

REVISÃO

PASSIFLORA edulis SIMS: THE CORRECT TAXONOMIC WAY TO CITE THE YELLOW PASSION FRUIT (AND OF OTHERS COLORS)

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ABSTRACT – *Passiflora edulis*, the passion fruit native from Brazil, has several common names (such as sour passion fruit, yellow passion fruit, black passion fruit, and purple passion fruit), and presents a wide variability with the different rind colors of its fruits, which are very easy to notice. However, in 1932, Otto Degener suggested that the yellow passion fruit had its origin in Australia through breeding, calling it *P. edulis* forma *flavicarpa*, and that it could be distinguished by the color of the fruit, the deeper shade of purple of the corona, and the presence of glands on the sepals. These distinctions do not support themselves, for the glands are common to the species (although they may be absent), and the corona has a wide range of colors, regardless of the color of the fruit. A more critical ingredient is the fact that the external coloration of the fruit is a character of complex inheritance and is not dominant, thus displaying a number of intermediate colors, making it difficult to identify the extreme colors. For the correct scientific naming of agricultural plants, the International Code of Botanical Nomenclature must be used in conjunction with the International Code of Nomenclature for Cultivated Plants, with the selections with significant agronomic characteristics recognized and named cultivars. In accordance with the international convention promoted by the UPOV, of which Brazil is a signatory, several colors (light yellow, yellow, orange yellow, pink red, red, red purple, green purple, purple, and dark purple) can be recognized in order to adequately characterize passion fruit cultivars within the species *P. edulis*. At taxonomic level, *Passiflora edulis* Sims must be used for any plant and color of sour passion fruits, in combination with a cultivar name for the selected materials.

Index Terms: cultivar, nomenclature, *Passiflora edulis*, Passifloraceae, yellow passion fruit.

PASSIFLORA edulis SIMS: A MANEIRA TAXONÔMICA CORRETA DE REFERIR-SE AO MARACUJÁ-AMARELO (E AOS DE OUTRAS CORES)

RESUMO – *Passiflora edulis*, o maracujá é nativo do Brasil, apresenta vários nomes populares (tais como maracujá-azedo, maracujá-amarelo, maracujá-preto e maracujá-roxo) e grande variabilidade, sendo que diferentes cores da casca do fruto são facilmente observadas. Entretanto, em 1932, Otto Degener sugeriu que o maracujá-amarelo tenha originado através de melhoramento genético, na Austrália, denominando-o como *P. edulis* forma *flavicarpa*, e poderia ser reconhecido pela cor do fruto, pela porção colorida da corona, maior e de um arroxado mais escuro, e pela presença de glândulas nas sépalas. Essa distinção não se sustenta, pois essas glândulas são comuns na espécie (embora possam estar ausentes), e a corona tem grande variação de cores, independentemente da cor do fruto. Ainda mais crítico é o fato de que a coloração externa do fruto é um caráter de herança complexa e não tem dominância, existindo, por isso, várias cores intermediárias e dificuldades para reconhecer quais as cores extremas. Para a correta denominação científica das plantas agrícolas, devem ser utilizados, simultaneamente, o Código Internacional de Nomenclatura Botânica e o Código Internacional de Nomenclatura de Plantas Cultivadas, sendo que seleções com características agrônomicas importantes devem ser reconhecidas e denominadas como cultivares. De acordo com a convenção internacional promovida pela UPOV, da qual o Brasil é signatário, várias cores (amarelo-pálido, amarelo, amarelo-alaranjado, vermelho-rosado, vermelho, roxo-avermelhado, roxo-esverdeado, roxo e roxo-escuro) podem ser reconhecidas para a adequada caracterização das cultivares de maracujá, dentro da espécie *Passiflora edulis*. Ao nível taxonômico, portanto, correta, prática e simplesmente, deve-se utilizar *Passiflora edulis* Sims, para toda e qualquer planta e cor de fruto do maracujá-azedo, associando-se a elas um nome de cultivar para os materiais selecionados.

Termos para Indexação: cultivar, maracujá-amarelo, nomenclatura, *Passiflora edulis*, Passifloraceae.

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INTRODUCTION

To name the plants observed in their natural environment, taxonomy or systematic Botany follows a set of rules and recommendations, defined in the International Code of Botanical Nomenclature (hereinafter called the Botanical Code), which are periodically revised and updated (Greuter, et al., 2000; McNeill et al., 2006). Proposals of amendment are given careful consideration at the Nomenclature Section meetings, and modifications to the code can only be made on resolution by the deliberative assembly (Greuter, 2000 et al.; McNeill et al., 2006). These meetings are held at the International Botanical Congresses every six years, and each new edition of the code supersedes all previous editions (Greuter, et al., 2000 ; McNeill et al., 2006). Under the code, the basic taxonomic level is the species, although there may be subdivisional categories, such as subspecies, variety and form (McNeill et al., 2006). The subspecies category has been applied to geographic variations, but neither variety, nor form has been used for quite a while, due to their provisional character, being applied to variations for which there is no evidence of genetic inheritance, thus limiting themselves to only one character of low taxonomic value (Font Quer, 1985; Watanabe, 1987).

A specific set of rules and standards has also been agreed on for the nomenclature of cultivated plants – the International Code of Nomenclature for Cultivated Plants (hereinafter called the Cultivated Plant Code) – where the cultivar is considered the basic unit (Brickell et al., 2004). A few significant modifications have been made to the latest versions of the Cultivated Plant Code, but it is not revised/updated regularly, its last version dates from 1994 (Brickell et al., 2004).

Both codes complete each other, since cultivated plants must be associated with a genus name under the Botanical Code. However, the Cultivated Plant Code is more recent, and its consolidation process has just started. The rules of the Botanical Code are described in details in 62 articles, a number that was not altered in the previous edition, although the appendix ones changed from one to seven (Greuter, et al., 2000 ; McNeill et al., 2006), whereas the versions of the Cultivated Plant Code are shorter, its governing rules were presented in 32 articles in the two latest editions (Trehane et al., 1995; Brickell et al., 2004). While taxonomy focuses more on phylogeny for native plants, that is, how species and other taxonomic levels are related, the main aim of the nomenclature for cultivars is to highlight the differences and similarities among plants, which is the reason for a Group category.

Besides the academic field, scientific nomenclature is widely used in international trade, as well as in the laws established by the nations, including the Brazilian, with the purpose of accurately identifying the object studied and also standardize the way it is referred to, regardless of the official language adopted for the consideration, or the writing of documents resulting from the study.

This paper is aimed for removing doubts from scientific reference to passion fruits of the species *P. edulis* Sims (sour

passion fruit, yellow passion fruit, black passion fruit, and purple passion fruit). With the assistance provided by the botanical nomenclature, it is our intention to achieve the required uniformity in the references by researchers and the most respected scientific journals. We indicate that a single standard should be adopted for the citation of the species and its cultivars, in compliance with the rules of the Botanical and Cultivated Plant Codes.

Origin and cultivation of the yellow passion fruit

To the Old World, passion fruit only became known after America was discovered, with the first reference to a plant of this group published in 1553, by the Spanish Cieza de León, who mentioned the “granadilla” (*P. ligularis* Juss. – Kugler & King, 2004). The name *Passiflora* only appeared in 1651, with Frederico Cesì, although the resemblance with the Passion of Christ had already been pointed out by Nicolás Monardes, in 1569 (Harms, 1925; Kugler & King, 2004). That generic name was adopted by Linnaeus (1753) when he laid the foundations for the botanical nomenclature. Until then, only the Indians could taste those fruits, which would soon be popular among the first discoverers (Inglez de Souza & Meletti, 1997).

Currently, nearly 400 species of the genus *Passiflora* are known, most of which has its origin in the Tropical America, with 120 of them being native from Brazil (Bernacci et al., 2003). Many of these species are edible (Martin & Nakasone, 1970; Lorenzi et al., 2006). Although there is a wide genetic variability, represented by native biodiversity, in the commercial orchards of Brazil a single species, *P. edulis* (sour passion fruit) predominates, with people’s preference for fruits of yellow-colored rind, the yellow passion fruit. The yellow passion fruit accounts for 95% of the passion fruit-cultivating area, owing to the quality of its fruits, vigor, yielding, juiciness (Meletti & Brückner, 2001), and the consumer’s choice.

To a lesser extent, other species are also grown because of their culinary, medicinal, or ornamental properties, such as the sweet passion fruit (*Passiflora alata* Curtis), the breath passion fruit (*Passiflora nitida* Kunth), the shark passion fruit (*Passiflora cincinnata* Mast.), and, more recently, the purple passion fruit (of the same predominant species, *P. edulis*). Nonetheless, these other types of passion fruits together account for less than 5% of the home market, thus indicating their regional importance and limited commercialization (Meletti et al., 2005).

In Brazil, the preference for *P. edulis* of yellowish fruit is evident in the number of states where it is cultivated, making Brazil the largest producer of passion fruit in the world. According to Piza Junior (1998), in southeastern Brazil, passion fruit is one of the eight most cultivated species of fruit, thus contributing to value small producers for their work, as well as increasing their income. Among fruits, it has been considered an attractive farming choice since it provides a fast economic return, and a chance of an income distributed more evenly throughout the year.

According to FAO estimates, the consumption of tropical fruit juices has grown, with the passion fruit juice showing a significant increase as a result of its distinctive and special flavor. However, the market for passion fruit juice is highly unstable,

and there is a lack of coordination between the main producing countries and the exporting countries. The volume exported by Brazil is very low when compared to those of Ecuador and Colombia, which account for about 50% and 30% of the market, respectively, due to a high domestic consumption of the product and a poorly structured sector for the production at more competitive prices (Silva, 1999).

The fact that the species *P. edulis* is native can, in part, explain why it is extensively cultivated in Brazil. *Passiflora edulis* was effectively described in 1818, from material of purple fruits grown in England, and indicated as obtained from seeds received from Portugal (Sims, 1818; Degener, 1932), which were believed to be from Brazil (Degener, 1932; Killip, 1938; Cervi, 1997). Nevertheless, reports on the species had already been written in Europe in 1648 (Kugler & King, 2004). Moreover, on the occasion of the effective publication of the genus *Passiflora* (Linnaeus, 1753), mentions of references and illustrations, which corresponded to *P. edulis* were made, but these references and illustrations were mixed together with those of another species, *P. incarnata* L., to which it is related, and with which it presents great morphological similarities, although the latter is native from the United States (Killip, 1938). In short, *P. edulis* was confused with, and designated by *P. incarnata* (Killip, 1938). In the original description itself, the similarity of *P. edulis* with *P. incarnata* is indicated, but they could be differentiated by hairless seeds and nervures, perennial woody habit, bracts evenly serrated and with glands on the tip of each tooth, the corona shorter than the calyx, and bright purple fruit in *P. edulis*, instead of villous (sic) seeds and pubescent nervures, annual herbaceous habit, bracts with some big glands, the corona longer than the calyx, and greenish yellow fruit in *P. incarnata* (Sims, 1818).

The name *Passiflora incarnata* L. is associated with the species native from the United States because this species shows little variation, including in the shape of its leaf blade and in the relative length of the filaments of the corona (only the size of the stalk sometimes reaches that of *P. edulis*, but it is usually longer and narrower), and also because the only material, identified by Linnaeus himself, corresponds to this species (Killip, 1938; The Linnean Society of London, 2007).

Passiflora edulis, on the other hand, shows a wide variability, and was designated by many scientific names, although these were later considered synonyms (Masters, 1872; Killip, 1938; Cervi, 1997). Thus, *P. verrucifera* Lindl. (Lindley, 1840), *P. pomifera* M.Roem. (Roemer, 1846), *P. pallidiflora* Bert., *P. rubricaulis* Jacq. were indicated as replaced synonyms of *P. edulis* by Masters (1872), followed by Killip (1938) and Cervi (1997). *Passiflora rigidula* Jacq. was indicated as a possible synonym by Masters (1872) and in fact considered a synonym of *P. edulis* by Killip (1938), followed by Cervi (1997); whereas doubts about the synonymy of *P. diadema* Vell. (Velloso, 1831) was indicated by Masters (1872) and Killip (1938), and was synonymized by Cervi (1997). Killip (1938) also added *P. vernicosa* Barb.Rodr. and *P. middletoniana* Paxton to the list of synonyms of *P. edulis*, followed by Cervi (1997). Additionally, *P. iodocarpa* Barb.Rodr., described as presenting yellow fruits, as well as purple fruits, *P. picroderma* Barb.Rodr., and *P. gratissima*

A.St.-Hil. were indicated as possible synonyms (Killip, 1938), and later considered synonyms (Cervi, 1997). *Passiflora cuneifolia* Cav. (Cavanilles, 1790) was indicated as a possible synonym for *P. edulis* (Masters, 1872), but Killip (1938) considered that it was more likely to be a synonym for *P. filamentosa* Cav. or a hybrid between *P. caerulea* L. and that one.

Illustrations with only analysis are considered sufficient for recognition of species as long as they had been prepared before 1908 (McNeill et al., 2006). Proposals of species by Velloso (1831) were made only through analytical illustrations, and due to technical/logistical problems diagnoses and brief descriptions of these species were published later (Velloso, 1881). In the meanwhile, descriptions of the species illustrated by Velloso (1831) were published by Roemer (1846) and in the cases where the names proposed by Velloso (1831) represented illegitimate homonyms, other names were proposed by Roemer (1846). Thus, *P. pomifera* M.Roem., described by Roemer (1846), has *Passiflora edulis* Vell. (Velloso, 1831), as a replaced synonym, which therefore must be considered a replaced synonym for *P. edulis* Sims.

Masters (1872) proposed the distinction of varieties in *P. edulis*, and described the occurrence of yellowish and purplish fruit in the typical variety, *P. edulis* Sims var. *edulis*. The varieties proposed and indicated by Masters (1872) were *P. edulis* var. *kerii* (Spreng.) Mast., which could be distinguished by leaves of entire margin; *P. edulis* var. *verrucifera* (Lindl.) Mast., which could be recognized by sepals with glands, such as the bracts, filaments of the corona slightly shorter than the petals, pubescent ovary and styles, and oblong-ovoid yellowish-green fruits; *P. edulis* var. *pomifera* (M.Roem.) Mast., with the filaments of the corona much shorter than the petals, puberulent spheroid ovary and golden yellow, villous spheroid fruits; and *P. edulis* var. *rubricaulis* (Jacq.) Mast., distinguished by its reddish stem, absence of bract glands, filaments of the corona longer than the petals, and yellow spheroid fruits. That is, variations were observed regarding the presence of glands on the bracts and sepals, relative size of the corona, pilosity, and form of the ovary and fruits, and color of branches and fruits, and differences in the yellowish color of the fruits. Moreover, it can be observed that the color of the fruit has little taxonomic importance in *P. edulis*. Nevertheless, despite the proposal to recognize varieties in *P. edulis*, Masters (1872) pointed out that the difference between them was gradual. He also pointed out the difficulties in distinguishing the species *P. incarnata*, indicating the woody habit, leaves almost always hairless, and filaments of the corona shorter than the petals as characteristics of *P. edulis*.

Passiflora edulis var. *kerii* was synonymized for *P. incarnata* (Killip, 1938), and, similarly, *P. edulis* var. *verrucifera*, *P. edulis* var. *pomifera* and *P. edulis* var. *rubricaulis* were neither recognized, nor differentiated from one another, not even from what was the typical form of the species *P. edulis*, so they were not accepted by Killip (1938), followed by Cervi (1997). Killip (1938) stated that the most significant differences he had observed in *P. edulis* related to the relative length of the corona, which could be either longer or shorter, and that this type of variation also occurred in *P. caerulea* L., also used in cultivation

(although as ornamental). Despite the fact that Killip (1938) had not observed any material with glands on the sepals, he indicated that *P. edulis* var. *verrucifera* resembled the morphology in the fairly longer corona, whereas *P. iodocarpa* and *P. picroderma* were more extreme with regard to the relative size of the corona. According to Killip (1938), many of the *P. edulis* materials he examined were likely to be of plants either from a cultivation area, or that had escaped that condition, and could have even hybridized with other species, what could have helped to increase the natural variability of the species.

Similarly, Cervi (1997) neither included *P. edulis* var. *kerii* within the species *P. edulis*, nor recognized the distinction of infraspecific categories within *P. edulis*, stating that the color of the stem, size and shape of the fruit could vary, depending on the place the plant was located, and that the polymorphism in the species could be caused by its extensive cultivation. The variability observed in *P. edulis* includes the occurrence of specimens with entire, bilobed or trilobed leaves, and bracts ranging from deeply to superficially serrate, on the same plant (Cervi, 1997).

Summarizing, it has been concluded that the variations observed in materials of *P. edulis* are not correlated, that is, a variation in a given character neither depends on, nor occurs simultaneously with another or other characters, nor it is associated with the area or environment where it occurs. In other words, it has been concluded that patterns corresponding to different species, or even to varieties within a single species cannot be recognized, that is, the sour passion fruit corresponds to a single species, and, although highly variable, there is a continuous, or variation gradient so that for any set of extreme differences, considering two or more individuals, or populations of the species, there is a set of individuals, or populations, which have the character of intermediate sizes, approaching one of the individuals or populations in some of the characters, but approaching other individuals or populations in other characters. In *Passiflora edulis*, even occur differences between the plants proceeding from an only fruit.

Nevertheless, *Passiflora edulis* f. *flavicarpa* O.Deg. was described in 1932 from material cultivated in Hawaii (US Experimental Station, Pensacola Street, Honolulu), when it was indicated that it was also cultivated in Australia (Degener, 1932), where it was likely to be the result of breeding ("horticulturally"). Degener (1932) indicated that, in Hawaii, before 1931, there were only purple passion fruits, either under cultivation, or escaped. However, Purseglove (1968), by suggesting that the yellow passion fruit had originated in Australia from mutation, stated that it was introduced in Hawaii in 1923.

It must be mentioned that although Degener (1932) had clearly indicated that the yellow passion fruit was neither native from Australia, nor from Hawaii, but under cultivation, was equivocal when he considered that the yellow passion fruit had originated there. Or better saying, it must be pointed out that *P. edulis* is actually native from Brazil, where it has its center of diversity (as defined by Vavilov, 1992), also showing plants with yellowish fruit (yellow passion fruit), apart from other variations. Since *P. edulis* f. *flavicarpa* is a plant under cultivation, it should

be named according to the rules of the Cultivated Plant Code.

Problems in the characterization and differentiation of the yellow passion fruit

When a species has a considerable morphological variability, which is the case of some species of Passifloraceae, it is possible to recognize infraspecific taxa (Killip, 1938; Bernacci et al., 2003). Nevertheless, there must be a variation pattern for characters of less weight or taxonomic significance, that is, it must be fully recognized that two or more populations must show similarities in order to be identified as belonging to a single species, but at the same time they must show some differences that makes it possible to distinguish one from the other.

According to the Botanical Code, the name of the species and those of eventual infraspecific categories must be associated with the author's name, as well as with the categories being described. When an author validly describes a species, a subspecies, a variety, etc., its name must be linked with the name of the author (McNeill et al., 2006). If at any time, another author, or even the same author believes that a certain variety must be changed into a species, he/she is not allowed to merely use a new combination. The new combination must be validly published (which will then be linked with his/her name) (McNeill et al., 2006). Any amendments or modifications proposed for better recognition and distinction of species or other taxa must also be validly published, with the name of the author of the proposal accompanying the name of the taxon (McNeill et al., 2006).

However, it must be mentioned that names of forms, varieties, or even of species described under the Botanical Code may be considered and used as names of cultivars, as the Botanical Code itself has defined (Greuter et al., 2000; McNeill et al., 2006) outside the Cultivated Plant Code, since they clearly represent materials selected for cultivation (Trehane et al., 1995; Brickell et al., 2004). As names of cultivars, however, reference to their authors is not required, since that is an option established for greater accuracy (Trehane et al., 1995; Brickell et al., 2004). Under this condition, a Latin word was used for the name of the cultivar, differently from that currently describing a cultivar (as the one of January 1, 1959), which must be in a modern language (Trehane et al., 1995; Brickell et al., 2004).

Another important aspect of the Botanical Code is that when an infraspecific entity is recognized, the corresponding typical entity in the hierarchical level is also established (McNeill et al., 2006). Under the Botanical Code, as the first variety of *Passiflora foetida* L., *P. foetida* var. *variegata* G.Mey. was recognized, *P. foetida* L. var. *foetida* was established as its typical variety. Likewise, when the name *P. edulis* forma *flavicarpa* O.Deg. (Degener, 1932) was proposed, *P. edulis* Sims forma *edulis*, its typical form, was also established, which was the material originally described by Sims (1818). It must be observed that no reference to the author is given when the typical variety is described, since it corresponds to the primary description of the species, with which the author must be associated, whereas plants described as varieties are associated with their authors, thus making it possible for any author to simultaneously describe

a species and a variety. Every variety belongs to that species, but differs from one or other varieties within the species in some aspect; the same principle applied to other infraspecific taxa (McNeill et al., 2006). In other words, both *P. edulis* f. *edulis* and *P. edulis* f. *flavicarpa* belong to the species *P. edulis*, but differ from one another in one or more features.

The yellow passion fruit is distinguished by more vigorous and productive plants, larger fruits of yellow color, acid pulp, richer aroma and flavor (Piza Junior, 1966; Pursglove, 1968), but many of these characteristics can be achieved through selection and may vary, regardless of the color of the fruit (Meletti & Brückner, 2001). Among the morphological features, one that characterizes the yellow passion fruit is the red or purplish pigment on the branches, tendrils (Piza Junior, 1966; Pursglove, 1968); dark brown seeds, instead of black seeds, which is the case of the purple passion fruit (Piza Junior, 1966); larger leaves (Pursglove, 1968), a deeper shade of purple or purplish of the corona (Degener, 1932; Pursglove, 1968) and the presence of glands on the sepals (Degener, 1932).

The flowering habit has been pointed out as another character that distinguishes *P. edulis* plants of purple fruits from those of yellow fruits (Akamine et al., 1956). Some studies report that the yellow passion fruit displays the anthesis in the afternoon, after midday, whereas the purple passion fruit blossoms only in the morning. Other authors, however, have not observed significant differences between the flowering periods for both forms on the same day (Piza Junior, 1966). Oliveira et al. (1987) and Meletti et al. (1992) observed in two São Paulo cities that the opening of the flowers occurs between 10h30 am and 11h30 am, and that full anthesis is displayed in the afternoon, regardless of the botanical forms under consideration. In a nutshell, the only characteristic that supports the use of the name *P. edulis* f. *flavicarpa* is the production of fruits of yellowish color.

In specialized taxonomic literature, the name *P. edulis* f. *flavicarpa* rarely appears. Of a total of 23 references included in VAST database, only 22% distinguish the forms in *P. edulis* (Solomon, 2008). In the Brazilian herbariums, BHCB, CEPEC, CESJ, EAC, HRCB, HUFU, IAC, IAN, IBGE, INPA, MAC, MBM, MBML, MG, R, RB, RFA, SP, SPF, SPSF, UB, UEC, UPCB, VIC (see Holmgren & Holmgren, 1998) and others, forma names in *P. edulis* are hardly used. On the other hand, in the last forty years, most of the scientific papers on specialized literature on the technology for the yellow passion fruit production make a distinction between the forms, although changes have been noticed more recently. In *Revistas Brasileiras de Fruticultura* and *de Sementes* (Brazilian Magazines of Seeds and Fruit Culture), for example, 97% of the papers that are published use the designation *P. edulis* f. *flavicarpa*. However, considering only the most recent papers available online, in those journals and in *Pesquisa Agropecuária Brasileira* (PAB), the percentage of the use of the designations at form level for *P. edulis* falls to 76% (out of a total of 37 publications referring to the species - Scielo, 2008).

But, as previously mentioned, long before Degener (1932) suggested the name *P. edulis* f. *flavicarpa*, other authors had

proposed different names for the yellow passion fruits, even at species level, such as *Passiflora verrucifera* Lindl., proposed in 1840, or at variety level, such as *P. edulis* var. *verrucifera* (Lindl.) Mast. (Masters, 1872; Killip, 1938). Although Killip (1938) considered the possibility of whether or not recognize infraspecific taxa in *P. edulis*, he did not refer to the study and results, discussions and conclusions by Degener (1932). As he verified that the variant characters in the species were not correlated, he concluded that it was impossible to recognize infraspecific taxa in the species. Killip (1938) knew about the taxonomic studies and previous publications on the taxonomy of *P. edulis*, due to the fact that he proposed several synonymies for the species, or else he may not have learned from the study by Degener (1932) because of the relatively short period between the two or communication difficulties at the time. Degener (1932) did not mention any authors or previous publications related to that issue, and his proposal that *P. edulis* with fruits of yellow color had originated in Australia indicates that he did not know about those studies. Although Killip (1966) later published an article on the taxonomy of Passifloraceae, in which he described new species and dealt with the distribution of others, he did not give the taxonomy of the species *P. edulis* further consideration.

Another designation found in literature is *P. edulis* varietas *flavicarpa* (Piza Junior, 1966), which is also equivocal since it is considered a "nomen nudum" under the Botanical Code, and therefore has not been validly published. There is an earlier name, validly published, for the species at the taxonomic level of variety, which should be adopted under the principle of priority (McNeill et al., 2006).

If the yellow passion fruit could be recognized and characterized as one single taxonomic grouping at variety level, it could be given one of the names proposed by Masters (1872), and if it could be recognized as one single group, it could be named *P. edulis* var. *verrucifera* (Lindl.) Mast., which has the oldest basionym among the names of varieties of the species, was the first one to be presented, and therefore has priority over the others.

The reason for the indication of the yellow color of the rind in the Latin diagnosis presented by Degener (1932) as he proposed *P. edulis* f. *flavicarpa*, may be the association made, in a general sense, with the plants of that species producing fruits of yellowish color. Nevertheless, Degener (1932) added a very brief description of the characteristics that distinguished the taxon proposed: "Differs from the species chiefly in the yellow color of the fruit, in having the colored part of the corona darker and more uniformly purple, and in bearing 2 marginal glands on the outer fourth of the 3 outer sepals." Therefore, the typical form, *P. edulis* f. *edulis*, should have purple fruits (or that were neither yellow nor yellowish), no glands on the sepals, and the lighter color of the corona distributed over a smaller portion of it. Degener (1932) even indicated the existence of plants with purple fruits and corona totally white.

In the genus *Passiflora*, glands on the sepals are not commonly found, which is why the occurrence in *P. edulis* was suggested as a result of hybridization, possibly with *P. setacea*, another Brazilian species (Killip, 1938). Although hybridization

with *P. setacea* is possible (there are F1 and backcrossing studies with *P. edulis* on resistance to diseases and yield – Junqueira et al., 2005), further investigation into the hybrid origin of *P. edulis* has not been conducted. However, the presence of glands on the sepals of *P. edulis* is not limited to plants with yellow fruits (Purseglove, 1968; Bernacci et al., 2003). Similarly, the corona ranges in color from totally white to almost entirely purple, regardless of the color of the fruit (Figures 1-3; IAC, 2008), which is why the distinction made by Degener (1932) is not well-founded for a taxon.

Colors of the sour passion fruit

Although it is a well-known fact that the name *P. edulis* f. *flavicarpa* is botanically unfounded, it has been widely used due to a practical value it seems to have (Piza Junior, 1966). Since the sour passion fruit is a plant of economical importance and the rind color plays a major role in the Brazilian consumer market, with the addition that the Latin term “flavicarpa” signifies yellow fruit, many people could infer that its correct scientific name is *P. edulis* f. *flavicarpa*, even if a logical difference does not exist, in practical terms, in using either the common name yellow passion fruit, or the Latin term “flavicarpa”. Moreover, the popular names used (yellow passion fruit, black passion fruit, and purple passion fruit) for *P. edulis* also show that the color does not range between only two colors (purple and yellow). In scientific descriptions, different colors for the rind of the fruit have likewise been indicated, such as golden yellow for *P. edulis* var. *pomifera*, yellow for *P. edulis* var. *rubricaulis* and yellowish green for *P. edulis* var. *verrucifera* (Masters, 1872). Oliveira & Ferreira (1991) reported that the shades of purple and yellow are very distinctive, especially the former one.

It is evident that the species *Passiflora edulis* Sims, the sour passion fruit, is very variable, with many other differences, greater still, both in taxonomic and market terms, than those for the color of the fruit in the materials observed. There are yellow passion fruits with very small fruits and others with larger fruits, like there are purple passion fruits with very small fruits and others with larger fruits. More vigorous and productive plants of larger fruits with pulp of a tarter taste, attributed to *P. edulis* f. *flavicarpa* (Piza Junior, 1966), are clearly passive characteristics and object of selection for the passion fruit crop, and not an intrinsic characteristic of passion fruit plants with yellowish fruits.

In addition to the absence of correlation between the different characteristics of the plants, especially regarding the glands of the sepals and the color of the corona, an aggravating factor is that the genetic inheritance of the color of the fruit does not have any dominance, which is why the plant produces fruits of intermediate colors (Nakasone et al., 1967). The first, and probably the only study on the genetic inheritance of the color of the fruit rind, has already indicated that several pairs of genes were likely to be involved with the inheritance of this character, and that a number of intermediate colors could be recognized (Nakasone et al., 1967). Many other colors have been recognized up to the moment for the sour passion fruit (*Passiflora edulis*): light yellow, yellow, yellow orange, pink red, red, red purple, green purple, purple and dark purple, indicated in the UPOV

document (Union pour la Protection des Obtenciones Vegetales). Recognition of several shades of yellow for the sour passion fruit makes it even more impracticable to associate and use the name *Passiflora edulis* forma *flavicarpa*, since each of them represents a different category, and there are no conclusive studies showing neither the type of inheritance involved, nor the extreme colors for the rind. Moreover, there are selected materials of sour passion fruit that can produce plants with yellow fruits, as well as plants with red fruits (Borges et al., 2005).

In a broader sense, genetic analyses of similarities have shown that it is not possible to separate materials of *P. edulis*, based only on the color of the fruit. Although preliminary analyses have signaled this possibility (Sánchez et al., 1999), analyses of a higher number of materials showed some similarity between different accesses of *P. edulis*, also as a consequence of the place of origin of each material, and breeding work (Bellon et al., 2007). However, none of these aspects, isolatedly, (color of the fruit, geographical proximity, or breeding) allows the recognition of any group within the species *P. edulis*, because, genetically, there are purple passion fruits that show stronger similarity with yellow passion fruits than with other yellow passion fruits; Brazilian materials that show stronger similarity with Australian materials than with some Brazilian materials; and native materials that show stronger similarity with improved materials than with other native materials (Bellon et al., 2007). In other words, it is not possible to classify all the variability observed in *P. edulis* into just two groups.

Expansion in the number and use of cultivar names for the sour passion fruit

The publishing of the Cultivated Plant Code and cultivar names, as well as the adoption of standardized color charts (for example, RHS, 2007), have now given opportunity to scientifically interpret, name, and describe selected materials. As previously pointed out, under the Botanical and Cultivated Plant Codes, the names of varieties, forms or even species, may be used as cultivar names, as long as they refer to the same group of plants and have logically been obtained from cultivation (Trehane et al., 1995; Greuter et al., 2000; Brickell et al., 2004; McNeill et al., 2006).

Since *Passiflora edulis* forma *flavicarpa* has already been recognized and is a cultivar name, along with several other cultivars, including the yellow fruit, recognized for the species (Vanderplank, 2000), it must be referred to as *P. edulis* ‘Flavicarpa’, under the current rules of the Cultivated Plant Code. Even León (1987) had early put on a similar interpretation, calling it a cultivated variety, and making a representation in conformity with the Cultivated Plant Code (‘Flavicarpa’). However, his distinction was still made based only on the yellow fruits opposed to the rest of the materials with purple fruits. There are some very clear and plain indications, supporting the interpretation of Vanderplank (2000) that *P. edulis* f. *flavicarpa* did not represent a population observed in nature, but was in fact material obtained from cultivation (Degener, 1932). Additionally, *P. edulis* f. *flavicarpa* has a very confined circumscription, thus only including a very limited set of materials of the species, that is, it does not include all the materials with fruits of yellow rind (or all

shades of yellow on the fruit rind), for example. This interpretation has also been defended by Bernacci et al. (2003). Therefore, the description by Degener (1932) can be considered a description of a cultivar under the Cultivated Plant Code, but not adequate for a botanical form, or another taxonomic level under the Botanical Code.

Despite the fact that the Cultivated Plant Code establishes the International Cultivar Registration Authorities (ICRAs), which are responsible for the registration of cultivars from a certain cultivation, and there is now an ICRA for *Passiflora* (Brickell et al., 2004), the listing of cultivars for the genus is still on the initial stage (Feuillet et al., 2000; Frank, 2001; Vanderplank, 2003; Fischer, 2004; King, 2007a; King, 2007b). Attempts were made to include every cultivar known in the genus (Feuillet et al., 2000; Frank, 2001; Vanderplank, 2003; Fischer, 2004), but some were placed in a list, but not others. Afterwards, a list including the registration number and an illustration of every cultivar registered was produced, of interspecific hybrids in particular (King, 2007a). Subsequently, an additional list of cultivars was made, but did not contain any illustrations, or the registration number of the plants, warning that inclusion in that list did not mean acceptance of the name under the Cultivated Plant Code (King, 2007b). Moreover, in some cases, the references did not relate to the material they referred to (<http://montereybaynsy.com/P.htm>, for *Passiflora* 'Allspice'), or they can no longer be found (<http://groups.msn.com/Passiflora/neuehybriden.msnw>, for *Passiflora* 'Aragorn'). In a nutshell, that list (King, 2007b) cannot even be considered a cultivar listing.

The best organized stage (King, 2007a) for the registration of *Passiflora* cultivars began with the indication of the authority by the Cultivated Plant Code (Brickell et al., 2004). However, that did not advance with the same strictness (King, 2007b), for some gaps are evident. Although Vanderplank (2000) had recognized *P. edulis* 'Flavicarpa', he did not list it afterwards, having referred to *P. edulis* f. *flavicarpa*, but only for some (7%) of the cultivars, involving *P. edulis*, mentioned (Vanderplank, 2003). Although *P. edulis* is from South America, and its native habitat is Brazil, the first three certified Brazilian cultivars of *P. edulis* were only launched in 1999, all of them with fruits of yellow rind (Meletti, 1999; Donadio, 2000). And, only in 2006 the first Brazilian cultivar with purplish fruits (reddish purple), intended for the international market, was launched - the 'IAC-Paulista', with a rind of intermediate color, and a hybrid between a selected plant of yellow fruits and a plant of purple fruits, obtained from nature (Meletti, 2007). Nevertheless, none of *Passiflora* cultivars officially recognized (though not always named under the rules of the Cultivated Plant Code) by Brazil (Brasil, 2008), have been registered in any of the lists indicated by the International Registration Authority for *Passiflora* (King, 2008), though Brazilian materials have been listed (but not registered at Brasil, 2008), thus worsening the problems related to the registration of cultivars from this cultivation.

Replacement of cultivars is common practice, for better quality, higher yield, and resistance to pests and diseases of newer cultivars. The material described by Degener (1932) was under cultivation at the time, or probably for a longer period,

especially in Australia (Purseglove, 1968). Both in Australia and Hawaii other cultivars were later developed, including hybrids between materials of purple and yellow fruits (Morton, 1987), and possibly the interpretation of the name of the materials as yellow fruits representing a botanical form must account for the impossibility of presently recognizing the current cultivars which may contain genetic material of that material described by Degener (1932). Based on the impossibility to recognize, or distinguish an old cultivar, as well as the cultivars that may be its offspring, its name could be reused for a new cultivar, as long as that did not create any confusion (Trehane et al., 1995; Brickell et al., 2004), but that does not seem the case of *P. edulis* 'Flavicarpa'.

Suppose that we use just the fruit color to distinguish botanical forms in the species *P. edulis* Sims, that would logically imply recognition of a different scientific name for the intermediate colors. In order to broaden and conclude this discussion, assuming that *Passiflora edulis* forma *flavicarpa* O.Deg. did not correspond to a single cultivar, the plant resulting from the crossing between passion fruit plants with purple fruits and passion fruit plants with yellow fruits, must be considered a hybrid and, therefore, cannot be given either the name *P. edulis* f. *edulis*, or *P. edulis* f. *flavicarpa*. Besides, no names exist for the other colors at form level. Thus, it is correct and more appropriate to simply associate the cultivars with the species, that is, *Passiflora edulis* Sims, only. It must still be considered that if it were reasonable to use a single characteristic to distinguish taxonomic forms in *P. edulis*, it must be assumed, based on the great variability of the species, that it would be reasonable to equally create an indefinitely large number of scientific names in the same category of form, in order to name each of the variations of the species.

In other cultures, such as rice (*Oryza sativa* L., rice, black rice, red rice, etc.) and beans (*Phaseolus vulgaris* L., beans, carioca beans, mulatinho beans, pink beans, purple beans, etc.) color is one of the aspects influenced by market preference, and yet neither colors nor color patterns correspond to taxonomic entities which have biological support. Although all red rice found commercially in the United States has traditionally been classified as *Oryza sativa* ssp. *indica* S.Kato, it was observed that, by using DNA markers, different samples of red rice should be classified as *O. sativa* L. ssp. *indica*, *O. sativa* ssp. *japonica* S.Kato, or *O. rufipogon* Griff. (Vaughan et al., 2001). *Oryza rufipogon* is widely known as wild red rice (Purseglove, 1972). The evolution history of *Phaseolus vulgaris* is not reflected on its infraspecific taxonomy, though genetic isolation of wild populations among themselves, and also within Central and South America, has resulted in morphological and molecular differentiation (Pickersgill et al., 2003).

In melon (*Cucumis melo* L.), for which the fruit color is also commercially significant, 360 infraspecific names, together with 526 synonyms (Solomon, 2008) have been listed, but it has been difficult to accept and use those names since the different materials intercross, thus resulting in many individuals with intermediate characteristics (Purseglove, 1968).

Due to the impossibility of presently recognizing any material that corresponds to the cultivar *P. edulis* 'Flavicarpa' an

alternative to be considered, as already suggested by Bernacci et al. (2005), is the use of the epithet to name a Group, like that established by the Cultivated Plant Code, that is, a set of cultivars sharing similarities. In that respect, the similarity would be the fruit color, and the group could be named, for example, *Passiflora edulis* (Flavicarpa Group) 'Monte Alegre' and *P. edulis* (Flavicarpa Group) 'Maravilha'. However, it must be considered whether this organization may be truly useful, also defining the grouping circumscription, that is, if it will include all shades of yellow, or if it will be limited to gradations 001A, 002A, 002B, 003A, 003B, 003C 004A, 004B, 005A, 005B, 005C, 006A, 006B, 006C, 007A, 007B, 007C, 007D, 008A, 009A, 009B, 012A e 012B (RHS, 2007).

Therefore, presently, at taxonomic level, in a correct, practical and simple manner, we indicate the use of the name

Passiflora edulis Sims for any plant and fruit color of sour passion fruit. Selected materials must be given cultivar names that allow naming plants with significant agricultural differences, and recognize their existence. Thus, according to the rules of the Botanical and Cultivated Plant Codes, for example, the cultivars (Brasil, 2008) have been registered, which must be named *Passiflora edulis* 'Monte Alegre', *P. edulis* 'Maravilha', *P. edulis* 'Jóia' and *P. edulis* 'BRS Gigante Amarelo', *P. edulis* 'BRS Sol do Cerrado', all of them of yellow fruits; *P. edulis* 'IAC-Paulista', of red purple fruits, and *Passiflora edulis* 'BRS Ouro Vermelho', which produces yellow and red fruits.



FIGURE 1 - Flower of *Passiflora edulis* 'IAC-Paulista', which produces red purple fruit.



FIGURE 2 - One of the types of flowers, from the Tietê access, of *Passiflora edulis*, which produces yellow fruit.



FIGURE 3 - Another type of flower, from the Tietê access, of *Passiflora edulis*, which produces purple fruit.

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