

Effect of various maturity levels on the psychochemical properties of Cayenne peppers (*Capsicum frutescens* L.)

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Abstract

In this study, three types of cayenne pepper, namely catas, segana, and domba, were each harvested at three levels of maturity, namely green maturity, orange maturity and red maturity. The results obtained that the type and level of maturity have a significant effect on $P > 0.05\%$ on the content of capsaicin and physical properties of cayenne pepper. Small cayenne pepper has the highest capsaicin content at the level of red maturity. Catas type of pepper has the highest capsaicin content of 394,253 ppm. The type and level of maturity of cayenne pepper influences the capsaicin content. Different types of cayenne pepper give a real influence on the texture, weight, color, length and diameter of the fruit, while the level of maturity does not significantly affect the weight, length and diameter of cayenne fruit.

Keywords: *capsicum frutescens*, capsaicin, maturity, colour, texture, HPLC

1. Introduction

Cayenne pepper has been widely cultivated and is widely known by the public. Demand for cayenne pepper in Indonesia continues to increase from year to year. In Indonesia Spicy eating habits have become part of the culture for spicy food lovers. The use of cayenne pepper in the culinary field depends on the shape, color, size, weight, and texture, where all these factors are determined by the type and stage of maturity. The process of pepper maturity involves a number of complex reactions that will affect the quality. Different types require different levels of maturity when harvesting, this depends and is influenced by market demand and consumer tastes. The right harvest time will provide optimal quality cayenne pepper which will affect the shelf life^[1, 2].

Among the types of cayenne pepper that are very popular in Indonesia are the types of small cayenne pepper, green cayenne pepper, and white cayenne pepper. The types of cayenne pepper (*Capsicum frutescens* L.) used in this study are catas for small cayenne pepper, segana for green cayenne pepper, and domba for white cayenne pepper. Each type used has a different character when the harvest process is carried out. The three types of cayenne pepper are harvested at different levels of maturity to meet market demand and follow consumer tastes. In Indonesia, small cayenne peppers and green cayenne peppers are consumed in a fresh state at the level of green maturity, while for the type of white cayenne pepper the sheep is consumed mostly at the level of orange or red maturity. The type and level of maturity affect the content of secondary metabolites in pepper. Capsaicin is a secondary metabolite found in solanaceae^[3]. The content of capsaicin in pepper is determined by genetic traits, cultivation factors and is also influenced by various factors such as weather conditions

during the growing season, fertilization, harvest time, and fruit maturity stage^[4, 5]. The amount of secondary metabolite content in all types of plants is strongly influenced by species and varieties as well as environmental conditions^[6]. Environmental stress factors due to lack of water can increase the production of capsaicin content in pepper. In addition, it is known that the capsaicin content in pepper can vary between different fruits in the same plant, even though it is harvested at the same time^[7].

Several studies have shown that capsaicin starts to accumulate in the early stages of fruit development and accumulates during the ripening stage until it reaches its maximum concentration^[8]. The placenta contains more capsaicin than other parts such as pericarp and seeds^[9]. Capsaicin is also found in the vegetative organs of pepper plants such as leaves and stems^[10]. The capsaicin found in the vegetative organs of pepper plants comes from the fruit, this was proven in a study in which at the development stage the flower buds were removed and the formation of fruits were prevented, showing that capsaicin was not found in the vegetative organs of leaves and stems of pepper plants^[11]. Pepper has good nutrition and is high in vitamin C^[12]. The content of capsaicin has been widely used, one of which is in the pharmaceutical industry. Capsaicin has pharmacological effects, including fibrinolytic agents, chronic pain therapy, migraine, and arthritis^[13]. Capsaicin is useful as anticancer and anticarcinogenic^[14], antioxidants, regulate fat metabolism, anti-inflammatory, play a role in protecting the gastric mucosa and antimicrobials^[15-18]. Capsaicin is also useful as an anti-allergic because it has the ability to blunt the peripheral nerves, pepper can help cure bronchitis, influenza, sinusitis, and asthma with the ability of capsaicin to remove mucus from the lungs. Capsaicin is

Able to protect trachea, bronchial, and bronchoconstriction cells from air pollution and cigarette smoke [19].

In some food industries, pepper processing requires a different level of spiciness for each product produced. A different level of spiciness is needed by the food processing industry which processes raw pepper raw materials into various processed food products, for example one of the results is processed pepper sauce. Spicy pepper sauce requires different spicy sweet pepper or hot spicy pepper (hot spicy), as well as spicy pepper plow different from the sambal for sardines and rendang. To obtain the desired level of spiciness, pepper sauce companies often add the raw material of pepper to a certain ratio when processing pepper sauce in order to modify the spicy taste. This is because cayenne peppers have higher capsaicin content.

High capsaicin content in pepper is needed for raw materials for food and pharmaceutical industries. An important issue for producers of horticultural products is to determine the type of cayenne pepper and the optimal level of maturity to carry out the chilli harvest process so as to obtain the quality of pepper that will have the highest capsaicin content. With the consideration that the high content of capsaicin as a raw material for industry. Fruit harvest time and maturity level are important factors to get the harvest according to the needs and demands of consumers. The purpose of this study is to look at the effect of the type and level of maturity of cayenne pepper at the green maturity stage, the orange maturity stage, and the red maturity stage.

2. Materials and methods

2.1 Materials

Catas, segana, and domba cayenne peppers are harvested by hand at full green, orange and red maturity stages from Lembang farmers, West Java, Indonesia. The pepper yields are transported to Padjajaran University's food testing laboratory in 2.5 hours. Fresh cayenne pepper is separated from twigs, stems and leaves that are carried during the harvest process and the pepper quality is not physiologically good because of disease pests. The peppers selected from each type are weighed 300 grams and distributed in 100 gram containers each into three groups.

2.2 Capsaicin extraction

The extraction method carried out refers to the capsaicin extraction method using Soxhlet, the extraction is carried out for 30 minutes [20]. Capsaicin was measured through High Performance Liquid Chromatography (HPLC).

2.3 Color

The color of the cayenne was measured with a Minolta Chroma Meter CR-400, AC Adapter = 2A, USE AC-A305, 1.5Vx4.0.2A Batteries, Konica Minolta, Inc., Japan, with a measuring tip 8 mm in diameter calibrated with a white plate C factory standard illuminant C y 86.1 x 3164 y 3230. Based on the CIELab colorimetric system (L *, a * and b *). Samples of cayenne each of ten pieces in each treatment and carried out three times. Color measurements were carried out at three points for each pepper, namely the base of the fruit, the middle of the fruit, and the end of the fruit. The results obtained were calculated in Lab values.

2.4 Texture

The texture was measured using a TA Express Texture Analyzer (Stable Micro Systems Ltd., UK) which was

Equipped with an SMS-P/6 CYL cylinder pusher. Compression mode test pre-test speed 1.50 mm/s, test speed 2.00 mm/s post-test speed 10.00 mm/s, distance 15,000 mm, trigger type 5.0 g. Texture analysis of ten cayenne for each treatment, each treatment was repeated three times. The sample was stabbed to penetrate the fruit. The texture parameters of Upper Skin Strength and Lower Skin Strength were determined from the style-time profile.

2.5 Weight, length and diameter

Weights were measured using OHAUS CP214 digital analytical balance. The weight of each cayenne sample was ten pieces per treatment and three replications were repeated for each treatment.

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The diameter of the cayenne pepper was measured using a sorong term, and 20 cayenne peppers were measured for each experimental unit. Measurements were made at three points in each fruit, namely, the base diameter of the cayenne pepper (the part near the stem), the middle diameter of the cayenne pepper and the diameter of the cayenne pepper end. Each experiment was repeated three times for each experiment. Measurement of cayenne pepper was measured using calipers, ten pieces of cayenne pepper measured for each unit of experiment. Measurements were made at three points in each fruit, namely, the base diameter of the cayenne pepper (the part near the stem), the middle diameter of the cayenne pepper and the diameter of the cayenne pepper end. Each experiment was repeated three times for each experiment.

2.6 Statistical analysis

Data were analysed statistically through ANOVA by using SAS 9.1.3. All experiments were repeated three times. Duncan multiple range tests were conducted at a 0.05 level (Steel *et al.*, 1994).

3. Results & Discussion

3.1 Capsaicin

The type and level of maturity have a significant influence on the level of P > 0.05% on the content of capsaicin in cayenne pepper, as shown in Table 1. Of the three types used catas type has the highest capsaicin content when compared to the other two types namely 394,253 ppm. This is due to the influence of genetic differences where the type of catas has a high genetic content of capsaicin. In Indonesia, catas pepper is known as a small cayenne pepper which is famous for its spiciness and is widely cultivated by the community. In accordance with the results of research that has been done in which the production of capsaicin is influenced by genetic and environmental factors [22].

The content of capsaicin is observed in green, orange, and red maturity, the results show that the level of maturity has a significant effect on the content of capsaicin. At the level of red maturity has the highest content of capsaicin and green maturity has the lowest content of the three types tested. This type of information and level of maturity will be very useful for commercial harvesting processes in accordance with market needs and consumer demand. Of the three types of cayenne pepper, two of them are harvested according to commercial market demand at the level of green maturity,

namely catas and segana types. The types of market and industry demand sheep are harvested in a state of ripe red or ripe orange. The harvest process at different levels of maturity also determines the quality of cayenne pepper according to the organoleptic nature of each species. Cayenne pepper consumed fresh is usually the type of catas and segana.

In a study stated that the maturity level of pepper harvested significantly affected the content of capsaicin [4]. Some research that has been done shows that capsaicin starts to accumulate in the early stages of fruit development, subsequently and accumulates during the ripening stage until it reaches its maximum. In other studies also mentioned that the content of capsaicin is also determined by the level of fruit maturity at harvest [23, 24].

The capsaicin content continues to increase along with the fruit maturity process [8]. Late harvest process causes excessive level of maturity and decreases the capsaicin content, the results of a study say that the decrease in capsaicin harvested at a longer harvest time after flowering has decreased water content and increased dark red pepper and decreased capsaicin content by 55 % [8]. Capsaicin biosynthesis occurs in the fruit placenta and is produced through the cinnamic acid pathway [25]. The capsaicin content increases with increasing level of maturity and will decrease when the level of maturity is over 60% the rate of degradation [23].

Table 1: Content of capsaicin in three types of cayenne pepper at various levels of maturity

Types of Cayenne Pepper	Capsaicin (ppm)
Catas	394.253 ^a
Segana	264.140 ^b
Domba	248.048 ^b
Stage of ripening	
Green	245.063 ^c
Orange	292.091 ^b
Red	369.287 ^a

Values with the same letters in each column are not significant (P < 0.05)

3.2 Texture

The type and level of maturity of cayenne pepper significantly affected the level of P > 0.05% on the texture, as shown in Table 2. Catas type small pepper has a stronger and harder texture, this is because the texture of catas cayenne is denser due to the number and composition of catas pepper seeds which are denser and many are arranged tightly on the placenta, this results in pressure applied to penetrate peppers are bigger and make the value of the texture produced from the gauge even greater when compared with the other two types. While the level of maturity also has a significant effect on the texture of cayenne pepper, green cayenne pepper gives a stronger and harder texture value, this is due to the fact that the cayenne pepper with green maturity level of the cell wall of the composted fruit is still intact and has not experienced softening due to fruit ripening which will cause the fruit to decrease the level of hardness due to softening and degradation of cell wall. As we know that the process of fruit maturation will be followed by changes in fruit texture caused by the activity of the enzymes pectin methylesterase

and polygallactorose which remodel pectin compounds that are not soluble in water (protopectin) into pectin compounds that are soluble in water so that the texture of soft fruit [26].

Table 2: Texture of three types of cayenne pepper at various levels of maturity

Types of Cayenne Pepper	Texture (g)
Catas	4768.60 ^a
Segana	4463.35 ^b
Domba	4232.77 ^c
Stage of ripening	
Green	4634.18 ^a
Orange	4362.07 ^b
Red	4468.63 ^b

The same letters in each column are not significant (P < 0.05)

3.3 Color

The type and level of cayenne pepper maturity significantly affected the level of P > 0.05% on the color (L, a, b, and hue), as shown in Table 3. Type significantly affects the color value, this is due to different genetic factors, and each type will give a phenotype (different appearance) on each type. Sheep pepper has a higher brightness level of 50.22 compared to catas and segana. This is due to genetic factors that are more dominant where the type of sheep has bright fruit based on value (L *). The lowest a * value is owned by the segana type of pepper, this shows that the segana pepper has a slight red brightness and is lower when compared to the catas and sheep species, where the red color is very bright and bright. The highest b * value is in the type of domba pepper, where an increase in b * value indicates increasing yellow. While the highest hue value is in the domba pepper. The difference in the color of cayenne pepper in each type is caused by different genetic factors so that it gives a different genetic effect. The level of maturity significantly affects the color, this is because at different levels of maturity give a different color display so that the resulting value is different. Visually clearly visible differences in green, orange and red colors at different maturities. Orange maturity level has the highest L * value and red maturity has the lowest L * value. The green maturity level has the lowest negative a * value, which means the negative value indicates the color that is legible is green. The highest positive b * value is obtained at the level of orange maturity. Whereas the smallest hue value is in green maturity which has a negative value which shows green color. The difference in color at the level of maturity is due to differences in genetic factors that give different appearance according to the genetic of each type.

Table 3: Colors of the three types of cayenne pepper at various levels of maturity

Types of Cayenne Pepper	Color			H° (hue)
	L	A	b	
Catas	29.16 ^d	14.49 ^a	11.95 ^d	2.02 ^b
Segana	28.69 ^d	8.96 ^b	9.21 ^c	2.89 ^c
Domba	50.22 ^a	16.03 ^a	26.72 ^a	4.82 ^a
Stage of ripening				
Green	35.14 ^d	-6.95 ^b	13.93 ^d	-57.98 ^b
Orange	40.54 ^d	23.63 ^a	21.93 ^d	41.27 ^a
Red	32.39 ^d	22.81 ^a	12.02 ^d	26.44 ^a

3.4 Cayenne pepper weights, lengths and diameters

Different types gave significant effect on the level of $P > 0.05\%$ test on the weight of cayenne pepper, as shown in Table 4. Sheep pepper produces higher fruit weight compared to the other two types, this is due to genetic differences where sheep pepper has a genetically larger fruit size so that it affects the fruit weight. From the three types of cayenne pepper the average weight of the catas species has the lowest weight compared to the other two types. This is because the type of catas has a smaller fruit size when compared to other types so that it gives an effect to the lighter weight.

The level of maturity does not have a significant effect on fruit weight, this is because after the fruit reaches an optimal generative phase size the fruit no longer experiences an increase in size but changes color from green to orange and red. In previous studies mentioned that the level of maturity did not affect the weight of pepper [27]. This is because in this study the weight of the fruit was weighed in a fresh state after the harvesting process without any storage process. One decrease in fruit weight after harvest is influenced by the time and storage conditions.

The type of cayenne pepper had a significant effect on the level of P test $> 0.05\%$ on the length and diameter of the fruit, while the level of maturity had no significant effect on the level of P test $> 0.05\%$ on the length of cayenne pepper,

as shown in Table 5. Sheep pepper has a length and diameter of fruit that is greater when compared to the other two, this is due to genetic factors, where the genetic type of sheep pepper produces a larger fruit size and length, so this affects the fruit size.

Maturity level does not affect the length and diameter of the fruit, this is because the harvest process is carried out when the fruit has experienced optimal growth and harvest in physiological maturity, so that no more fruit growth but has entered the generative development phase. The three types used by the level of maturity did not show any significant difference in fruit size, both the length and diameter of fruit.

Table 4: Weight of three types of cayenne pepper at various levels of maturity

Types of Cayenne Pepper	Weights(g)
Catas	1.06 ^c
Segana	1.52 ^b
Domba	2.55 ^a
Stage of ripening	
Green	1.75 ^a
orange	1.66 ^a
Red	1.72 ^a

Values with the same letters in each column are not significant ($P < 0.05$)

Table 5: Length and diameter of the three types of cayenne pepper at various levels of maturity

Types of Cayenne Pepper	Lengths (cm)	Base Diameter of Fruit (cm)	Middle Diameter of Fruit (cm)	Tip Diameter of Fruit (cm)
Catas	3.40 ^b	0.69 ^c	0.49 ^c	0.39 ^c
Segana	2.77 ^c	0.75 ^b	0.67 ^b	0.44 ^b
Domba	4.19 ^a	1.29 ^a	1.32 ^a	0.81 ^a
Stage of ripening				
Green	3.49 ^a	0.90 ^a	0.82 ^a	0.55 ^a
orange	3.45 ^a	0.90 ^a	0.84 ^a	0.56 ^a
Red	3.43 ^a	0.93 ^a	0.84 ^a	0.53 ^a

4. Conclusions

The type and level of maturity of cayenne pepper influences the capsaicin content. Catas cayenne pepper has the highest capsaicin content and the level of red maturity has the highest capsaicin content compared to the other two types. Type affects the texture, weight, color, length and diameter of the fruit, while the level of maturity does not affect the weight, length and diameter of cayenne.

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