Effect of several food processing methods on volatile composition of strawberry

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Abstract

Strawberry is one of the most economically important fruit in the food industry, because it is used as an ingredient in jam, jelly, yogurt, several milk based products, ice cream, syrup, fruit juice, tea, and other processed foods. Strawberry has a unique fresh and fruity flavour with the contribution of more than 360 volatile compounds, which were widely studied by many researchers. Strawberry aroma is a complex mixture of furanones, esters, aldehydes, acids, alcohols and sulphur compounds. Besides, it is highly changed during processing. Jam making and fruit juice processing are important methods to preserve strawberry, which require heat treatment. Actually, fresh characteristic of strawberry volatiles is mostly replaced in processed strawberry by certain heat-induced volatile compounds, such as isobutyraldehyde, furan, furfural and dimethyl sulphide. In this review, change of volatile compounds of strawberry after several processes (heating, blanching, osmotic dehydration, high hydrostatic pressure, pulsed electric field etc.) is summarized.

Introduction

Strawberry (*Fragaria* x *ananassa* Duch) has a specific, enticing aroma and is one of the most popular fruits. Strawberry is the 6th most eaten fresh fruit after banana, apple, orange, grape and watermelon in the world. The United States is the world's largest producer of strawberry. Turkey, Spain, Egypt, Korea, Mexico, and Poland are the next highest producing countries. Consumers prefer to purchase strawberry and its derived products for their unique sensory characteristics and nutritional value. It is commonly used as an ingredient in several food products such as jam, jelly, yogurt, several milk based products, ice cream, syrup, fruit juice, tea and other processed foods.

Strawberry is rich in phytochemicals such as phenolic acid, ellagic acid, anthocyanins, catechins, quercetin and kaempferol (and their glucosides) which make a positive impact to human health. Studies made by several researchers determined that total phenolic content of strawberry ranges from 43 to 273 mg/100 g fresh weight (FW). Total anthocyanin content was identified between 6 to 102 mg/100 g FW and total ellagic acid content was less than 84 mg/100 g FW [1]. The predominant anthocyanin in strawberries is pelargonidin 3-glucoside and it defines the red colour of the fruit [2, 3]. Some researchers determine that quercetin 3-rutinoside is the major flavonol while others indicate quercetin 3-glucoside and quercetin 3-glucuronide [4].

Strawberry has unique fresh and fruity flavour with contribution of more than 360 volatile compounds [5]. Furanones, esters, aldehydes, acids, alcohols, and sulphur compounds are the main groups, which form desired strawberry aroma [6]. Several processes such as heat treatments and storage can impact the concentrations of aroma characteristics [7, 8]. In this review, differentiation in aroma profile of strawberry after several processes and storage is summarized.

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Thermal Processes

Andujar-Ortiz et al. [9] investigated the cooked and fermented flavour in strawberry juices. They stated that, heating of juice to 60ºC and 90ºC generates cooked flavour, similar to the report of Schieberle [8]. Some of the volatile compounds are present in strawberries, such as mesifurane, methyl butanoate, hexyl acetate, and butyl butanoate [10, 11], while some of them have not previously been identified in strawberries such as α-bisabolol, (*Z*, *E*)-farnesol and nerol. These alcohols and γ-undecalactone found in strawberry jams [12]. Andujar-Ortiz et al. [9] also found that some chemical compounds such as α-bisabolol oxide, epoxy-linalool oxide and 1-octen-3-one were contributing to fermented flavour of strawberry mainly came from fresh fruit, while others could be formed during processing.

Heat has an important effect on aroma profile of strawberry. Sterilization treatment at 120°C for 20 min caused a significant increase in the concentration of butyl acetate, hexanal, linalool, heptan-2-one, hexen-2-al, 2-methyl propanoic acid, butanoic acid, hexanoic acid, benzene methanol, furaneol, nerolidol, octanoic acid and γ-decalatone when compared to raw strawberry [13]. Sterilization also increases the concentration of acetaldehyde [14]. However, the flower-scented strawberry flavour is lost due to heat treatment, with a significant decrease in nerolidol and furaneol concentrations. Sterilization (120°C, 20 min) also formed geraniol and vanillin [13]. Also dimethyl sulphide and isobutyl aldehyde, which are not present in raw strawberry puree, were formed. Also isobutyraldehyde may be formed by Strecker degradation of valine. 2-Furaldehyde, 2-acetyl furan and ethyl furoate were the heat generated compounds found in strawberry jam [14]. Sloan et al. [14] identified heat induced dimethyl sulfide in strawberry puree which is heated at 120°C for 30 min. It was not determined in freshly prepared puree but was noticed higher than its threshold level after heating for 10 min.

Heating affect the odour characteristics of strawberries. Sweet caramel like odour turns into a dominant odour in heated strawberries while green and fruity odours are the most desirable odour in the fresh strawberry [8]. Short thermal treatments retain volatiles which contain fruity and fresh flavours better than long thermal treatments [15]. Thermal treatments with long time and high temperature lead to caramelization as well as Maillard reaction, which cause undesired burnt and caramel flavours during strawberry jam production [16, 17].

Ozcan and Barringer [11] studied the concentration change of volatile compounds in the headspace of whole undamaged, whole punctured, and whole bruised strawberries under refrigerated storage conditions for 8 days. (*E*)-2-hexenal, (Z)-3-hexenal, hexanal, and hexanoic acid level increased in undamaged strawberries due to the continuing activity of enzymes during storage. The concentration of (*E*)-2-hexenal and hexanoic acid was significantly higher in bruised strawberries, which have severe damage, than undamaged strawberries.

Also some processes such as freezing and thawing did not change the furaneol and mesifurane level of strawberries while esters changed [18].

Non-thermal Processes

The traditional preservation methods require high temperatures which can destroy several food components [19]. In contrast to this, novel or non-thermal processes preserve the colour, flavour, nutritious and bioactive components of food.

Lambert et al. [13] investigated the differences in aromatic volatile composition of strawberry after high pressure treatment. Researchers applied 200 and 500 MPa for 20 min to strawberry puree and found no major difference in aromatic profile compared to untreated fruit. When they used 800 MPa for 20 min, 3,4- dimethoxy 2-methyl furan and γ-decalactone were detected as new compounds and concentration of many volatiles contributing to fresh strawberry flavour, such as nerolidol, furaneol, linalool and some esters were importantly lower in the strawberry puree compared to unprocessed sample. Also pressure processed samples did not have geraniol and vanillin which are typical volatiles originated from sterilization (120°C, 20 min.).

Esters are the most important flavour compounds, which give fruity note to strawberry. According to Lambert et al. [13], many esters remain after high pressure treatment, while other researchers did not determine any ester compounds after high pressure treatment (200, 400, 600 or 800 MPa/18-22°C/15 min) [20].

Cao et al. [21] studied the effects of high hydrostatic pressure (HHP) combined with blanching on volatile profile of cloudy and clear strawberry juices. In comparison with cloudy and clear juices, the concentration of total volatile constituents in HHP-treated (600 MPa for 0, 2, 4, and 6 min) cloudy juice increased by 13.21% while HHP-treated clear juice declined by 6.92%. The acid esters such as butanoic acid methyl ester, butanoic acid ethyl ester, and acetic acid hexyl ester decreased and the content of (*E*)-2-hexenal increased in both HHP-treated cloudy and clear juices. They also determine rise in one of the key aroma compounds of strawberry, 2,5-dimethyl-4-methoxy-3(2H)-mesifurane, 19.76 and 3.80% in HHP-treated cloudy and clear juices, respectively.

High pressure processing is also used in jam making process. Gimenez et al. [22] declared that application of 400 or 800 MPa pressure at 22°C for 5 min caused soured and lower fruity smell than conventional processed strawberry jam.

Bermejo-Prada et al. [23] investigated the effect of hyperbaric storage (0.1, 50, and 200 MPa for 15 days) at 20°C on the aroma profile of strawberry juice. They found that volatile content of samples stored under pressure were similar to beginning day. Even no changes were observed in important aroma compounds after hyperbaric storage. The study showed that hyperbaric storage was more effective than refrigeration in retaining the volatile profile of strawberry juices unchanged for 15 days.

Combined osmotic-blanching treatments were applied to strawberries for increasing shelf life and retain fresh flavour during that time [24]. When blanching step is implemented before osmotic dehydration process, volatile profile of strawberries remained like the original. Whereas, esters and furaneol promoted when blanching is performed after the osmotic process.

Geveke et al. [25] determined the effect of pilot plant pulsed electric field process (field strengths: 24.0–33.6 kV/cm, outlet temperatures: 45.0–57.5ºC and flow rate: 100L/hr) on flavour of strawberry puree. Researchers did not measure specific compound concentrations but noticed that colour and flavour of a strawberry beverage containing pulsed electric field processed purée was bright red and fresh.

Beyond the free flavour compounds, high amount of flavour compounds are aggregated as non-volatile and flavourless glycol conjugates [26]. Application of enzyme hydrolysis for clarification of juices allows freeing the volatile constituents from the attached fraction by hydrolyzing glycosides, and also reduces the consistency of the mixture by degrading pectin. This process makes possible the volatile components to deliver from the complex structure of food more easily [27].

Conclusion

The results obtained by several studies showed that heating affects the aroma profile of strawberries while non-thermal processes preserve flavour of fruit better. If blanching process applies before osmotic dehydration process, volatile compounds of strawberries remained like fresh. Pulsed electric field process, hyperbaric storage and refrigerated storage also had minimal negative effect on fresh strawberry flavour.

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