ID: 415

Application of hydrogen in food processes improves the sensory and physicochemical properties and extends the shelf life of the product

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Abstract

Food is prone to many spoilage phenomena, causing undesirable changes in its quality, loss of nutritive value, and shortening its shelf life. Our team studied the effect of hydrogen application in different food processes on the quality attributes of products. In food drying, including hydrogen in the drying atmosphere allowed for the protection of the nutritional and sensory properties of the product (apricot and apple). Additionally, incorporating hydrogen in the atmosphere of the food package allowed for the protection of the physico-chemical and nutritional properties of various foods, including strawberries, fish, and fresh cheese, with an extended shelf life. The results show that the use of hydrogen in food processes can be useful for the preservation of freshness and quality attributes of foods.

Key Words: *Hydrogen, Food, hydrogen-rich water, Quality*

Gıda proseslerinde hidrojenin uygulanması, ürünün duyusal ve fizikokimyasal özelliklerini iyileştirir ve raf ömrünü uzatır

Özet

Gıdalar birçok bozulma olayına eğilimlidir ve bu da kalitesinde istenmeyen değişikliklere, besin değerinin kaybına ve raf ömrünün kısalmasına neden olur. Ekibimiz, farklı gıda süreçlerinde hidrojen uygulamasının ürünlerin kalite nitelikleri üzerindeki etkisini inceledi. Gıda kurutmada, kurutma atmosferine hidrojen eklenmesi, ürünün (kayısı ve elma) besinsel ve duyusal özelliklerinin korunmasını sağladı. Ek olarak, gıda paketinin atmosferine hidrojen eklenmesi, çilek, balık ve taze peynir gibi çeşitli gıdaların fiziko-kimyasal ve besinsel özelliklerinin, uzatılmış raf ömrüyle korunmasını sağladı. Sonuçlar, gıda süreçlerinde hidrojen kullanımının gıdaların tazeliğinin ve kalite niteliklerinin korunması için yararlı olabileceğini göstermektedir.

Anahtar Kelimeler: *Hidrojen, Gıda, hidrojen açısından zengin su, Kalite*

Introduction

The deterioration of the quality of fresh food is a natural phenomenon that happens due to many chemical and biological factors, including microbiological and enzymatic activities. Oxidative reactions are one of the primary sources of food quality deterioration. The oxidative destruction of antioxidants, unsaturated fatty acids, vitamins, and pigments can shade the color and deteriorate the flavor and taste, which in turn shortens the shelf life of the food. Our team found that including hydrogen gas in some processes can help protect the nutritional and sensory properties of the food product and extend its shelf-life.

Food Drying

In the drying process, the inclusion of hydrogen gas in the atmosphere could preserve the color and antioxidants of fruits such as apricots (Alwazeer & Örs, 2019) and apples (Alwazeer, 2018) and herbs such as mint green tea leaves. This technique was called Reducing Atmosphere Drying (RAD). The color indices of the hydrogen-included atmosphere (RAD_{mix}) dried apricot slices were the closest to the fresh sample, while the freeze-dried slices were characterized by light and dully notes of color compared to a fresh sample. The antioxidant activity, total phenolic content, and total flavonoid content of RAD-dried apricot samples were the closest to fresh samples compared with hot air oven and vacuum-dried samples (Alwazeer & Örs, 2019). In another study, both apple and apricot slices were dried using RAD_{mix} (4% H_2, %5 CO_2, 91% N_2), which was compared with nitrogen (100%) and hot air drying.

Results showed that the color parameters (L*, a*, b*) of RAD apple slices were the closest to the fresh ones besides the freeze-dried samples. However, the high increase in the L* value and the high decrease in the b* value of freeze-dried samples are reflected by the lightness of the yellowness of the sample color, which is considered undesirable for dried apples and apricots (Alwazeer, 2018).

Food Packaging

The packaging process aims to preserve the food product from external deteriorative conditions. The preservation of crops and foods under the atmosphere, different from air, is a technique that aims to prolong the shelf life of a product. This technique is called modified atmosphere packaging that generally uses a gaseous mixture of carbon dioxide (CO_2), nitrogen (N_2), and oxygen (O_2) (Alwazeer, 2019). Our team revealed that the inclusion of hydrogen gas (H_2) with CO_2 and N_2 could preserve the nutritional and sensory qualities of fruits, such as strawberries, and dairy products, such as fresh cheese and fish. This technique was called Reducing Atmosphere Packaging (RAP), which extended the shelf life of these food products. Different formulations of RAP were tested for preserving fresh cheese: [RAP 1 (90% CO_2/6% N_2/4% H_2), RAP 2 (50% CO_2/46% N_2/4% H_2)], modified atmosphere packaging (MAP) [MAP 1 (90% CO_2/10% N_2), MAP 2 (50% CO_2/50% N_2) during cold storage at + 4°C for 7 weeks. Results showed that the color and acidity of RAP1 cheese samples were the closest to the fresh sample. At the end of storage, the lowest mesophilic-aerobic bacteria counts were found for RAP1 samples, while the yeast-mold counts were the lowest for all RAP samples (Alwazeer et al., 2020).

In another product, rainbow trout fish was packaged under a hydrogen-included atmosphere (RAP) [RAP1 (50% CO_2 / 46% N_2 / 4% H2) and RAP2 (60% CO_2 / 36% N_2 / 4% H_2)] beside MAPs [MAP1 (50% CO2 / 50% N_2), MAP2 (60% CO_2 / 40% N_2)] and control (air). The fish samples were stored at 2°C for 15 days. RAP-packaged fish samples showed better results regarding TBARS and TVB-N (Bulut et al., 2023).

Rice milk

Our team revealed that when HRW was used for the preparation of rice milk from four varieties, the essential mineral content (Na, Mg, K, Ca, and Se), essential amino acids (Ile, Leu, and Met), desirable aroma, and sensory notes were improved (Zor et al., 2024).

Minced meat

Our team found that incorporating hydrogen-producing magnesium into minced beef meat allowed to control the microbial growth, restricted the formation of thiobarbituric acid reactive substances, restricted the formation of biogenic amines, limited the formation of the off-volatile compounds, and protected the whole quality of the product (Çelebi et al., 2024).

Butter

Recently, our team revealed that the incorporation of hydrogen gas into melted butter could improve microbial and chemical stability, enhance color (increasing yellowness), minimize the formation of biogenic amines (BAs), and produce no off-flavor or undesirable volatile compounds (Alwazeer et al., 2024). The results of the physicochemical parameters showed that the values of the butter samples incorporated with H_2 were similar to those of the control samples 30 days before. This technique was characterized by its application at normal conditions of temperature (40ºC) and pressure (1 atm) without adding any catalyst.

Conclusion

The integration of hydrogen in the food process can provide many advantages to the product. The preservation of the color, physicochemical properties, and microbial stability were reported in different hydrogen-processed food products. The use of hydrogen brings many advantages to both producers and consumers, such as its antioxidant properties, non-toxicity, natural notes, and low-cost equipment needs. The use of hydrogen needs, of course, precaution due to its explosion property with air.

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