Physalis peruviana L. Growth, Yield and Phytochemical Content: A Review

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**ABSTRACT**

*Physalis peruviana* is one of the species in genus Physalis which is often cultivated in various regions including Indonesia. In Indonesia, *P. peruviana* is often called ciplukan. *P. peruviana* plants produce various phytochemical compounds which have beneficial medicinal properties. *P. peruviana* plants have not been widely cultivated commercially as the information about cultivation practices of this plant are still limited. Many research activities have been done to study about its chemical and biological properties, but they are still not widely spread. Therefore, an effort has been made to compile the available information in this paper.

Key words: Ciplukan, Cultivation, Phytochemical, Physalin.

**Phytochemical Content**

*Physalis peruviana* was also reported belong to moderately tolerant crop to several environmental stress conditions such as salinity (Miranda et al., 2010) and cadmium contaminant (Thiebeauld et al., 2005). Though it has a great potential, the *P. peruviana* plant is still not cultivated widely and instead left to grow as wild crop. It is important to research further about the various species of *P. peruviana*, one of them being *P. peruviana*, to obtain appropriate information and to support the wide spread cultivation of *P. peruviana*.

**MORPHOLOGY**

*P. peruviana* is a herbaceous, semi-bushy annual plant in its region of origin i.e., subtropics. *P. peruviana* forms a bush in the shape of a dome that can grow up to 1 m in height. *P. peruviana* has a branched root system that is 10 to 15 cm deep and fibrous, with the primary root length being between 50 and 80 cm. The primary stem of *P. peruviana* is green colored and composed of 8 to 12 nodes. Each node produces 2 sprouts, a vegetative sprout and a flowering sprout. The leaf of *Physalis* is heart-shaped and alternating, with a length of 5 to 15 cm and has a width of 4 to 10 cm. *P. peruviana* has uniquely shaped flowers, which are pedunculated and hermaphrodite, originating from an axillary sprout with 5 yellow petals. The fruit of the *Physalis* is berry-shaped, similar in form to a globe with a green to yellow color and has a diameter of 13-20 mm, weight of 2-4 g and fruit hardness of 5-10 N (Yildiz et al., 2015). One *P. peruviana* fruit...
contains approximately 100-300 seeds. The fruits are small in size, colored bright orange and sweet when ripe. The most characteristic part of the *Physalis* fruit is the calyx, a fruit petal that enlarges to resemble a lantern and wraps around the fruit. The calyx is green, composed of 5 sepals of 5 cm length. The primary function of the calyx is to protect the fruit from insects, birds, diseases and unfavorable climatic conditions. The calyx will change its color when the fruit ripens. The calyx will stop growing in size 20 to 25 days after the fruit formation (Fischer et al., 2011).

**GROWTH AND CULTIVATION**

**Growth requirements**

*P. peruviana* possesses good adaptive capabilities toward a wide variety of soils and climatic conditions. In its area of origin, *P. peruviana* is cultivated at high land. In India physisil can be cultivated at elevation of 1200-1800 m above sea level. The elevation of a place has a significant effect on the growth of *P. peruviana*. An increase in exposure to UV rays and a decrease in air temperature will affect the morphology of the plant, for which the plant becomes smaller in size and the leaves become smaller and thicker. Temperature plays an important role in the growth and development of *P. peruviana*. Basically, *P. peruviana* is a crop cultivated in warm season. The optimal temperature for the growth of *P. peruviana* 21°C. Very high temperatures (>30°C) can disrupt the phases of flowering and fruit formation and accelerate senescence; very low temperatures (<10°C) can also inhibit the growth of the plant. In addition to temperature, sunlight also has an important role, being one of the requirements of photosynthesis. *P. peruviana* needs approximately 1500-2000 hours of sunlight in a year (Ali and Singh, 2013).

*P. peruviana* is ideally cultivated in an area receiving rainfall between 1000-1800 mm and a relative humidity of 70-80%. The water needs of *Physalis* plant is 800 mm during the period of growth. An increase in soil moisture can aggravate the development of diseases, negatively affect pollination and cause the leaves to turn yellow and fall (Muniz et al., 2014). The soil having sandy clay texture with good drainage is ideal for *Physalis* cultivations. *P. peruviana* is sensitive to water logging. The soil should be rich in organic matter (> 4%). The pH should be between 5.5-6.8. The soils that have been previously used to cultivate other species of the Solanaceae family should be avoided (Tyagi, 2016).

**Cultivation technology**

The *P. peruviana* exhibits indeterminate growth (Fischer et al., 2011). The plant can grow up to a height of 1-1.5 to 2 m. The plant can remain productive up to an age of 9 to 11 months from the first harvest. After this point, both productivity and fruit quality will decrease. The growth phases of *P. peruviana* can be grouped into 7 stages viz., sprouting, leaf growth, formation of lateral shoots, budding, flowering, development of fruit and fruit and seed ripening (Ramirez et al., 2013).

The *P. peruviana* plant may be propagated both sexually through the seeds and asexually through in vitro culture and grafting. Production through seeds is the most common method. The seeds of *Physalis* exhibit 85 to 90% of germination and the process of transplanting seedlings starts after 10 to 15 days growth. The germination of *Physalis* seeds are also affected by temperature. Germination will be normal at temperatures of 7-13°C at night and 22-28°C in the day time.

Before sowing the seeds are first extracted by crushing the fruit and allowing it to dry for 48 hours. After that the seeds are rinsed with air and left to dry on filter paper. Before sowing, the seeds ought to be disinfected with the fungicide to prevent the diseases of *Clostridium, Phoma, Alternaria, Pythium, Botrytis* and *Colletotrichum*. Before transplanting the seedlings, pruning may be carried out. The pruning of seedlings may be performed when the plant reaches a height of 15-20 cm and possesses 3-4 leaves. This pruning of seedlings reduces transpiration.

*P. peruviana* plants may be transplanted in field or planted in a polybag. When planted directly on the field, a plant distance of 0.5 x 1.5 m may be followed (Tyagi, 2016). Planting should be carried out in the afternoon to avoid plant dehydration. The necessary maintenance for cultivation of *P. peruviana* is not much different as compared to other plants. The plant needs to be watered with 2-6 liters of water per plant per day. The *P. peruviana* crop need about 150 kg N, 100 kg P and 60 kg K/ha (Deepti et al., 2018; El-Tohamy et al., 2009). Half of the doses of N and K and the entire dose of P is given as basal dose and the rest is top dressed at 30 days after planting. Beside of fertilizer management, application of plant growth regulator is a technology for improving growth and Yield of *P. peruviana*.

*Kaur and Kaur (2016) reported that application of 20 ppm GA3 was able to improve growth yield and fruit quality in *P. peruviana*.*

*P. peruviana* plant forms many branches that widely spread and as such, the plant requires a support system that consists of structures of wood and/or ropes to support plant growth. Pruning is also necessary to increase fruit yield and quality (size in particular). Pruning also optimize the absorption of sunlight to increase photosynthesis and to increase water use efficiency. There are four kinds of pruning: (1) formation, the thinning of primary stems and elimination of sprouts; (2) maintenance, cutting off branches that are not productive; (3) sanitation, cutting off branches that are attacked by pests and diseases; and (4) maturation, cutting off parts of the plant to renew the plant from branches that have grown old.

The control of pests and diseases on *P. peruviana* plants may be done chemically or with integrated pest management. The pests that are most often found in the cultivation of *P. peruviana* included Spodoptera sp., Agrotis sp. and *Feltia* sp. on the ground and *Linomyza* sp., *Epitrix cucumeris*, *Aphys sp.*., *Myzus sp.*., *Frankliniella sp.* and *Trialeurodes* on the leaves. The most important disease that attacks *P. peruviana* plants is *Fusarium oxydysporum* (Muniz et al., 2014).

The visual indicator of harvesting time for *Physalis* fruits can be seen in the color of the calyx. When a fruit ripens, its calyx will change color to yellow-green. At the physiological ripeness that occurs 56 days after anthesis, the *P. peruviana* fruit shows a Brix value of 12.7%; pH of 3.52 and citric acid of 12.12 g/100 g. *P. peruviana* is a climacteric fruit, for which respiration continues to occur in the fruit although the fruit contains...
has been picked. The fruits may be harvested 2 to 3 times in a week. Harvesting may be performed in the morning or afternoon, when temperatures are not too high. Harvesting may also be done while sunny or in conditions other than rain. The fruit may be stored up to 1 month with the calyx and 4 to 5 days without the calyx (Muniz et al., 2014; Fischer et al., 2011).

CHEMICAL COMPONENTS

General components

The chemical content of *P. peruviana* fruits grown in the turkey and harvests in summer season included 17-20% water, 1.2-2.05% titrated acids, 63-65 g/kg total sugars, 13.70-14.30° Brix total soluble solids, 57-59% antioxidant capacity, 1.5-1.8% protein and 12-16% carbohydrates (Yildiz et al., 2015; Puente et al., 2011). Other contents of *P. peruviana* fruit grown in Brazil included 3.16 g/100 g total lipids, 1.85 g/100 g proteins and 13.22 g/100 g total carbohydrates (Rodrigues et al., 2009). The fruits of *P. peruviana* contain three kinds of sugars that are dominated by sucrose with the largest amount, followed by glucose. The sugar in the least amount by percentage in the fruit is fructose. The glucose content in fruits of *P. peruviana* is almost similar to fruits of other genera of Solanaceae, with an amount around 0.5%. The sugar content of fruit is usually small in the form of reducing sugar. Reducing sugars are a group of carbohydrates that can reduce compounds that accept electrons. Examples of reducing sugars are glucose and fructose. Oztürk et al. (2017) reported that the content of reducing sugars in *P. peruviana* ranges from 6.55-7.80%.

Minerals

Minerals play an important role in physiological and biochemical processes as co-factors of enzymes and are linked to energy efficiency, fertility, mental stability and immunity. *P. peruviana* contains minerals such as K, Mn, Mg, Fe and Zn with higher amounts in comparison to several other kinds of fruits such as papayas, apples, oranges, strawberries and acerola. The Fe content was recorded up to 1.47 mg/100 g, far higher than papayas (0.2 mg/100 g), apples (0.1 mg/100 g), oranges (0.1 mg/100 g), strawberies (0.3 mg/100 g) and acerola (0.2 mg/100 g). The Mg content was recorded up to 34.70 mg/100 g and it was far higher than papayas (17 mg/100 g), apples (5 mg/100 g), oranges (14 mg/100 g), strawberries (10 mg/100 g) and acerola (13 mg/100 g). Similarly the K content was around 347 mg/100 g, higher than papayas (222 mg/100 g), apples (117 mg/100 g), oranges (158 mg/100 g), strawberries (184 mg/100 g) and acerola (165 mg/100 g). Zn content of *P. peruviana* and the five comparison fruits stated above are nearly the same in a range of 0.1-0.2 mg/100 g. The Ca content was around 9.00 mg/100 g. Compared to the other five fruits, this value is only higher than apples (3 mg/100 g) and lower than the other four fruits, papaya (25 mg/100 g), oranges (34 mg/100 g), strawberies (11 mg/100 g) and acerola (13 mg/100 g). The Na content is 1.1 mg/100 g, nearly equivalent to that of apples and oranges (1 mg/100 g), but lower than papayas (3 mg/100 g) (Rodrigues et al., 2009). In another study, Pereda et al. (2018) reported that the mineral content of *P. peruviana* fruits per 100 g fresh fruit weight consists of 375 mg K, 48.7 mg Mg, 11.17 mg Ca, 8.78 mg Na and 0.35 mg Cu. Considering the analysis of all parts of the plant, Oztürk et al. (2017) reported that the mineral content of *P. peruviana* plant per 100 g total dry weight consists of 1160-1460 mg N, 178.46-233.49 mg P, 1794.98-19.68 mg K, 34.12-43.65 mg Ca, 102.50-122.51 mg Mg, 3.68-4.09 mg Fe, 0.59-0.78 mg Mn, 1.78-2.32 mg Zn and 2.19-3.28 mg Cu.

Fatty acids

The juice of *P. peruviana* fruits is known to contain 0.2% fatty acids. The primary fatty acids are composed of linoleic acid, oleic acid, palmitic acid, γ-linolenic acid and palmitoleic acid. In addition, there are several other identified fatty acids, including gadoleic, dihomo-γ-linolenic, erucic, lignoceric and arachidonic acids. Ramadhan and Morsel (2007) reported that the content of linoleic acid was 70.5% and oleic acid was 12.87% in *P. peruviana*.

Vitamins

*P. peruviana* contains vitamin C in high amounts. The ascorbic acid content of *P. peruviana* juice was around 46 mg/100 g (Zhang et al., 2013). The findings of Oztürk et al. (2017) indicated that the ascorbic acid content of *P. peruviana* ranges from 31.40-35.10 mg/100 g and approximates the results of Pereda et al. (2018) who reported that the ascorbic acid content of 32.21 mg/100 g. The vitamin C content of *P. peruviana* fruits ranged from 20-50 mg/100 g. This value is considered high when compared to mangoes (15.36 mg/100 g) and oranges (50 mg/100 g) but still below guavas (120-228 mg/100 g) or marula (120 mg/100 g) (Olvaures-Tenorio et al., 2016; Hiwilepo-van Hal et al., 2012; Sogi et al., 2012). Apart from vitamin C, the vitamin E content is considerably high. The vitamin E content in the oil extracted from the pulp and peel of *P. peruviana* fruit is greater than the oil content in the seeds. The vitamin A content of *P. peruviana* fruit was around 103.33 mg/100 g (Pereda et al., 2018).

Carotenes

The juice of *P. peruviana* is known to contain β-carotene. Etzbach et al. (2018), reported that 53 carotenoids were detected at different levels of ripeness (unripe, ripe and overripe) and different parts of the fruit (skin, pulp and calyx). The composition of carotenoids is dominated by (all-E)-β-carotene. Results from other studies also indicated that carotenoids of *P. peruviana* are composed of 76.8% trans-β-carotene and approximately 3.6 and 3.5% are 9-cis-β-carotene and all-trans-a-cryptoxanthin, respectively (De Rosso and Mercadante, 2007). The carotenoid content is low enough which is <0.5 mg/100 g (Breithaupt and Bamedi, 2001). β-carotene has an important role in vision, cell division and differentiation and reproduction in human beings. In *P. peruviana* fruit, the β-carotene content ranges from 0.34-1.77 mg/100 g (Pereda et al., 2018).

Flavonoids and polyphenols

The total phenol content in the juice of *P. peruviana* fruit grown in Czech Republic which has altitude 340 masl, determined by the Folin-Ciocalteu method was approximately 4.09 to 6.30 mg/100 g (Rob et al., 2012).
was lower compared to another commodity such as carrot which had reach 29-31 mg/100g (Kaur and Aggarwal, 2015). The most dominant phenolic compound was quercetin, followed by myricetin and kaempferol. Total phenolic content was affected by fruit size and maturity stage. Full maturity stage had higher phenolic than start of maturity (Liciodiedoff et al., 2013). The phenolic content was also found in leaf and shoot. The phenolic content found in shoot extract was lower than in leaf extract (Cakir et al., 2014). Processing of fruit will effect on physicochemical of fruit including total phenolic content. It was reported by Tanwar et al. (2014), processing fig fruit pulp into jam and nectar decreased total phenolic, falavonoid and anthocyanin of fruit.

Withanolides

Withanolides are natural lactone steroids that are produced by most plants in the Solanaceae family. These compounds have antimicrobial, antitumor, anti-inflammatory, hepatoprotective or immunomodulatory activity, as well as insect antifeedant property. It was reported by Goztok and Zengin (2013) that extract of P. peruviana fruit showed antimicrobial activities against most of bacteria, yeast and dermatophyta. Withanolide glycosides that have been isolated from various parts of the P. peruviana plant included perulactone, perulactone B, blumenol A and (þ) (S)-dehydrovomifoliol.

Physalins

Physalins are a series of pseudo-steroids that have been isolated and characterized from the Physalis plant. The primary compounds of P. peruviana included physalin A, B, D, F and glycoside that indicate anticancer activity as well as antioxidant and anti-inflammatory activities (Zhang et al., 2013).

CONCLUSION

From this review, it may be concluded that research work need to be carried out mainly on cultivation aspects to standardize the productin technologies on P. peruviana so that its production can be enhanced under different agro-climatic conditions. Further there is a need for detailed studies on pharmacological aspects to utilize the P. peruviana which is rich in phytochemicals and bioactive compounds for human health.

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