Time of Synthesis, Concentration and Localization of Essential Oil in The Fruit of Coriander

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Abstract

Coriander *(Coriandrum sativum* L.) of the family Apiaceae is one of the major spice crops in Saskatchewan and produces the essential oil linalool. The essential oil in coriander fruit accumulates in oil ducts (vittae) during formation and maturation of the fruits. A study was conducted to determine when, where, and how much the essential oil is produced in the fruit of coriander. The results of this study indicated that: The concentration of essential oil during fruit development of coriander was the highest at 3 and 4 weeks after flowering and declined after that. Splitting of coriander fruits resulted in the loss of about 30 % of the essential oil. Dehulling of coriander fruit resulted in the loss of about 55 % of the essential oil. The hull of coriander contained only about 0.3 ml/l 00g essential oil. High density coriander fruits averaged two seeds per fruit with a high 1000-fruit weight, but they were lower in essential oil than the low density fruits. The essential oil in coriander fruit is stored in two oil ducts, located on the inner edge of each hemisphere-shaped mericarp.

Key words: Coriander, spice, essential oil, vittae, linalool, mericarp

Introduction

Coriander *(Coriandrum sativum* L.) of the family Apiaceae (Umbelliferae) is an annual herbaceous plant originally from the Middle East. Coriander is a major spice crop and produces an essential oil in its fruit. It grows well under a wide range of conditions, but thrives best on a medium to high fertility soil in sunny locations with good drainage and well distributed moisture. The ideal temperature for fruit growth and development is 15 - 18°C (Rosengarten, 1969; Purseglove ***et al.***, 198 1). Coriander is widely grown as a winter crop in tropical and subtropical countries such as India, Morocco, Pakistan, Romania and Russia. whereas the major trade markets of coriander are Sri Lanka, Malaysia, Japan. and the USA (Purseglove *et al.*, 1981).

The fruit of coriander is a schizocarpium, consisting of two united hemisphere-shaped carpels which separate at maturity into two mericarps within the ovary wall of the round to elongated fruit (Parry, 1969). Two types of coriander, based on fruit size are the small-

fruited type (1.5 - 3.0 mm in diameter) with about 1.1 ml/l 00g essential oil and the large-fruited type (3.0 - 5.0 mm in diameter) with about 0.7 to 0.8 ml/100g essential oil (Purseglove *et al.*. 1981). Gaudiel (1993) reported the world production of coriander essential oil is 710 metric tons, the fourth largest after orange. commint, and citronella essential oil. The essential oil of coriander is used extensively in the food. perfume. cosmetic, and pharmaceutical industries. Kerrola and Kailio (1993) and *Pino et al.* (1993) reported that the main component of the essential oil in coriander fruit is linalool (monoterpene alcohol), comprising up to 70 % of the essential oil.

The essential oil in Apiaceae fruits accumulates in oil ducts (vittae) during the growth. development and maturation of the fruits (Savchuk, 1976). The vittae vary in number. size, shape and position (Parry, 1969; Roth, 1977). Therefore, the amount of essential oil depends primarily on the number and size of the vittae. Parry (1969) reported that two commissural vittae are usually present in the inner side of each hemisphere-shaped mericarp of the ripe fruits of coriander. However, Smith (1977) presented some drawings of the vittae in fruits from members of the family Umbelliferae and indicated that the vittae occurred in the fruit wall (hull) of coriander. Purseglove *et al.* (1981) noted that vittae are present either in the periphery or in the mericarp of the coriander fruit.

The primary objectives of this study were to determine: 1) Time of synthesis of essential oil during fruit development, 2) Concentration of essential oil in intact fruits, split fruits, dehulled seeds. and hulls. 3) Concentration of essential oil in high density and low density coriander fruit, and 4) Localization of essential oil ducts in coriander fruit.

Materials and Methods

1. Time of synthesis of essential oil during fruit development.

Two lines each of large-fruited (ND-1 and Santo) and small-fruited (Saskatoon Early and PGR 5741) coriander were grown at Saskatoon in 1996 and about 50 umbels were collected every seven days starting 21 days after the first flower and ending 63 days after the first flower. Fruits were threshed and collected from these umbels and duplicate analyses were made for concentration of essential oil for each genotype at each date.

2. Concentration of essential oil in intact fruits, split fruits, dehulled seeds, and hulls.

Essential oil of coriander fruits was isolated using an essential oil trap apparatus (Clevenger-type). Samples were ground using a Krups coffee grinder and 20 g of the air-dried ground material of each sample was hydrodistilled with 500 mL of distilled water for 2 hours to extract the oil (Kerrola and Kallio, 1993). The concentration of essential oil was expressed as ml/100g.

Fruits of these same four genotypes from the 1995 crop at Saskatoon were treated in various ways to determine the localization of the essential oil and fixed oil in the fruit.

Smith (1977) reported that the essential oil was found in ducts in the fruit wall or hull. Accordingly, 50 g of fruits of each of the four genotypes was dehulled using the tangential abrasive dehulling device for two minutes (Sokhansanj, personal commun.) and the hulls and seeds were separated by an aspirator. Intact fruit and split fruit (from a threshing machine) were also included. The concentration of essential oil in these four samples was determined as described above.

3. **Essential oil concentration, lOOO-fruit weight, and number of seeds per fruit in high density and low density coriander fruit.**

Fruits of each of the original four genotypes were sorted into two densities by immersion in hexane. Fruits that sank in hexane were classed as high density fruits and those that floated were classed as low density fruits (Reaney, personal commun.). Weight of lOOO-fruits and number of seed per fruit for high and low density fruits were determined with three samples of each treatment. Concentration of essential oil was also determined as above.

4. Localization of essential oil ducts in coriander fruit.

Localization of the essential oil ducts in coriander fruit was determined by scanning electron microscopy (SEM). Fresh fruits of genotype Santo (a large-fruited genotype) and genotype PGR-5741 (a small-fruited genotype) were harvested 63 days after first flower in 1996. Cross sections of the fruits were further prepared for SEM through primary fixation in a buffered glutaraldehyde solution, post fixation in an osmium tetraoxide solution, dehydration with acetone, drying, gold coating, and then the scanning electron micrographs were taken (Gabriel, 1982; Davis, personal commun.).

Results and Discussion

1. Time of synthesis of essential oil during fruit development.

The percentage essential oil in coriander fruit increased up to four weeks after flowering and then gradually decreased in both small-fruited and large-fruited genotypes (Figure 1). The percentage of essential oil in coriander fruits at harvest (63 days after the first flower) was about 30 and 50 % less than at four weeks after the first flower for small-fruited and large-fruited genotypes, respectively. Similar results were reported by several researchers reviewed by Purseglove et ***al. (198 1). Thus,*** coriander fruit has the highest percentage of essential oil early in fruit development and the essential oil concentration decreases about one-third during further maturation and development. These results suggest that the essential oil is synthesized before completion of starch synthesis during fruit growth and development.

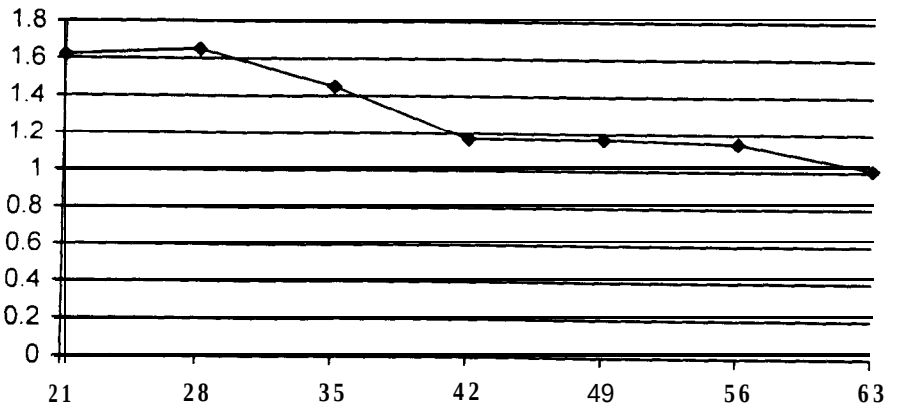

Figure. 1. Essential oil concentration during development of coriander fruit in 1996 (mean of four genotypes)

2. **Concentration of essential oil in intact fruits, split fruits, dehulled seeds, and hulls.**

The concentration of essential oil in the hull was only about 30% of the concentration in the intact fruit (Figure 2), indicating that little essential oil was associated with the hull. The concentration of essential oil in the dehulled seed was only about 46% of the concentration of the intact fruit, indicating that some essential oil was associated with the seed. The concentration of essential oil in the split fruit was only about 69% of the concentration in the intact fruit, indicating that much of the essential oil was lost during splitting, either by volatilization losses, contamination losses in the splitting machine, contamination losses on the hull or some combination. Volatilization losses were ruled out by the low vapour pressure of the essential oil.

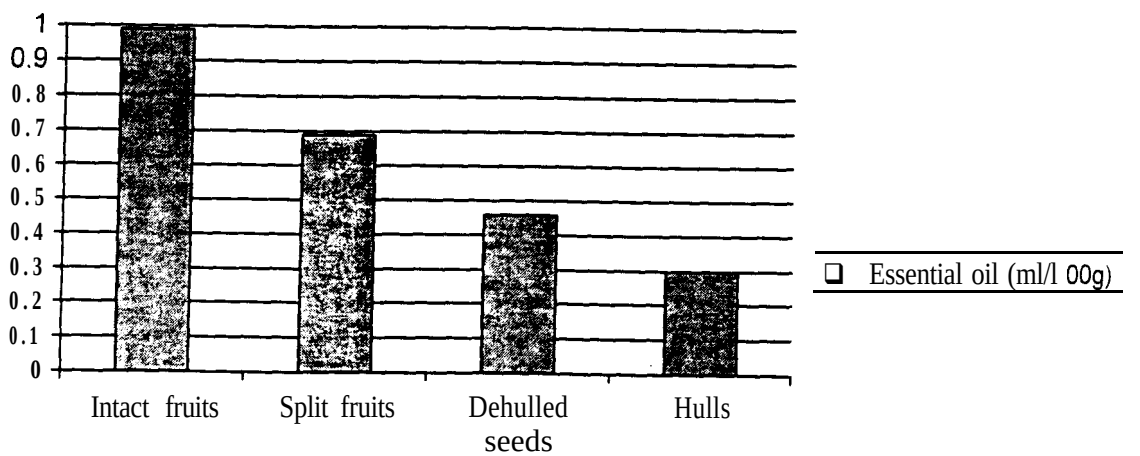

Figure 2. Concentration of essential oil in intact fruits, split fruits, dehulled seeds, and hulls of coriander (mean of four genotypes).

3. Essential oil concentration, lOOO-fruit weight, and number of seeds per fruit in high density and low density coriander fruit.

The high density coriander fruits were higher in lOOO-fruit weight, due primarily to the higher number of seed per fruit (Table l), which resulted in a higher hull percentage and a lower essential oil concentration. The higher concentration of essential oil in the low density fruit may be the result of larger oil ducts in the predominantly one-seeded fruits vs the two-seeded fruits.

Table 1. Essential oil concentration, l OOO-fruit weight, and number of seeds per fruit in high density and low density coriander fruit

Density	Essential oil (ml/l 00g)	1000-fruit weight (g)	Number of seed per fruit
High	0.85	11.5	2.0
Low	1.09	8.0	1.3
S.E. (density)	0.02	0.1	0.1

4. Localization of essential oil ducts in coriander fruit.

Scanning electron micrographs of the essential oil ducts in coriander fruits after 63 days of flowering are shown in Figures 3 to 5. Two oil ducts are located in the inner side of each mericarp.

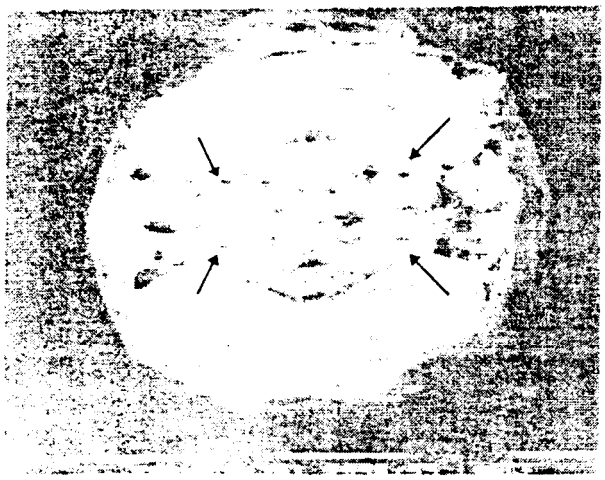

Figure 3. Scanning electron micrograph of a cross section of a fruit of coriander showing four oil ducts (arrows). The endosperm (E) of each is evident.

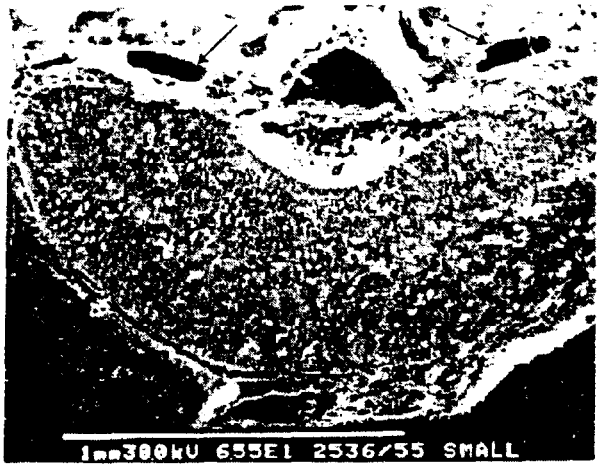

Figure 4. Scanning electron micrograph of the two oil ducts in a mericarp of coriander

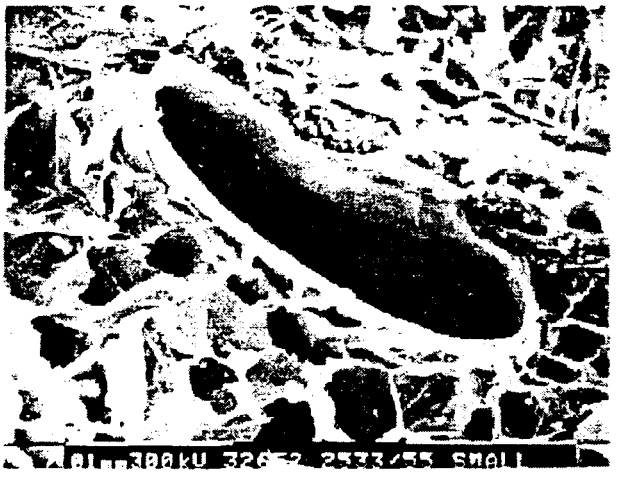

Figure 5. Scanning electron micrograph of a single oil duct of coriander.

Conclusions

Based on the results of the above experiments, it can be concluded that:

1. The concentration of essential oil during fruit development of coriander was the highest at 3 and 4 weeks after flowering and declined after that.
2. Splitting of coriander fruits resulted in the loss of about 30 % of the essential oil.
3. Dehulling of coriander fruit resulted in the loss of about 55 % of the essential oil.
4. The hull of coriander contained only about 0.3 ml/lOOg essential oil.
5. High density coriander fruits averaged two seeds per fruit with a high lOOO-fruit weight, but they were lower in essential oil than low density fruits.
6. The essential oil in coriander fruit is stored in two oil ducts, located on the inner edge of the hemisphere-shaped mericarp.

References

Gabriel. B.L. 1982. Biological scanning electron microscopy. Van Nostrand Reinhold Company. New York. 186pp.

Gaudiel, R. 1993. Essential oil crops and oil quality. Pages 50-54 *in* Proc. Special "cropportunities II conf. Extension Division University of Saskatchewan.

Kerrolla, K. and H. Kallio. 1993. Volatile compounds and odor characteristics of CO, extracts of coriander fruit. J. Agric. Food Chem. 41: 785-790.

Parry, J. W. 1969. Spices. Morphology, histology, chemistry. Chemical Publishing Company. Inc., New York. 245pp.

Pino J., P. Borges and E. Roneal. 1993. Compositional differences of coriander fruit oils from various origins. Die Nahrung 37: 119- 122.

Purseglove, J.W., E.G.Brown, C.L.Green, and S.R.J.Robbins. 1981. Spices. Longman, New York. 789pp.

Rosengarten, F. Jr. 1969. The Book of Spices. Livingston Publishing Co. Wynnewood, Pennsylvania. 489pp.

Roth I. 1977. Fruits of angiosperms. Encyclopedia of plant anatomy. Gebruder Bomtraeger, Caracas. 675pp.

Savchuk, L.P. 1976. Influence of weather conditions on the amounts of essential oils in lavender and coriander. Soviet Meteorol. Hydrol. 7: 94-99.

Smith, J.P.J.R. 1977. Vascular plant families. Mad River Press Inc., California. 32 lpp.

Acknowledgement

Thanks to Dr G. Arganosa for his assistance and Drs F.W. Sosulski and R. Bhatty for their lab facilities.