

From farm to fork: cultivation, postharvest and processing of strawberry in Japan

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Abstract

Strawberry cultivated in Japan widely known for its sweet and soft nature which regards as premium fruits in Japan. The objective of the present study was to give an overview of strawberry cultivation, and postharvest processing in selected manufacturers and farms in Nagano, and Hokkaido, Japan. The information was obtained through an interview session, and questionnaire distribution. Case study approach was used to obtain data. The cultivation of strawberries in Japan at the selected study area was mainly planted in the greenhouse under controlled temperature to maintain the quality and yield of strawberries. The strawberries in all the selected farm used manual grading process during the strawberry picking process. Processing of strawberries into other products was often done in small-scale by farmers and sold directly from the farm and distributed to other local seller and supermarket which portrayed “from farm to fork” practice. Strawberries processed into products such as jam, drinks and ingredients in bakery goods were labelled as premium products sold in special shops in Japan. Japan’s Strawberries and strawberry-based products produced by the larger manufacturer were able to penetrate the Hong Kong, Malaysia and Thailand market.

1. Introduction

Strawberry or scientifically called *Fragaria ananassa* is popular among consumer worldwide due to its distinctive taste, unique appearance and nutritional benefit. Strawberry is a non-climacteric fruit, originated from temperate regions but, can also be cultivated under sub-tropical, and tropical regions (usually at higher altitude area which has lower temperature (Al-Madhagi *et al.*, 2018; Muzaffa *et al.*, 2018). Strawberry required a cultivation temperature of day and night ranging from 20 to 28°C and 12 to 18°C respectively (Abidin *et al.*, 2018). Strawberries can be cultivated either sexually from the seed, or asexually through runners which grown from the mother plant (Rubinstein, 2015).

The main producers of strawberries are USA, Turkey, Spain, Egypt and Mexico, which USA leading the market with an approximate production of 4 million tonnes of strawberries annually (Muzaffar *et al.*, 2018).

In Japan, strawberries are the third most valuable crops produce alongside rice and tomatoes, which Tochigi, Fukuoka and Kumamoto were the top 3 producers of strawberries (Ishikawa *et al.*, 2018; Petlock and Sugimoto, 2015). In the early years, the cultivation of strawberries in Japan was done in an open field farm but changed to greenhouses (Petlock and Sugimoto, 2015). Strawberries can be cultivated either in soil or soilless system using a hydroponic method of the plantation (de Miranda *et al.*, 2014). The cultivation of strawberries in Japan mainly use soil as growth medium under greenhouse plantations enable farmers to control the temperature, water, pest, disease and pollination of strawberries during cultivation, pre and post-harvest process (Petlock and Sugimoto, 2015).

Despite the highly nutritious composition of strawberries, the shelf-life of fresh strawberries is short due to the susceptibility to fungal spoilage, and highly

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perishable due to natural ripening process (Octavia and Choo, 2017; Muzaffar *et al.*, 2018). Fresh strawberries stored at an average temperature of 5°C may last up to 13 days (Nicolau-Lapeña *et al.*, 2019). Thus, a good pre and postharvest handling were required in maintaining the quality of fresh strawberries. Strawberries often process into other products such as jam, juice, dried fruits and as bakery products to lengthen the shelf-life of strawberries (Muzaffar *et al.*, 2018). Japan's consumer prefers fresh strawberries, but 2 to 3% of strawberries often processed into confectionery products (Petlock and Sugimoto, 2015).

The present study intended to report the current cultivation, postharvest and processing techniques and practices of strawberries by the selected farms and manufacturers from a selected area in Japan. The cultivar, effect of farm area, manpower to production yields, processing technology, the product and market of end products were obtained through a questionnaire, site visit and interview.

2. Methodology

2.1 Study area

In this study, ten respondents from selected farms, and manufacturer from Nagano, and Hokkaido were selected. Nagano is located about 200 km from Tokyo, Japan (as shown in Figure 1) having a dry climate with low annual precipitation rates (Nagano Prefecture, 2013). Hokkaido Island is located in the north of Japan having extreme weather during the winter (Yamasaki, 2013; Morishita, 2014) which popular with winter variety strawberries.



Figure 1. Selected area of study. Source: <https://www.ezilon.com/maps/asia/japan-road-maps.html>

2.2 Demographic information

The demographic information of selected farms and manufacturer including the farm's area, employee, business operation, and establishment year were tabulated in Table 1. Based on the information obtained, farm 2, 3 and 4 produced their strawberry-based product to be sold directly to the consumer or visitor of their farm.

2.3 Case study approach

The results obtained in the present study were reported as a case study. The case study is an empirical evaluation of real-life conditions aiming to report comparable arguments or specific idea (Gabel *et al.*, 2018). The information was obtained through the dissemination of the questionnaire, in-site visit and interview session with person-in-charge of selected study areas. The questionnaire includes both close-ended and open-ended questions covering the demographic information, cultivation techniques, processing of products and market of distributions. The respondents were picked randomly from the selected area of Nagano and Hokkaido. The obtained data then presented and discussed thoroughly with support from prior research available.

3. Results and discussion

3.1 Cultivation of strawberry

Based on the questionnaire distributed, in-site visit and interview, all farms selected in this study (Farm 1, 2,3, 4, 5, 6, 8 and 10) using runners originated from the parental plants during cultivation of strawberries. The runners were placed approximately 10 cm away from each other. The spacing between plants is important for each plant to obtain optimum nutrients, moisture, light and space for growing (Shahzad *et al.*, 2018). All farms used their own mother plant which the seedling was done using the potting technique, except Farm 8, that bought 70% of the mother plant from Hoishu as they were unable to fully breed their own mother plants. According to Hasan *et al.* (2011), the production of runner from the parental plant is effective at a day length of 12 to 15 hours of temperature ranging from 10 to 22.7°C. The matured mother plant will produce runners through vegetative propagation that will produce new roots system (Kuchi and Sharavani, 2019). Farm 3 also uses the seedling method of strawberry's planting on their farm. The used of seed in strawberries planting reduce the risk of pathogen and viruses attack but much higher in cost, which stolons are preferred as it is more cost-effective (Rubinstein, 2015).

The cultivation of strawberries was done using soil in the bed system as indicated in Figure 2. Most of the farmer (Farm 2, 3, and 4) used coco-peat as the media for strawberries plantation. Coco-peat obtained from coconut able to retain water and increase the porosity of media which relatively improve the physical quality of strawberries produces, which is why it is often used in strawberries plantation worldwide (Hesami *et al.*, 2012; Shamsudin *et al.*, 2020). Farm 1 and 5 mixed coco-peat with rockwool and organic soil with rice husk respectively. Meanwhile, Farm 8 and 10 only use rockwool and organic soils respectively as the plantation media. The use of rockwool as media for strawberries plantation allowed a sustainable irrigation process (Depardieu *et al.*, 2016). The use of organic soil meets the consumer demands of organic-based products with greater fruit quality but may increase the risk of microbial spoilage and pests (Shahzad *et al.*, 2018).

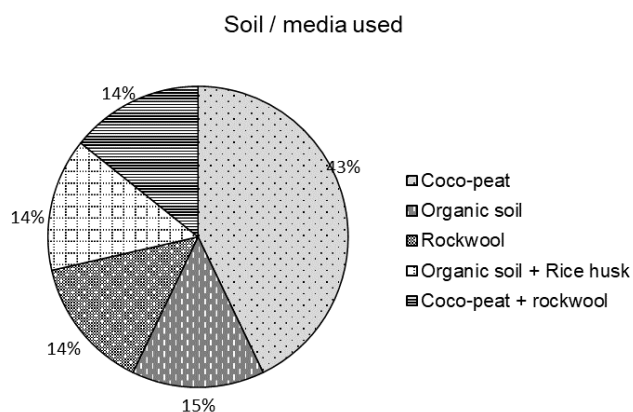


Figure 2. Soils or media used in strawberry plantation by selected farms in Japan

All selected farms in Japan in this study cultivate strawberries under greenhouse. Greenhouse cultivation under controlled environment enables all year production with constant yield, quality and better energy management in strawberries plantation (Miyoshi *et al.*, 2013). Both Nagano and Hokkaido experience changes of temperature yearly due to the four-season climate in which the weather may become over humid and dry during summer and winter respectively (Shamsudin *et al.*, 2020). The implementation of greenhouse cultivation over open field provides a solution for the climate limitation through the possibility of controlling the environmental parameters of temperature, humidity, air composition, and sunlight exposure for strawberries cultivation (Khoshnevisan *et al.*, 2013). In the present study, more advance temperature controlling was observed in Farm 1 in Nagano, a research farm cultivating a summer cultivar of Shindai BS8-9. An automated temperature controller and, automated irrigation was set up on the farm. While Farm 6 from Hokkaido implied both open and greenhouse cultivation technique in which the farm area was let open during the

planting period and closed during the flowering period under greenhouse. The flowering of strawberries usually appeared 3 months after planting which required higher temperature between 18 to 26°C (Rubinstein, 2015).

Other quality management in the cultivation of strawberries is the use of fertilizer and pesticide. Based on Figure 3, Farm 1 used both chemical and organic fertilizer on their farm. Farm 2, 3, 8, and 10 used chemical-based fertilizer and pesticide, while Farm 4, 5 and 6 used the organic fertilizer and pesticide. Fertilizer was added to the plants through the irrigation process directly to the soils for all studied farms. The addition of fertilizer through the fertigation process promotes the slow release of the macro and micronutrients needed for the growth of strawberries (Nestb and Guéry, 2017). The used of pesticide in strawberries cultivation is unavoidable as pathogenic and spoilage microorganism carried by the pests may result in lower yield and quality of fruits. *Botrytis cinera* is the most common fungus attacking strawberries both during pre and postharvest resulted in fruit softening and the appearance of gray mould on fruits surfaces (Feliziani and Romanazzi, 2016).

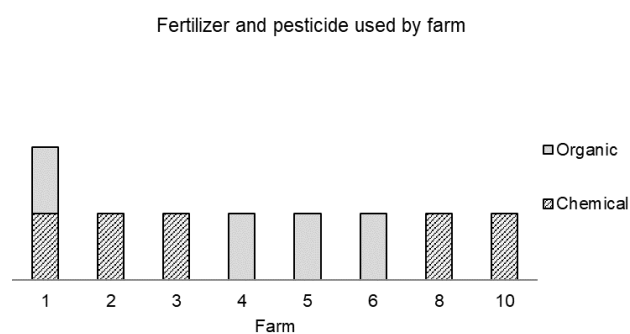


Figure 3. Fertilizer and pesticides used by farmers

3.2 Post-harvest of strawberries

The variety of strawberries in Japan varies according to the cultivation area, farms and climate suitability. Winter type varieties planted by selected farmers include Akiheme, Tochiotome, Bennihoppe, Kentara Houka, Yutshuboshi, and Shinku no misuza. In the meanwhile, Shindai BS8-9, Kaori Noh, Shuzu Akane, Karuizawa, and Aoh Akane were the summer variety planted by selected farmers from Nagano and Hokkaido. From Figure 4, Farm 3, and 4 cultivated different varieties of strawberries including both the winter and summer variety to ensure the sustainability of the produce both for local and export, as the farm also processed their strawberries into products. Farm 8 also cultivates different varieties in their farm to meet the market demands as they export their fresh-strawberry to Hong Kong.

The matured strawberries were harvested manually

by all farms to ensure only high-quality fruits were picked. The manual picking also intended to minimize bruising or physical damage on fruits as strawberries is highly perishable (Petlock and Sugimoto, 2015). The fresh strawberries then, manually graded before distribution. The grading was done based on shapes, colour and weight. The shape of strawberries varies according to the variety planted by the farmer. There were approximately 9 types of strawberry shapes which are reiform, conical, cordate, ovoid, cylindrical, rhomboid, obloid, globose and wedge (Ishikawa *et al.*, 2018). Harvested strawberries can be stored within 5 to 9 days in cool temperature above 0°C depending on ripeness upon harvesting (Rubinstein, 2015). No sanitization process either with water or chemical sanitiser was done to fresh strawberries by all the studied farms as such practice may affect the texture and inhibit bacterial growth especially moulds if not properly dried afterwards.

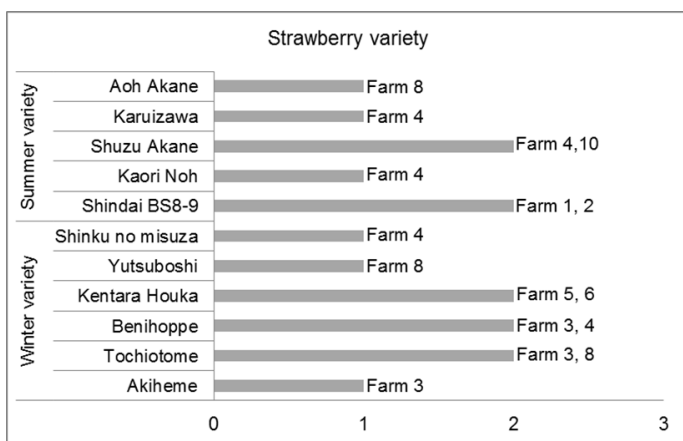


Figure 4. Varieties of strawberry cultivated in selected farms in Nagano and Hokkaido, Japan

Fresh strawberry then carefully packed into clamshell container intended for direct selling, while corrugated box was used for wholesale and export market of fresh-strawberries. Farm 3 distributed their fresh strawberries to Kyoto prefecture and exported to Thailand, Mongolia, and Hong Kong. Farm 4 also, exports their strawberries to Thailand via airport distribution. Meanwhile, Farm 8 distributed their fresh produce within the country to Tokyo through Kansai airport. Styrofoam was often added on top of the packaging material to protect the strawberries from any shocking damages during transportation (Petlock and Sugimoto, 2015).

3.3 Processing of strawberry-based product

Based on Table 1, Farm 2, 3, and 4 processed their strawberry into other products in small-scale and sold the products only within their farm area with nearby supermarkets and specialty shops. The results obtained in Figure 5 shows that confectioneries products such as jam, chocolate, and sweets top the market demands of

strawberry based product in the selected study area in Japan. Manufactures 7, and 9 produced strawberry-based products on a larger scale. Manufacturer 9 is one of the popular food processors in Japan which produced strawberry based confectionery (includes chocolate, strawberry sweets and biscuits) and bakery products include cookies, muffin and cakes. Their products were not only for the local consumption but also for the export market of Hong Kong and Malaysia. In the processing of strawberry into other goods with longer shelf-life, the quality of products was taken care of starting from the raw ingredients. Fresh strawberry used was obtained directly from the farm and manually graded before processing. Manufacturer 9 obtained their raw material from a farm located 15 km away and transported via land transportation.

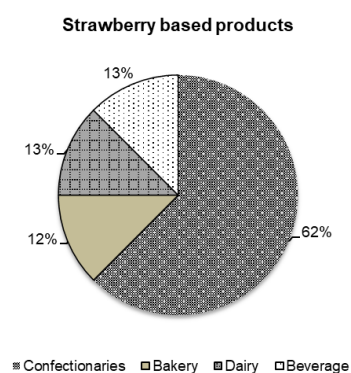


Figure 5. Strawberry based products

Strawberry jam is the main and best-selling product produced by manufacturer 7. Jam is a product with at least 45% of fruits contents with total soluble solid approximately 45°Brix (Mohd Naeem *et al.*, 2017). The processing of strawberry jam was done using conventional heating method. In conventional jam processing, fruits will be crushed after washing and heated at temperature 90°C and below for a period (Ismail *et al.*, 2018). The jam was sold in Sapporo through the small and large retailer, supermarket and sold online through an e-commerce website. Farm 2, and 3 also produced jam as one of their side products sold directly to the customer who visited their farm. The jams were packed in a glass bottle to illustrate the premium quality of products produced.

Strawberry cakes and sweets are popular among woman and children in Japan (Masaki, 2010) which made it as one of the popular strawberry-based products sold locally. The processing of strawberry cakes or other bakery products were often made fresh and directly sold in specialty shops or cake shops. Strawberries are added as one of the flavouring and colouring ingredients or for decoration purposes. The bright red colour of strawberry and distinctive aroma attract consumer interest which influenced the processing company to produce a wide

Table 1. Demographic information of selected farmer and manufacturer of strawberry in Japan

Business type	1	2	3	4	5	6	7	8	9	10
	Research farm	Farm	Farm, small-scale manufacturer	Farm, small-scale manufacturer	Farm	Farm, agro-tourism	Small-scale manufacturer	Farm	Manufacturer	Farm
Farm/ factory area	1200 m ²	2000 m ²	9000 m ²	4500 m ²	Not mention	15000 m ²	Farm 15 km from factory	4000 m ²	Farm 10 km from factory	17000 m ²
Establishment year	2018	2019	1998	2012	2000	1810	1991	2014	1958	2000
Number employee	1	6	30	10	4	10	3	43	770	4
Product produce	Fresh strawberry	Fresh strawberry; Dairy; Confectionary; Beverage	Fresh strawberry; Dairy; Confectionary; Beverage	Fresh strawberry; Dairy; Confectionary;	Fresh strawberry	Fresh strawberry	Strawberry jam	Fresh strawberry	Fresh strawberry; Confectionery; Bakery	Fresh strawberry

1 to 4 and 5 to 10 are from Nagano and Hokkaido respectively.

variety of strawberry products (Gössinger et al., 2009).

4. Conclusion

The present study showed that the cultivation, postharvest processing of strawberries in a selected area in Japan was still done in small-scale. However, in order to meet the market demands of all year round, farmers cultivated multiple varieties of strawberries to ensure the consumer can have the products both during summer and winter season. Greenhouse cultivation enabled the farmers to have control of their strawberry qualities even in extreme weather conditions. Strawberry based products produced in small-scale by the farmers were also sold as premium products not intended to increase their gross income.

Conflict of interest

All authors did not have any conflict of interest.

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