

Reduction of 'Kohansho' Disorder in Stored Hassaku (*Citrus hassaku* hort. ex Tanaka) Fruit by Vegetable Oil, Fatty Acid and Wax Coating

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Summary

Occurrence of 'Kohansho' disorder in Hassaku fruit was investigated in relation to corn oil, safflower oil, linoleic acid and wax coating. The injury did not occur during the storage at 5°C but started to appear just after the fruit were transferred to 20°C. Coating fruit with vegetable oil emulsions markedly reduced symptoms of 'Kohansho' disorder on the surface of the fruit when applied at 10% or higher concentrations. Moreover, the disorder was not observed on the half part of fruit surface treated, whereas the non-treated side developed the symptoms. The development of injury was also somewhat suppressed by wax coating. However, visible rind damages, which are apparently different from 'Kohansho' disorder, were observed on the rind during the prolonged period of storage when vegetable oils and linoleic acid were employed.

Introduction

After harvest, there appear many pitted spots on the rind of Hassaku fruit when stored above 10°C and these spots develop into large brown spots (Ogawa et al., 1979; Yamashita, 1967). This injury was tentatively designated as 'Kohansho' at the 1977 Annual Meeting of Evergreen Fruit Trees organized by the Fruit Tree Research Station, Ministry of Agriculture, Forestry and Fisheries. This term is coined from 'Kohan' which means tiger's speckles and 'Sho' which means disease. However, it seems that there are many causes that induce such disorder because similar symptoms also develop by chilling temperatures. Disorders like 'Kohansho' occur not only in Hassaku fruit, but also in other citrus fruits. The occurrence varies with variety (Grierson, 1981), growing districts (Hasegawa and Iba, 1981) and stages of fruit development (Manago, 1988; Sato et al., 1983). 'Kohansho' disorder of Hassaku fruit was reduced by treating with thiabendazole (TBZ) (Kitagawa and Tarutani, 1980) and by wrapping with polyethylene film bag (Ben-Yehoshua et al., 1970; Ogawa and Sasaki, 1979). Sawamura et al. (1984) reported that a rind spot-like disorder could be induced by exogenously applied rind oils. However, complete preventive

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measures of the disorder have not yet been established because the causal factors and mechanisms affecting the occurrence are not clearly known.

Aljubri and Huff (1984) found that vegetable oils were effective to prevent stored grapefruit from chilling injury. In this study we report the effect of vegetable oil, linoleic acid and wax coating on 'Kohansho' development of Hassaku fruit.

Materials and Methods

In the first experiment, Hassaku fruit were harvested on December 24, 1985 from commercial groves in Matsuyama, Ehime Prefecture. All the fruit were washed and disinfected with a 2-min soak in a 1 : 5 (v/v) dilution of commercial bleach. After blotted, a 10 μ l drop of benomyl (0.05%) was applied to the exposed vascular system at the stem end to reduce the incidence of decay. All fruit were stored at 5°C and 90% RH (relative humidity). Fruit were dipped for 1 min in vegetable oil emulsion, linoleic acid or water(control). The concentration of emulsion was 10, 20, 100% for safflower oil, 20, 100% for corn oil and 100% for linoleic acid. After treatment, the fruit were placed again at 5°C. After a certain period of storage at 5°C, the fruit were transferred to 20°C and 70% RH. Numbers of fruit injured and rind spots per fruit were counted. The respiration rate of the fruit which were coated with corn oil was measured after the transfer to 20°C with an infrared CO₂ gas analyzer.

In the second experiment, Hassaku fruit were harvested from commercial groves on December 25, 1987. The fruit were similarly treated as mentioned above, and then stored at 5°C and 90% RH. Fruit were coated with wax, placed at a 5°C room and then transferred to a room where temperature was kept at 20°C and RH 70%. Numbers of fruit injured and rind spots per fruit were counted.

Results and Discussion

The occurrence of 'Kohansho' in Hassaku fruit coated with safflower oils is shown in Fig. 1. In the control plot, about 70% of the fruit developed pitting on the rind surface. In contrast, treated fruit did not exhibit any injurious symptom. As shown in Figs. 2 and 3, similar results were obtained in corn oil as well as in linoleic acid treatment.

When half of the fruit surface was treated with safflower oil, the treated part did not develop injurious symptoms but rind spots appeared in the untreated side (Fig. 4). Wax coating was also somewhat effective for preventing the rind spots (Fig. 5).

Respiration rates of the fruit treated with corn oil were compared with that of the control fruit (Fig. 6). Corn oil coating considerably depressed the respiration.

It has been reported that 'Kohansho' disorder in Hassaku fruit is controlled by the following treatments; wrapping individual fruit with polyethylene film (Ben-Yehoshua et al., 1970; Ogawa and Sasaki, 1979), coating with wax (Manago, 1988), and dipping fruit in hot water (Manago, 1988) before storage. Manago (1988) reported that the occurrence of 'Kohansho' was significantly lower in fruit grown in plastic houses than those grown outdoors.

It is clear from our results that although there appears no injury during the low temperature

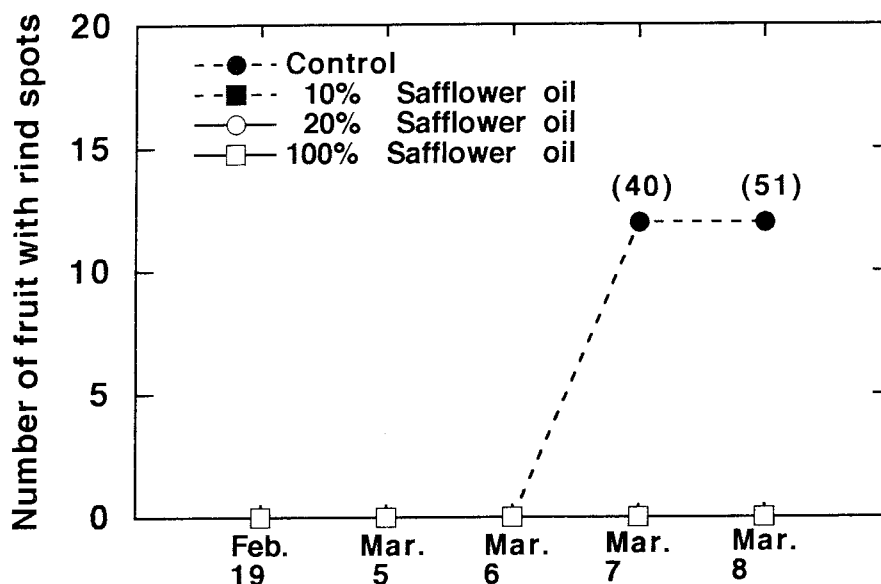


Fig. 1 The occurrence of 'Kohansho' disorder in Hassaku fruit coated with safflower oil. Fruit were harvested on December 24, 1985, then stored at 5°C. On February 19, 1986, fruit were dipped in safflower oil emulsions, then placed at 5°C. The fruit were transferred to 20°C on March 5, 1986. The numbers in parentheses are the total numbers of rind spots per fruit.

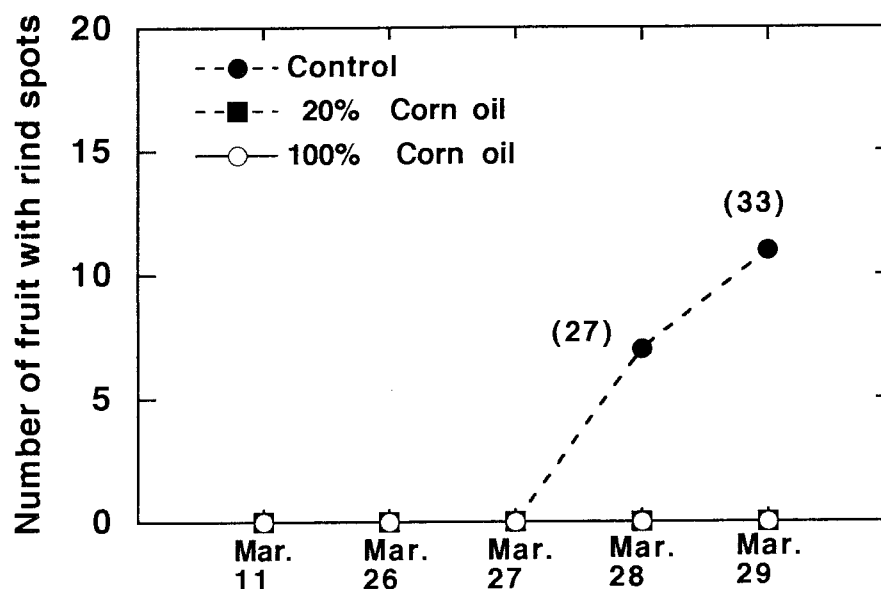


Fig. 2 The occurrence of 'Kohansho' disorder in Hassaku fruit coated with corn oil. Fruit were harvested on December 24, 1985, then stored at 5°C. On March 11, 1986, fruit were dipped in corn oil emulsions, then placed at 5°C. The fruit were transferred to 20°C on March 26, 1986. The numbers in parentheses are the total numbers of rind spots per fruit.

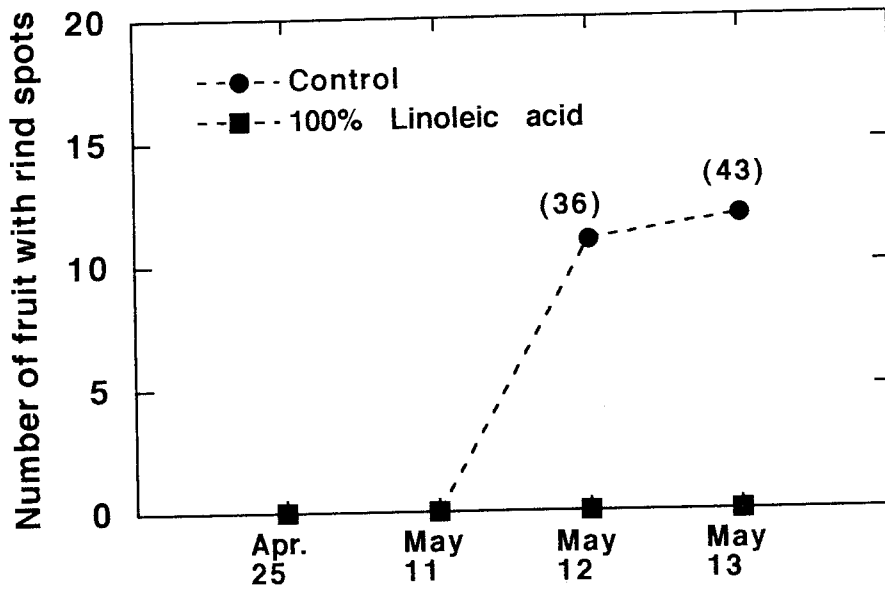


Fig. 3 The occurrence of 'Kohansho' disorder in Hassaku fruit coated with linoleic acid. Fruit were harvested on December 24, 1985, then stored at 5°C. On April 25, 1986, fruit were dipped in linoleic acid, then placed at 5°C. The fruit were transferred to 20°C on May 11, 1986. The numbers in parentheses are the total numbers of rind spots per fruit.

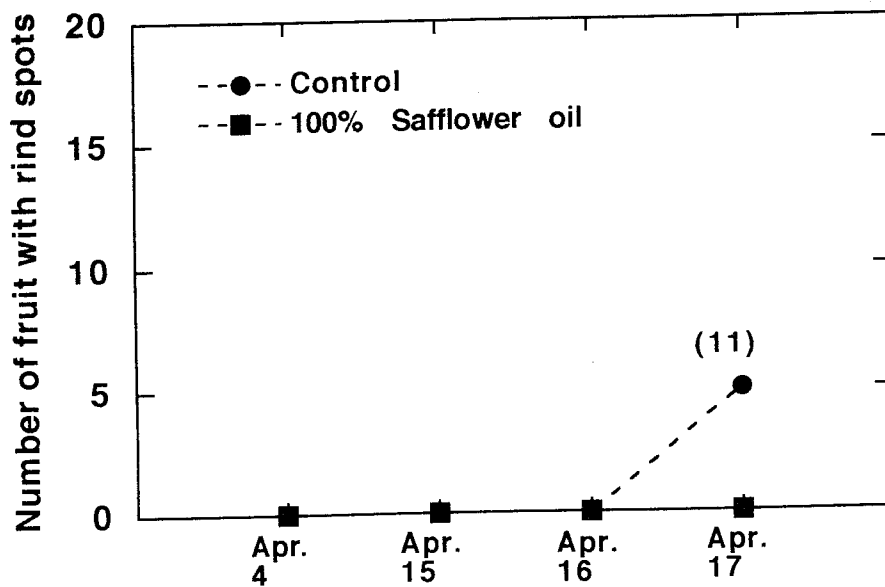


Fig. 4 The occurrence of 'Kohansho' disorder in Hassaku fruit coated with safflower oil. Fruit were harvested on December 24, 1985, then stored at 5°C. On April 4, 1986, half part of the fruit surface was dipped in safflower oil, then placed at 5°C. The fruit were transferred to 20°C on May 11, 1986. The numbers in parentheses are the total numbers of rind spots per fruit.

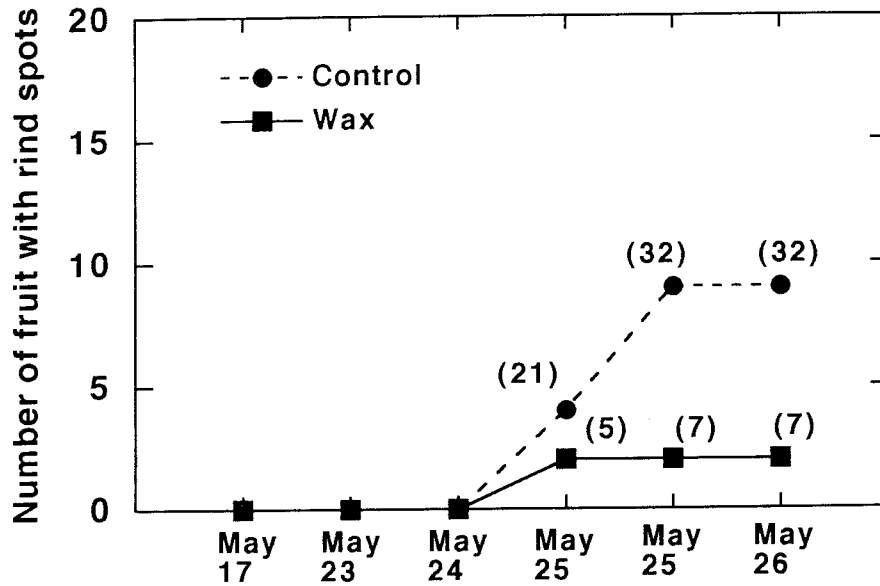


Fig. 5 The occurrence of 'Kohansho' disorder in Hassaku fruit coated with wax. Fruit were harvested on December 25, 1987, then stored at 5°C. On May 17, 1988, fruit were treated with wax, then placed at 5°C. The fruit were transferred to 20°C on May 23, 1988. The numbers in parentheses are the total numbers of rind spots per fruit.

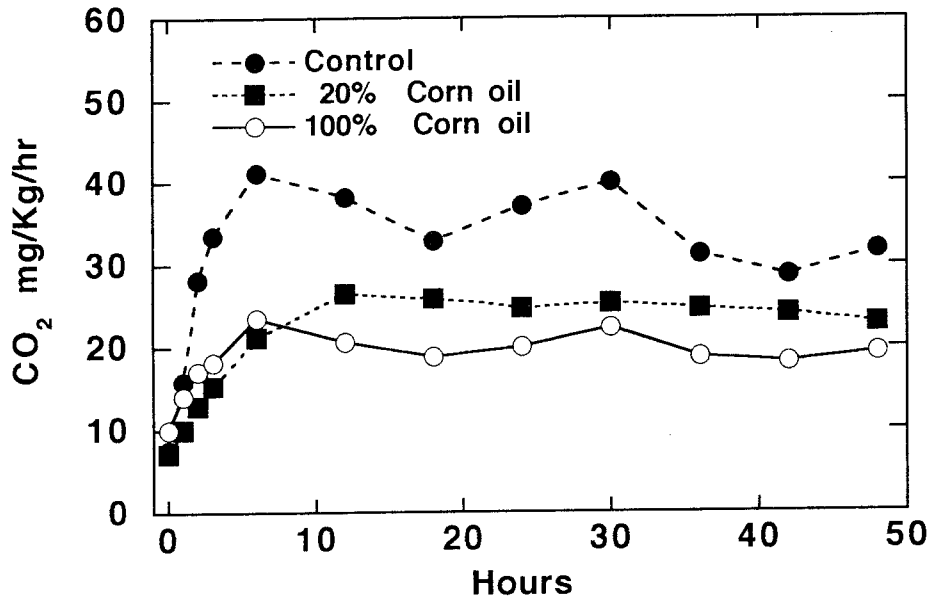


Fig. 6 The respiration rates of Hassaku fruit coated with corn oil after the transfer from 5°C to 20°C. For details see the legend in Fig. 2.

storage at 5°C, the symptoms rapidly develop just after the fruit are transferred to 20°C. This suggests some chemical processes are involved throughout the injury development. Oil coating reduced the respiration rate of the fruit (Fig. 6). The treatment may substitute for the role of low temperatures (5°C), because low temperatures also depress respiration. Furthermore, another explanation is possible from the aspect of transpiration. The transpiration rate is low at low

temperatures, but when fruit are transferred to high temperatures, the rate also enhances. However, by oil or wax coating or film sealing, the transpiration rate is reduced even at high temperatures. Therefore, it is interesting to know whether 'Kohansho' occurs under such conditions as high oxygen levels and high relative humidity. The former promotes respiration while the latter depresses transpiration.

Although vegetable oils are effective for preventing the 'Kohansho' development after the transfer of fruit from low to high temperatures, they also cause rind damages, which are apparently different from 'Kohansho' symptoms, during the prolonged period of storage. However, Aljubri and Huff (1984) reported that vegetable oils were effective to prevent chilling injury in grapefruit and that there were no injuries due to oil application. In the case of grapefruit, the injury appears during the storage at a low temperatures such as 3°C (Aljubri and Huff, 1984). Hassaku fruit do not develop injurious symptoms during the low temperature storage and they develop only after the transfer from a low temperature to a high temperature room. There may be some different causes or mechanisms between the two injuries.

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Literature Cited

- Aljubri, H. J. and A. Huff. 1984. Reduction in chilling injury to stored grapefruit (*Citrus paradisi* Macf.) by vegetable oils. *Sci. Hort.* 24 : 53-58.
- Ben-Yehoshua, S., I. Kobiler and B. Shapiro. 1970. Some physiological effects of delaying deterioration of citrus fruits by individual seal-packaging in high-density polyethylene film. *J. Amer. Soc. Hort. Sci.* 104 : 868-872.
- Grierson, W. 1981. Physiological disorder of citrus fruits. *Proc. Int. Soc. Citriculture* : 764-767.
- Hasegawa, Y. and Y. Iba. 1981. Kohansho : a physiological disorder of the rind of citrus fruits during storage in Japan. *Proc. Int. Soc. Citriculture* : 774-776.
- Kitagawa, H. and T. Tarutani. 1980. Studies on storage of Hassaku (*Citrus hassaku* Hort. ex. Tanaka) fruit. I. Effects of TBZ treatment on occurrence of Kohansho. *Abst. Jap. Soc. Hort. Sci. Autumn. Meet.* : 390-391.
- Ogawa, K., K. Sasaki and Y. Kurokawa. 1979 Studies on the storage of mid and late season citrus. I. Factors affecting the development and occurrence of 'Kohansho' in Hassaku (*Citrus hassaku* Hort. ex. Tanaka) fruit during storage. *Bull. Fruit Tree Exp. Station Hiroshima Pref.* 5 : 17-26.
- Ogawa, K. and K. Sasaki. 1979 Studies on the storage of mid and late season citrus. II. Effect of pretreatment and polyethylene film on the occurrence of 'Kohansho' in Hassaku (*Citrus hassaku* Hort. ex. Tanaka) fruit during storage. *Bull. Fruit Tree Exp. Station Hiroshima Pref.* 5 : 27-38.
- Manago, M. 1988. Studies on 'Kohansho' : a physiological disorder of fruit rind in Hassaku (*Citrus hassaku* Hort. ex. Tanaka). *J. Jap. Soc. Hort. Sci.* 57 : 295-303.

- Sato, M. T. Akita and T. Mitsumata. 1983. Studies on storage of mid and late season citrus fruit. Relationship between the occurrence of 'Kohansho' of Hassaku (*Citrus hassaku* Hort. ex. Tanaka) fruit and fruit setting in the tree crown, treatment of plant growth regulators and harvest time. Abst. Jap. Soc. Hort. Sci. Autumn. Meet. : 416-417.
- Sawamura, M. T. Manabe, S. Oonishi, K. Yasuoka and H. Kusunose. 1984. Effect of rind oils and thier components on the induction of rind spot in citrus species. J. Hort. Sci. 69 : 575-579.
- Yamashita, S. 1967. Studies on the storage of Hassaku (*Citrus hassaku* Hort. ex. Tanaka) at low temperature. I. About the thermal-humidical condition and the occurrence of oleocellosis and prevention of it. J. Jap. Soc. Hort. Sci. 36 : 250-258.

摘 要

ハッサク果実への植物油、リノール酸、ワックスの被膜処理がコハン症の発現に及ぼす効果を調査した。ハッサク果は5℃で貯蔵をしている間はコハン症の発現が見られないが、5℃から20℃に移すと症状が出始める。サフフラワー油、コーン油、リノール酸を処理するとコハン症の発現が完全に抑制された。また、果面の半分にサフフラワー油を処理したところ、処理した部分では発現が認められなかったのに対し、無処理の部分では症状が見られた。さらにワックスによる被膜によっても発現がいくらか抑制された。コーン油を処理すると対照区の1/2にまで呼吸速度が抑えられた。以上のように植物油やリノール酸にはコハン症の発現を抑制する効果が見られるが、果実をさらに貯蔵するとコハン症とは異なるこれらの薬品によると思われる果皮傷害が表れた。