509-45-1, a *Capsicum annuum* Pepper Germplasm Containing High Concentrations of Capsinoids

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Additional index words. capsiate, 4-hydroxy-3-methoxybenzyl (E)-8-methyl-6-nonenolate, CAS No. 205687-01-0, dihydrocapsiate, 4-hydroxy-3-methoxybenzyl 8-methylnonanoate, CAS No. 205687-03-2

Germplasm release 509-45-1 is a small-fruited *Capsicum annuum* L. pepper released in 2013 by the Agricultural Research Service (ARS) of the U.S. Department of Agriculture (USDA). Fruit of 509-45-1 contain high concentrations of capsiate [(4-hydroxy-3-methoxybenzyl (E)-8-methyl-6-nonenolate/ CAS No. 205687-01-0] and dihydrocapsiate (4-hydroxy-3-methoxybenzyl 8-methylnonanoate/ CAS No. 205687-03-2) in both immature and mature fruit. Concentrations of total capsinoids in immature fruit of 509-45-1 exceeded 1000 $\mu\text{g}\cdot\text{g}^{-1}$ fresh weight (FW), in the absence of capsaicinoids, in 2011. The release of 509-45-1 will provide researchers and plant breeders with a new source of capsinoids, thus facilitating the production of and further research on these non-pungent biologically active compounds.

Origin

The pungent capsaicinoids, vanillylamide moieties with $\text{C}_9\text{--C}_{11}$ branched chain fatty acids, exhibit various beneficial forms of biological activity. However, their use as ingredients in certain foods and pharmaceuticals has been limited by the very characteristic that makes them popular as a spice–pungency. The non-pungent capsinoids are analogs of capsaicinoids and were first isolated from the sweet pepper cultivar CH-19 (Kobata et al., 1998). Capsinoids offer similar types of biological activity as found in capsaicinoids in the absence of pungency (Rosa et al., 2002).

Known capsinoids include capsiate, dihydrocapsiate, and nordihydrocapsiate (Kobata et al., 1999). In addition to antioxidant activity (Rosa et al., 2002), capsinoids enhance adrenal catecholamine secretion, promote energy metabolism, and suppress body fat accumulation (Masuda et al., 2003; Onuki et al., 2001; Sasahara et al., 2010; Tani et al., 2004). Their thermogenic and metabolic effects have been noted as supportive of their potential role as an adjunct weight loss aid (Josse et al., 2010). Tanaka et al. (2009) screened 35 lines of *Capsicum* (including five species) and noted that all species evaluated had one or more genotypes that produced capsiate, the highest concentrations being found in fruit of *C. baccatum* var. *praetermissum* and *C. chinense*.

Interest in capsinoids resulted in a screening of 120 randomly selected PIs for the occurrence of capsinoids (capsiate and dihydrocapsiate) in 2005. During this screening, low concentrations of capsinoids were detected in bulked fruit harvested from plants of PI 645509. Typical fruit of PI 645509 are small and extremely pungent. In 2006, 100 plants of PI 645509 were grown in the field in Griffin, GA, and the fruit of individual plants were harvested and analyzed for total capsinoids and capsaicinoids. A single plant was

subsequently identified that had fruit with a low ($\approx 300 \mu\text{g}\cdot\text{g}^{-1}$ FW) concentration of total capsinoids and non-detectable amounts of capsaicinoids (as determined by high-performance liquid chromatography). This plant was self-pollinated and its progeny (100 plants) were grown in the field in 2007 and the single plant selection process for elevated concentrations of capsinoids repeated. Further selections were conducted in 2008, 2009, and 2010. In 2011, a single plant was identified bearing immature fruit that contained greater than 1000 $\mu\text{g}\cdot\text{g}^{-1}$ FW capsinoids with no detectable capsaicinoids. Seed harvested from this plant were designated 509-45-1.

Description and Performance

Fruit and plants of 509-45-1 are homogeneous. Plants of 509-45-1 are semispreading with numerous basal branches that have an erect attitude. The leaf shape is lanceolate, medium green [Royal Horticultural Society Color Charts (RHS) 137B, <<http://www.rhs.org.uk/Plants/RHS-Publications/RHS-colour-charts>>] in color with slight pubescence present on the leaves and petioles. Plants of 509-45-1 can reach a height of 80 cm in the field over the course of a 120-d growing season and flower and bear fruit continuously until killed by frost. The corolla color is white on flowers borne one per leaf axil. Styles are exserted. Fruit are scattered throughout the plant, which routinely produces many hundreds of fruit over a growing season. A typical 509-45-1 fruit is ≈ 28 mm in length, 0.8 cm in diameter, trapezoidal in shape (longitudinal section), round in cross-section, and weighs ≈ 0.6 g. Fruit have a mean of two locules and a flesh thickness of ≈ 1 mm. Fruit may be pendent, erect, or intermediate. The fruit base is rounded with a blunt apex. Immature fruit are a medium green color (RHS 137C). Mature fruit are a dark red (RHS 45A), moderately glossy, and with a moderately intense flavor. Anthocyanin is absent in seedlings, leaves, calyxes, and fruit and weakly present on stems, at nodes, and on pedicels. Capsaicin and its analogs are not present in fruit of 509-45-1. Concentrations of fruit capsinoids increase rapidly ≈ 10 d post-anthesis

Table 1. Effect of size and maturity on mean (standard deviation) capsinoid ($\mu\text{g}\cdot\text{g}^{-1}$ fresh weight) content in fruit of *C. annuum* germplasm 509-45-1.^z

Stage of maturity	Fruit class ^a	Capsiate ^y	Dihydrocapsiate ^y	Total capsinoids ^y
Immature green	A	34 (22) E	12 (9) E	46 E
Immature green	B	527 (70) B	203 (29) B	730 B
Immature green	C	704 (85) A	219 (25) A	923 A
Immature green	D	757 (121) A	256 (12) A	1013 A
Mature green	E	599 (32) B	236 (38) B	835 B
Turning	F	341 (14) C	105 (8) C	446 C
Mature red	G	196 (15) D	64 (7) D	260 D

^aRandomized complete block design with four replications (10 plants per plot) planted on 11 Mar. 2011; seedlings transplanted to the field in Griffin, GA, on 12 May 2011. All fruit were harvested from all plants on 26 and 27 Sept. and divided into classes A through G based on fruit weight and/or coloration (A = less than 0.1 g; B = 0.1 to 0.20 g; C = 0.21 to 0.30 g; D = 0.31 to 0.40 g; E = greater than 0.4 g fully green, F = turning color, and G = sound mature red). Fruit (500) in each category/replication were bulked, ground in a commercial blender, and samples taken for analysis of capsinoids as described by Singh et al. (2009).

^yValues within columns followed by the same letter are not significantly different ($\alpha = 0.05$) per Tukey's Studentized range test.

Received for publication 22 Oct. 2013. Accepted for publication 26 Nov. 2013.

This work was supported in part by USDA/NRI Grant No. 2006-35503-17179 and Hatch Grant No. ME08555-07.

We gratefully acknowledge the technical assistance of Mr. Chris Tatum, Dr. Satyavan Singh, and Valerie Antonio for the production of fruit, sample preparation/extraction, and analysis of capsaicinoids and capsinoids.

This is Maine Agriculture and Experiment Station Publication No. 3352.

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and peak in the immature green stage of maturity, declining thereafter. Immature green fruit of 509-45-1 can be expected to contain 750 to greater than 1000 $\mu\text{g}\cdot\text{g}^{-1}$ FW total capsinoids (Table 1). Concentrations of capsinoids in greenhouse-grown fruit are often substantially (greater than 50%) reduced when compared with field-grown fruit (data not shown).

Availability

Small quantities of seed of 509-45-1 are available for research purposes from Dr. R.L. Jarret, USDA/ARS, 1109 Experiment Street, Griffin, GA 30223, 770/228-7303. Genetic material of this release (PI 669378) has been deposited in the National Plant Germplasm System and is available for research purposes, including the development and commercialization of new varieties/cultivars. It is requested that appropriate recognition be made if 509-45-1 contributes to research, the production of capsinoids, or to the development of breeding lines or cultivars.

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