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FACTORS INFLUENCING SHELF LIFE OF HAZELNUT

FINDIKTA RAF ÖMRÜNE ETKİ EDEN FAKTÖRLER

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Özet

Türkiye için önemli bir tarımsal ihraç ürünü olan fındıkta, kalite kayıplarının nedenlerini belirmek ve gerekli önlemleri almak, kalitenin yükseltilmesi ve korunmasına açısından önemlidir. Yetersiz/uygun olmayan hasat, kurutma ve depolama yöntemleri ve koşulları nedeniyle, özellikle küfler faaliyet göstermekte, fındık ve ürünlerinde önemli kalite kayıplarına neden olmaktadır. İşleme hataları nedeniyle (depolama, kırma, kavurma, paketleme, taşıma) fındıklarda yağ oksidasyonu bağlı acılaşma meydana gelmekte ve raf ömrü önemli ölçüde azalmaktadır. En iyi kalite fındık ve ürünlerin üretebilmek ancak tüm işlemlerin doğru ve eksiksiz uygulanmasıyla mümkün olabilecektir.

Abstract

Determination of sources of quality losses in hazelnut and preventive measures is important to achieve and maintain high quality products. Microbial, chemical/biochemical changes contributes to the shelf life of the hazelnut and its products. Due to insufficient/inadequate harvest, drying and storage methods and conditions, mould activities bring about significant quality losses. Storage, cracking, roasting and packaging may contribute to lipid oxidation and subsequent rancidity that reduces shelf life of the hazelnut and its products. Improvement of the harvest, post-harvest and processing stages may improve the quality, but the best quality can only be attained if the whole production and processing line is designed and operated for that.

INTRODUCTION

Wild species of hazelnut, genus *Corylus*, are distributed in nearly all parts of temperate zones of the northern hemisphere while the major producers are Turkiye, Italy, Spain, and USA (Ayfer et al., 1986). Economically important varieties in Turkiye are selected from *C. Avellana var. pontica* (common hazelnut), *C. maxima mill.* (the giant hazelnut), and *C. Colurna var. glandulifera.* (Turkish hazelnut) (Ayfer et al., 1986; Kasaplıgil, 1972). Turkiye produces 400,000-450,000 tons of hazelnut annually. It is 73% of the total hazelnut production of the world. Turkiye exports 83% of its production, and gets about 750 million US$ annually (Anonymous, 1995). Almost eight million people are involved into production and processing of Turkish hazelnut (Akdağ and Öztürk, 1993). Hazelnuts provide a definite flavour in food products and plays a major role in human nutrition and health (Woodroof, 1967; Woodroof, 1973; Woodroof, 1975; Labell, 1983; Villaroel et al., 1987; Mattson, 1989; Elvevol et al., 1990; Nicolosi et al, 1990; Mehlenbacher, 1991; Labell, 1992; Sabate et al., 1993; Kinderlerer and Johnson, 1992; Garcia et al., 1994; Alphan et al., 1996; Pala et al., 1996). Hazelnuts are excellent source of vitamin E, and vitamin B6 (Mehlenbacher, 1991; Pala et al., 1996), and good source of minerals (Pala et al., 1996). They are low in saturated fatty acid content, and high in monounsaturated fatty acid. Saturated fatty acids in the human diet has been associated with cardiovascular illnesses. Total saturated fatty acid content is about 10 %, which is even lower than high nutritional value olive oil (15 %) (Garcia et al., 1994). The oleic acid constitutes major fraction of unsaturated fatty acids, with a mean of 76.68 (2.68) %. High content of oleic acid reduces cholesterol levels and indices of cardiovascular diseases (Mattson, 1989; Elvevol et al., 1990; Nicolosi et al., 1990; Alphan et al., 1996). It also contain essential polyunsaturated fatty acids of which daily requirement (1g) is satisfied with 8 hazelnut kernels (Garcia et al., 1994).

Shelf life is defined as the period of time during which the food product will remain safe, be certain to retain sensory, chemical, physical and microbiological characteristics, and comply with any label declaration of nutrition data so that customer is satisfied. Retention of food quality requires a total quality system in which each group of the food chain (growers, ingredient suppliers, manufacturers, distributors, wholesalers, and caterers, retailers, and customer) is responsible to apply suitable method of treatment to the product so as to ensure the shelf life (Anonymous, 1993b).

There are intrinsic and extrinsic factors effecting shelf life of hazelnuts. Intrinsic factors can be stated as composition, water activity, and redox potential while extrinsic factors are harvest and post harvest treatments, processing, hygiene, packaging materials and method, storage, distribution and retail display. Moreover, consumer handling and commercial considerations effects the shelf life of a product. Although these independent factors may interact in practice and their combined effect can be synergistic or antagonistic. (Anonymous, 1993b).

Composition is very often shelf life determining factor. It may also account for a change in the mode of deterioration. Variety, geographical origin, and cultivation method contributes variability of hazelnut fat composition (Gargano et al., 1982; Ninie and Cerovic, 1987; S Bonvehi and Coll, 1993; Parcerisa et al., 1993, Garcia et al., 1994; Parcerisa et al., 1994; Parcerisa et al., 1995; Botta et al., 1996). Among fatty acids, oleic and linoleic acid more susceptible to chemical auto-oxidation (Bonvehi and Coll, 1993; Garcia et al., 1994; Parcerisa et al., 1995; Bonvehi and Rosua, 1996). The rates of oxidation of fatty acids are approximately 1:10:100:200 for stearic ($C_{18:0}$), oleic ($C_{18:1}$), linoleic ($C_{18:2}$), linolenic ($C_{18:3}$) acids respectively (O'Keefe et al., 1993). Endogenous lipase, peroxidase, polyphenoloxidase enzymes plays important role in the shelf of the hazelnuts, and variety is the key factor determining their activities (Bonvehi and Rosua, 1996).

MECHANISMS OF DETERIORATION

Deterioration may arise from a number of mechanisms which practice may interact, and onset of one may well initiate the onset of the others. Mechanisms of deterioration can be summarised as followings: microbiological changes, chemical/biochemical changes including light-induced changes and product/packaging interactions.

Microbiological Changes

Microbial contamination of foods may result in food spoilage, or food poisoning. Properties of the food, such as aw, pH, total acidity, presence of preservatives, nutrients, natural microflora, redox potential, processing conditions, physical and chemical properties of the environment, gas composition, storage temperature and relative humidity are important factors for microbial status of the product (Anonymous, 1993b).

Mould contamination of hazelnut is widespread, and is an important risk for human health (Sanchis et al., 1988). *Penicillium, Aspergillus* and *Rhizopus* species isolated in unshelled hazelnuts during harvest or post-harvest treatments and storage (Anonymous, 1979; Eke and Göktan, 1987). *A. flavus* exits on the hazelnut at tree and its growth is enhanced with sun-drying of hazelnuts (Eke and Göktan, 1987). Unless a minor hole/crack on the shell of the hazelnuts occurred during harvest or post-harvest treatments, *A. flavus* was not isolated from the hazelnut kernel (Eke and Göktan, 1987). Adverse weather conditions during harvest and post-harvest operation increases total mould count from 10^5 to 10^8 (Pettit et al., 1971; Eke and Göktan, 1987). Sanchis et al., (1988) isolated *A. flavus, A. niger, A. glaucus, Penicillum, Mucor, Fusarium* from unroasted and roasted hazelnut kernels.

Mould activity changes texture of the product as a result of enzymatic activities of the spoilage organisms on carbohydrate, fat, protein or other structural component of the food. It causes dry matter loss, lowers oil content, increases free fatty acid content and changes flavours besides discoloration. Since mould can penetrate the intact food, it damage more than bacteria. (Hadorn et al., 1977; Singaravadivel and Anthoni, 1983Topal and Aran, 1987; Anonymous, 1993b).

A. flavus, A. tamarii, A. ochraceus, A. terreus, A. wentii (Anonymous, 1978), *A. paraticus* (Sanchis et al., 1988) can produce aflatoxin in hazelnut. During sun-drying of hazelnuts, hazelnuts with minor cracks/holes on their shells was found to be contain aflatoxin. Sun drying that requires 6-10 days to reduce moisture content to safe moisture levels increases risk of aflatoxin contamination (Eke and Göktan, 1987). It may be prevented by artificially drying hazelnuts at 40 ^oC within 24 hr after harvest (Booth, 1990; Duke, 1989). After four month of storage, aflatoxin level decreases due to degradation (Anonymous, 1978).

Unroasted, roasted ground hazelnuts are more susceptible to aflatoxin contamination compared to roasted hazelnuts (Sanchis et al., 1988). When Unroasted hazelnut and roasted hazelnuts are stored at water activities between 0.24 and 0.38, they are not susceptible to mould and subsequent aflatoxin contamination. However, at water activities between 0.78 and 0.81, hazelnut becomes a good substrate for aflatoxin and ergosterol contamination (Sanchis et al., 1988). 8% of the 142 samples analysed were found to be contain 2 to 100 ppb aflatoxin (average 34 ppb) (Anonymous, 1978). Aflatoxin has been associated with carcinogenesis (Anonymous, 1979; Bullerman et al., 1984; Bullerman, 1986; Sanchis et al., 1988; Wilson and Abrason, 1992; Jones, 1993; Anonymous, 1993ba). Total aflatoxin limit (B1, B2, G1, and G2) for Germany were decreased from 10 ppb to 4 ppb while limit of aflatoxin B1 decreased from 4 ppb to 2 ppb (Majerus, 1989).

Moreover, *Aspergillus* and *Penicillium* species, especially *A. ochraceus* and *P. viridicatum* may produce ochratoxins. Ochratoxin A is the most potent toxin among the other ochratoxins, and has been associated with kidney tumour in Balkans (Woller, 1989; Jones, 1995).

Hazelnuts may be contaminated with *S. aureus*, *Salmonella, E.coli* and *Coliform* from personnel, food ingredients including water, ingredients, plant and the environment that results in food poisoning-intoxication. Most pathogens requires a_w values above 0.9 (Beuchat, 1991). However, some pathojens such as *Salmonella* are infective pathogen microorganisms that survive in a food at reduced water activities. After digestion of the food, it can grow in the intestinal tract and bring about food poisoning. In addition to microbial contamination, chemical and physical contamination can occur before and/or after processing, and is possible in products that are hermetically sealed (Anonymous, 1993b). Special hygiene disciplines and procedures are required in the production of the food products to minimise post-process contamination and achieve desired quality.

Chemical/biochemical changes

While some chemical or biochemical changes in foods are favourable, most are undesirable in that oxidation or hydrolysis lead to the generation of off-flavour or the loss of characteristics aroma or colour. Once exposed to air, roasted and ground coffee very quickly losses its aroma, partly by volatilisation and partly through oxidation since coffee oils are easily oxidised (Anonymous, 1993b). Tocopherols are sensitive to atmospheric oxygen, and degrade due to oxidation (Anonymous, 1993b). Dried foods usually formulated, packaged, and stored to keep aw value near to 0.3 where microbial, chemical, biochemical, and physical changes are minimal (Anonymous, 1993b). Nevetheless, water activity value between 0.3 - 0.4 dried food containing high oil becomes susceptible to lipid oxidation.

Products containing high amount of oil and fats is susceptible to rancidity. Rancidity may result from *hydrolytic* reactions, including lipolysis catalysed by lipases, producing free fatty acids (FFA) of undesirable flavour characteristics. FFA above 1% indicates rancidity (Hadorn et al., 1997). *Oxidative* rancidity develops either by metal ion catalysis (via the classical free radical route) or by enzyme-initiated oxidative degradation (peroxidase, polyphenoloxidase) (Bonvehi and Rosua, 1996). Products of high aw containing the enzymes are particularly susceptible to lipolysis (Anonymous, 1993b). Once the free radicals are formed with primary oxidation reactions of polyunsaturated fatty acids or triglycerides (RH -> R' + H') during the course of fat oxidation, peroxidase promotes secondary and terminal oxidation. (Özilgen and Özilgen, 1990; Bonvehi and Rosua, 1996). Oxidation products, namely hydroperoxides, are active oxidants and have tendency to react with other compounds at room temperature, during storage and processing to form monocarboxylic acids, aldehydes, ketones, hydrocarbons, esters and lactons (Chang et al., 1978; St. Angelo et al., 1979; Stevenson et al., 1984; Serim, 1990; Liu and White 1992; Ünal and Işçioğlu, 1992; Przbylski et al., 1993). Reaction of the amino acids and proteins with these degradation products impairs flavour, odour, and/or lower nutritive value of food products besides staling (e.g., reaction of lysine and threonine with the oxidised linoleic acid) and toughening (St. Angelo et al., 1979; Senter et al., 1984; Labuza, 1988; Anonymous, 1993b). Moreover, they have been associated with possible carcinogenic effect and cause of many diseases (Pariza, 1990; Duthie, 1993).

Presence or absence of antioxidants e.g. tocopherols, trace metals, light, air, temperature, micro-organisms, moisture content, maturity, agronomic practices, and cracking method influence onset of rancidity besides fatty acid composition, total polyunsaturated fatty acid content and enzymatic activity (Forbus and Senter, 1976; Beucaht and Worthington, 1978; St. Angelo et al., 1979; Pershern et al., 1995; Ayfer, 1973; Özdemir and Özilgen, 1997).

Light induced changes

Light depending on its intensity, wavelength, the duration of exposure, the absorbability of the product, presence of senitisers, the temperature and amount of available oxygen may induce oxidative rancidity via mechanism of photo-oxidation in food with high oil content. Moreover, riboflavin may lose their activity and nutritive value through light exposure. It may also result in colour changes, and degradation of proteins (Anonymous, 1993b).

Product/packaging interactions

Moisture and water vapour exchange between the hazelnut and its environment or within different parts of a composite product e.g., Turkish delight, can cause physical changes, alter flavour or texture, or promote microbial growth (Anonymous, 1993b), especially when there is a temperature abuse during transportation, storage and retail display. Therefore, in addition to the factors discussed above, appropriate packaging material and method for the product will make sure optimum shelf-life of the hazelnuts. Physical properties of the packaging material such as permeability to water vapour and to gases determines inside pack environmental conditions in terms of gas composition and relative humidity which are important for the stability of the products. Control of oxygen levels in the packs is critical since many changes are dependent on the redox potential and available oxygen inside the pack Therefore, low water vapour and gas permeable packaging material and vacuum to reduce available oxygen is employed to prevent rancidity and extend shelf life of hazelnuts (Anonymous, 1993b).

Shelf life comparison of Turkish hazelnut varieties

Peshern et al., (1995) used unsaturation/saturation ratio to predict of the shelf life of hazelnuts. The lower the ratio the higher the shelf life. Karafındık, Tombul, Kalınkara, Çakıldak (from Akçakoca), Mincane (from Trabzon and Akçakoca) had the lower unsaturation/saturation ratio compared to Çakıldak (from Ordu) and Yomra (from Trabzon and Akçakoca), Sivri (from Giresun and Trabzon), Palaz. Degree of unsaturation is used to predict shelf life of oil which is measured as IV analytically. The lower IV is attributed to the higher shelf life. Mincane (from Akçakoca), Yomra (from Akçakoca and Trabzon), Tombul (from Giresun) obtained lower IV compared Çakıldak (from Ordu), Mincane (from Trabzon), Kalınkara (from Giresun), and Kalınkara (from Akçakoca). Shelf life prediction with IV and unsaturation/saturation ratio differs. In fact, shelf life of hazelnuts is dependent one many factors e.g., as presence or absence of antioxidants and pro-oxidants, a_w, temperature, enzyme activity. Therefore, measurement of one factor may lead to erroneous conclusions. Varieties, having low unsaturation/saturation ratio, rich in antioxidant components and low in enzymatic activities should be preferred so as to increase shelf life, and possibly reduce preservation requirements (Bonvehi and Coll, 1993; Perhern et al., 1995; Bonvehi and Rosua, 1996).

Result

Continued improvement of quality of hazelnut and its products through evaluation and optimisation of the present status of the production, harvest and post-harvest, and processing techniques may enable to increase market value and extend the market. It may even be necessary to design new production and processing techniques for hazelnut. Therefore, at least one research team in every university/research centre should study the hazelnut production and processing for quality and technology improvement. These studies should be supported by government, hazelnut dealers and exporters, and even by growers. The results should be implemented continuously, and disseminated through periodic meeting, publications, conferences.

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