.71 mm respectively [19].

As two different cultivars were reviewed, the L^* , a^* , and b^* values between the cultivars vary. The L^* values differentiation in a wide range, which indicates that color brightness differed between cultivars. According to the L^* value, Kencana cultivar has a lighter color than Amro-99. The mean value of a^* indicated the contribution to the red color. The result showed that Kencana has more red color than Amro. The b^* parameter which contributes to yellow for Kencana is also higher than Amro. According to that, for the fruit color, the cultivar Kencana is dark red.

Khyadagi [20] research on 17 chili cultivars showed that the physical characteristics of ripe chilies are varied. The average length of ripe chilies ranged from 7.02 to 15.65 cm. The highest length was recorded in cultivar Byadagi Kaddi (15.65 cm) and the lowest in MSH-11 (7.02 cm). The average diameter of chili cultivars varied from 2.79 to 12.15 cm. Maximum diameter was noticed in SH-5 (12.15 cm) and minimum in MSH-11 (2.79 cm). This showed that Kencana and Amro-99 had the size in the range of those chilies.

Teotia and Raina [21] evaluated chilies grown in Himachal Pradesh. They found that the average weight of chili ranged from 0.35 to 0.74 g. The seed and pod ratio

was 1:1.62 to 1:2.90; the average length was 3.66 to 5.65 cm, while the average seeds number per pod was 45 to 72, and the placenta percentage was 1.81 to 2.71. Teotia and Raina [22] studied the size of chili from different areas in Haryana, and showed that the girth of fruits ranged from 6.56 to 6.23 cm. Raina and Usha [23] reported the genotypes of the fruit weight and related characters. Their study showed that the fruit weight positively correlated with the pericarp weight, number of seeds per fruit, the fruit diameter, seed weight, and the weight of 100 seeds. Similarly, other research observed significant differences in fruit diameter and fruit length in capsicum genotypes [24, 25].

According to CODEX STAN 307-2011 [26] for chili packaging standards, each chili packaging must be uniform and contain only chili peppers of the same origin, quality, size, and variety. The noticeable part of the contents of the package must represent the entire contents.

3.2 Physical Descriptors

Nicolai [27] gives an illustration of the fruit shape groups as shown in Fig. 1. There are six chili shapes: spherical sharp-end, rectangular, triangular, spherical blunt-end, elongated short, and elongated long. According to this, chili of cv. Kencana and Amro-99 had elongated long shapes.

According to IPGRI [6], chili fruit shapes vary between cultivars, such as fruit shape, calyx margin, and calyx annular constriction. Figure 2 illustrates the calyx margin shape, and Fig. 3 shows the physical comparison of the two chili varieties. The physical descriptors of chili cv. Kencana and Amro-99 are almost the same except for the calyx margin (Table 3). Chili cultivar Kencana calyx margin is dentate, as for Amro-99 is intermediate. Calyx or also called a crown is the structural base of the flower. The color is generally green and its vertices are called sepals. In the case of chili is an obstinate calyx as it preserves with fruit.

In comparison with Adetula and Olekojo findings [18], the physical descriptors of shombo pepper were different from chili Kencana and Amro-99. Shombo pepper had a smooth calyx margin shape and acute fruit shape at the peduncle.

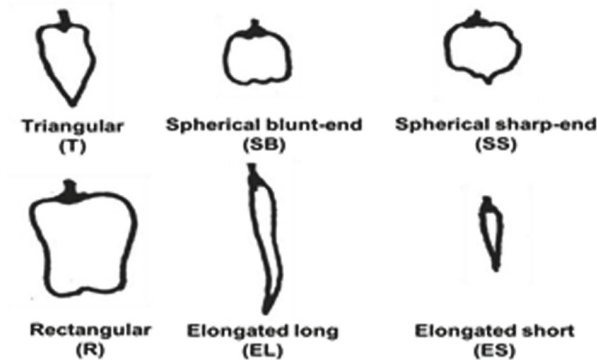


Fig. 1. Illustration of the chili fruit shape (adapted from Nicolai et al., 2013) [27].

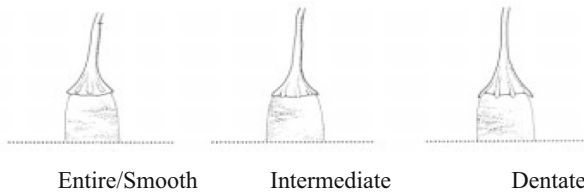


Fig. 2. Calyx margin shape (adapted from the International Plant Genetic Resources Institute/IPGRI, 1995) [6].

Table 3. Physical descriptors of chili Kencana and Amro-99 by IPGRI descriptors

Characteristics	Kencana	Amro-99
Fruit shape	Elongate	Elongate
Calyx margin	Dentate	Intermediate
Fruit shape at pedicel attachment	Obtuse	Obtuse
Calyx annular constriction	Absent	Absent
Fruit shape at blossom end	Pointed	Pointed
Fruit blossom end appendage	Absent	Absent



Fig. 3. The image of Chili cv. Amro-99 (a) and CV. Kencana (b) in this study.

3.3 Chemical Characteristics

Chemical characteristics of chili cultivar Kencana and Amro-99 are given in Table 4. The table shows that chili cultivar Amro-99 has higher fat, water, protein, capsaicin, and vitamin C content than chili cultivar Kencana. The fat, protein, vitamin C, and capsaicin content were significantly different between Kencana and Amro-99. Indonesian Standard for Fresh Chili (SNI 01-4480-1998) described three grades of standard for fresh chili, but there was no standard for chemical characteristics of fresh chili. The chili export standard has not yet referred to the detailed chemical requirements, so the results of the research characterization can be used as a proposed standard for chemical exports. According to Pednekar [11] for commercial judgments, chili has two basic criteria pungency/capsaicin content and red color. In this study, the capsaicin content of Kencana was 1,160 ppm, while Amro was 296.5 ppm. The Codex standard (CODEX STAN 307-2011) for total capsaicinoids (micro g/g dry weight) for chili are: mild (60–133 micro g/g), medium

Table 4. Chemical characteristics of chili Kencana and Amro-99

Chemical Characteristics	Kencana	Amro-99
Fat (%)	0.61 ± 0.07	2.24 ± 0.17
Water Content (%)	78.39 ± 0.68	78.96 ± 0.88
Ash (%)	1.53 ± 0.19	1.39 ± 0.28
Protein (%)	0.93 ± 0.05	3.86 ± 0.88
Total Soluble Solid (TSS) (⁰ Brix)	7.33 ± 0.64	–
Vitamin A (IU/100 g)	2,705.55 ± 997.16	–
Vitamin C (mg/100 g)	104.93 ± 12.67	140.10 ± 15.17
Vitamin E (mg/100 g)	104.26 ± 1.61	–
Anthocyanin (ppm)	104.26 ± 1.61	–
Capsaicin (ppm)	1,160 ± 0.47	296.5 ± 12.1

(134–1,333 micro g/g), hot (1,334–6,600 micro g/g), and extra hot (> 6,600 micro g/g). According to that standard, Kencana and Amro have a medium category for capsaicin content.

Nutritional and chemical compositions are varied in different chilies variety; also, in different chili planting locations [21, 28, 29]. Chili composition differs considerably among the cultivars. This is related to seasonal conditions and the fruit maturity at harvest. Fresh chili contains 0.1 to 2.6% of steam-volatile oil, fixed (fatty) oil of 9 to 19%, pigments, pungent principles resin, protein at 12 to 15.5%, cellulose pentosan, and minerals. Fresh chilies are rich sources of vitamin C and an important source of vitamin A [30]. Chili contained high levels of L-ascorbic acid and carotenoids at maturity. The L-ascorbic acid contributes 124–338% of the RDA for vitamin C, and carotenoids contribute 00.33–3.36 RE per 100 g of provitamin A activity [30, 31]. Chili fruits of high quality were large, heavy, and contained low content of capsaicin but higher sugar capsanthin [32]. Chili has a high concentration of vitamins A, C, and E, the oxidative vitamins [9].

Hot chili pepper contains capsaicinoids the chemical group of alkaloids, which caused the pungency. Pungency in chili is due to the alkaloid “capsaicin” contained in the placenta and pericarp of the chili fruits; it produces mild to intense spice when eaten. Pungency, a commercially important attribute of peppers, is related to chemicals from the capsaicinoids group [33]. The two most abundant capsaicinoids in peppers are capsaicin (8-methyl-N-vanillyl-trans-6-none namide) and dihydrocapsaicin. The capsaicin constitutes about 90% of the total capsaicinoids in most of the pungent varieties. The major parameter that determined chili commercial quality is capsaicin content [34–37].

Capsaicinoids are mostly consumed as naturally occurring pungency-producing components of Capsicum spices (chili, red pepper, and cayenne pepper). Their concentrations vary between the variety. It usually ranged from 0.1 mg/g in chili pepper, 60 mg/g in oleoresin red pepper, and 2.5 mg/g in red pepper [38]. The total capsaicinoids/g of dry weight content in pepper varieties from *Capsicum annum*, *C. frutescens*,

and *C. chinense* are around 0.22–20 mg [39]. Another study showed that cayenne pepper had average capsaicin and dihydrocapsaicin contents of 1.32 and 0.83 mg/g dry weight, respectively.

Capsaicin is a potent inhibitor of the Phosphorous (P) component. P is a neuropeptide related to inflammatory processes. The hotter the chili pepper, the more capsaicin contain in the chili. The topic of capsaicinoid content in chili pepper has recently been reviewed. The study concluded that the content of capsaicinoid responsible for the pungency of Habanero chili peppers varied between 41.8 and 65.9 mg/g of dry fruit. The average concentration of capsaicinoid in the red cultivar was 45.0 mg/g of dry fruit, while in the orange Habanero cultivar was 55.0 mg/g [40]. Kencana and Amro-99 are included as cayenne chili pepper. Cayenne characteristics were tapered and slender. This chili is typical in its dried, ground form—the powder known as cayenne pepper. Ground cayenne pepper is the main ingredient in chili powder such as chili con carne. The Scoville heat units are 30,000 to 50,000.

Important factors to be deliberated for the market value of chili peppers are color and pungency. The pungency of capsicum depends on capsaicinoid compounds, primarily capsaicin (8-methyl-N-vanillyl-trans-6-nonenamide) and dihydrocapsaicin, which are the major pungent principals of chili pepper. The commercial quality of chili pepper fruit is related to capsaicin content because of its presence in capsaicinoids. The capsaicin level in chili pepper is determined by two factors that were genotype of plant and environment interactions.

In 2011, the Vegetable Crop Research Institute (Balitsa) succeeded in releasing the chili of New Superior Varieties named Kencana. The variety is a selection of open-pollinated (OP) varieties from the high yield LV6401 strain which is around 12.1–22.9 t/ha with a harvesting age of about 95–98 DAH. Kencana variety has several advantages among others, and they are tolerant to inundation, tolerant to important pests, and adaptive to extra wet seasons. When viewed from the appearance of the fruit, the brightness of the Kencana variety is below the hybrid variety (TM 99). Still, the Kencana variety has a spiciness rate of 4x compared to the TM 99 variety (capsaicin level 86.1 ppm).

4 Conclusion

The research showed that the chili cultivar Amro-99 has a bigger size and is more prolonged than the chili cultivar Kencana. The physical descriptors of chili cv. Kencana and Amro-99 are almost the same except for the calyx margin. Chili cultivar Amro-99 has higher fat, water, protein, and vitamin C content than chili cultivar Kencana, but Kencana has the hottest taste since it has higher capsaicin content. According to Codex standard, Kencana and Amro have a medium category for capsaicin content.

Reviewing the properties of agricultural materials was important to practical utility in the machine and structural design, and process control and engineering. The geometric dimensions of chili are needed in designing the packaging and grading equipment. The dimensions of chili also influenced the drying characteristics. The fruit weight is important in the design of cleaning and grading equipment. The research work can be useful for mapping out a strategy for marketing.

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