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NUTRITION DESIGN MODELING METHOD DEVELOPMENT FOR STRUCTURAL AND ELEMENTAL ANALYSIS OF BERTİZ GRAPE PEKMEZ USING FIELD EMISSION GUN – SCANNING ELECTRON MICROSCOPE (FEG-SEM)

BERTİZ ÜZÜM PEKMEZİNİN ALAN EMİSYON TABANCALI–TARAMALI ELEKTRON MİKROSKOBU (AET-TEM) İLE YAPISAL İNCELEMESİ VE BİLEŞEN MODELLEMESİ İÇİN BİR BESİN TASARIM YÖNTEMİ GELİŞTİRİLMESİ

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ABSTRACT

Bertiz kabarcık (buble) grape pekmez nutrition design modeling method development was studied by structure analysis and composition modeling using the Field Emission Gun – Scanning Electron Microscope (FEG-SEM). A uniform static, soil-mineral like and non-crystal solid surface was detected in pekmez sample structural images. The high value of carbon (69.89%), oxygen (28.14%), phosphorus (0.69%) and potassium (1.28%) peak patterns indicated that the pekmez is a sugar and mineral composition model. Deficiency of purification and clarification were presented in the pekmez samples produced by traditional way, and less pure and clear pekmez product was detected in the structural images. However, the liquid concentrated form of these grape samples completely dissolved at room temperature. Pekmez soft drinks; Pekmez Cola including caffeine, Pekmez Gazoz with no additives and Pekmez Limon comprising lemon flavor were prepared using the carbonated pekmez solutions without any sugar additives.

Keywords: Nutrition design method modeling development, structure analysis, composition modeling, Bertiz grape pekmez, Pekmez Cola, Pekmez Gazoz, Pekmez Limon, Field Emission Gun – Scanning Electron Microscope (FEG-SEM)

ÖZET

Bertiz kabarcığı üzüm pekmezi besin tasarımı modelleme yöntemi geliştirmek için, Alan Emisyon Tabancası – Taramalı Elektron Mikroskobu (FEG-SEM) kullanılarak yapı analizi ve kompozisyon modellemesi ile çalışılmıştır. Pekmez örneğinin yapısal görüntülerinde katı-durağan, toprak-mineral benzeri ve kristal olmayan katı yüzeyler tespit edilmiştir. Karbon (%69.89), oksijen (%28.14), fosfor (%0.69) ve potasyum (%1.28) pik değerlerinin yüksek olması pekmezin şeker ve mineral bileşim modeli olduğunu göstermektedir. Geleneksel yöntemlerle üretilen pekmez örneklerinde saflaştırma ve durultma eksikliği görülmüş, yapısal görüntülemelerde ise daha az saf ve berrak pekmez ürünü tespit edilmiştir. Buna rağmen, bu üzüm pekmezinin sıvı yoğun hali oda sıcaklığında tamamen çözünmüştür. Gazlı pekmez çözeltileri kullanılarak hiçbir şeker katkısı içermeyen kafeinli Pekmez Kola, katkısız Pekmez Gazoz, ve limon aromalı Pekmez Limon meşrubatları hazırlanmıştır.

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Anahtar Kelimeler: Beslenme tasarımı modelleme yöntemi geliştirme, yapı incelemesi, bileşen modellemesi, Bertiz kabarcığı üzüm pekmezi, Pekmez Cola, Pekmez Gazoz, Pekmez Limon, Alan Emisyon Tabancalı – Taramalı Elektron Mikroskobu (AET-TEM).

INTRODUCTION

Pekmez is an evaporated sugar containing fruit syrup molasses, traditionally and industrially produced as a concentrated viscous liquid or soft solid forms, containing the basic daily nutrient needs such as carbohydrates, proteins, vitamins and minerals (Satıl & Selvi 2022). The exceptional nutrient composition of grape pekmez provides the best nutritional daily dietary supplements such as natural sugars and amino acids, essential vitamins and minerals, antioxidant agents and aroma compounds which need to be adequately formulated (Alkoshab et al., 1988; Spayd & Bagge 1996). The grape pekmez naturally comprises good source of certain specific sugars, amino acids, riboflavin (vitamin B2), phosphorus, potassium and an inimitable source of calcium (Batu 1993). Varieties of grapes (*Vitis Vinifera*) among many grown in Türkiye, Bertiz Kabarcık, Gülşehir Göğçek, Bornova Misket, Kırklareli İlkeren grapes… are commonly used for production of grape pekmez. The basic production steps of viscous liquid grape pekmez process include grape harvesting, picking, squeezing and syrup boiling and evaporation.

The squeezed grape syrup is boiled in open air pans under atmospheric pressure through the low scale fire application until thickening of the syrup to produce pekmez in most traditional applications (Riddel 1951; Batu 2005). Non-enzymatic browning reaction caramelization process is used in pekmez production by removal of water and breaking down of the sugars to get a sensational bitter flavor and brown color. The caramelization temperatures were determined approximately as 160 ^{o}C for sucrose and glucose, and 110 ^{o}C for fructose. Industrial pekmez production protocol includes low heat and low pressure vacuum pan operation techniques under controlled pekmez production process to evaporate water at low temperatures that protect the grape syrup from nutrition decomposition and further caramelization. A case study of pekmez was accomplished to optimize grape juice deacidification using mixture of adsorbents (Rezaei et al., 2020). White soil is used as adsorbent for clearing purposes in the traditional process, and calcium hydroxide is used in decantation process in industrial pekmez production. The soft-solid white and brown solid pekmez are produced using the liquid form of pekmez by addition of the solidifying and whitening agents and longtime mixing, and sold in cylindrical wooden boxes called as külek pekmez. The studies state that the liquid concentrated form of grape pekmez contains minimum of 65% total crystalline dry matter and soluble solids (45.3 to 75 °Brix), and the liquid concentrated and the solid pekmez are quickly and totally soluble even at room temperature. Pekmez samples as browned caramel like natural sweeteners have been tested to characterize sweetener features, color, and biochemical properties using standard and local pekmez samples of grape types grown in Türkiye (Alpaslan & Hayta 2002; Yoğurtçu &Kamışlı 2006; Kaya & Gunasekaran 2011).

The form of physical structure and assortment of nutritional composition of pekmez deviates depending on the grape origin and types, and traditional and industrial production process conditions (Türkben et al., 2016). All kinds of grapes and sugary fruits can be used for pekmez production; however white kabarcık (bubble) grapes which is exclusively grown in the right ecology and climate region of Bertiz of Kahramanmaraş province are the best proper type of grape for pekmez production. Bertiz kabarcık grapes are not only preferred for pekmez production, they are also favored as table grape consumption. Bertiz type pekmez alike the other pekmez types, is mostly produced through traditional way identically attributes vital nutrients, exclusive mouth feels, taste, color, odor and texture.
Processing factors and pekmez solidification and the material behavior were investigated, and increased pekmez viscosity was observed with high solid content at low temperature, and pekmez dry matter up to 75 °Brix was classified as a Newtonian product. Chemical and physical properties of various fruit pekmez samples were analyzed, and high bioavailable trace element contents of iron (Fe^{+2}) and selenium were determined in grape pekmez (Aliyazıcıoglu et al., 2009). The viscosity characteristics effect the freshness time of pekmez. The viscous pekmez stays fresh over months without microbial contamination and conserves highly nutritive value, flavors and red-brownie texture. The physical ability viscosity tests of the pekmez samples were accomplished to determine solidity specifics of dry pekmez samples and the average dissolving ability was detected by mixing the pekmez samples. The effects of storage period and conditions on chemical properties of grape pekmez produced classical and vacuum methods were investigated, and average copper, manganese, phosphorus, and sodium contents in

pekmez samples produced by the vacuum method were found higher than that of the classical method (Demirci 2006; Demirci & Kayışoğlu, 2006; Tunç et al., 2022).

Sweet food staffing are produced using pekmez, starch and walnut derivatives in different pekmez producing regions. Yoğurt and tahin mixed with pekmez mixtures are consumed at any time of the day, especially at breakfasts (Öztürk & Öner 1999). Pekmez boiling with bulgur, pumpkin and sour grape makes kırma, pumpkin and grape jams respectively. There are perfect spreading characteristics of all kinds of white or brown solid pekmez. The grape pekmez can be used as a natural sugar replacement, so trials have been made for the usage of pekmez in the production of ice cream, chocolates and choconuts. Production of the carbonated pekmez soft drinks is formulated and prepared by using various drink additives to produce Pekmez Gazoz without any additives, Pekmez Cola includes caffeine and Pekmez Limon contains lemon aroma (Ermurat 2006). No sugar addition was needed to the pekmez soft drinks due to natural and original grape sugar amount in pekmez syrups.

MATERIALS AND METHODS

Samples of kabarcık grape pekmez in concentrated liquid form produced by traditional processing method originated from Bertiz cultivar of Kahramanmaraş region were used in this research. The pekmez samples were dried away from the exposure of sun light at room temperature to get solid form without using any drying equipment. The dry pekmez samples were used for microstructural imaging and elemental analysis using the Quanta 250 Field Emission Scanning Electron Microscopy (FEG-SEM) of Düzce University, and the structural imaging, elemental peak patterns graph and elemental values table of the pekmez samples were obtained. The pekmez samples were used as natural sugar replacement to produce ice cream, chocolates and choconuts. Viscous liquid form of pekmez dissolved in water and food grade carbon dioxide gas was used for carbonation of pekmez solutions in soft drink carbonator for preparation of pekmez soft drinks.

RESULTS AND DISCUSSIONS

The dry Bertiz pekmez samples were analyzed using the FEG-SEM for the determination of the pekmez physico-chemical characteristics examinations to have a pekmez nutrition design modeling method development.

Figure 1 a and b show the FEG-SEM images of dried Bertiz pekmez samples which were provided in the size of 50 µm for the structure analysis.

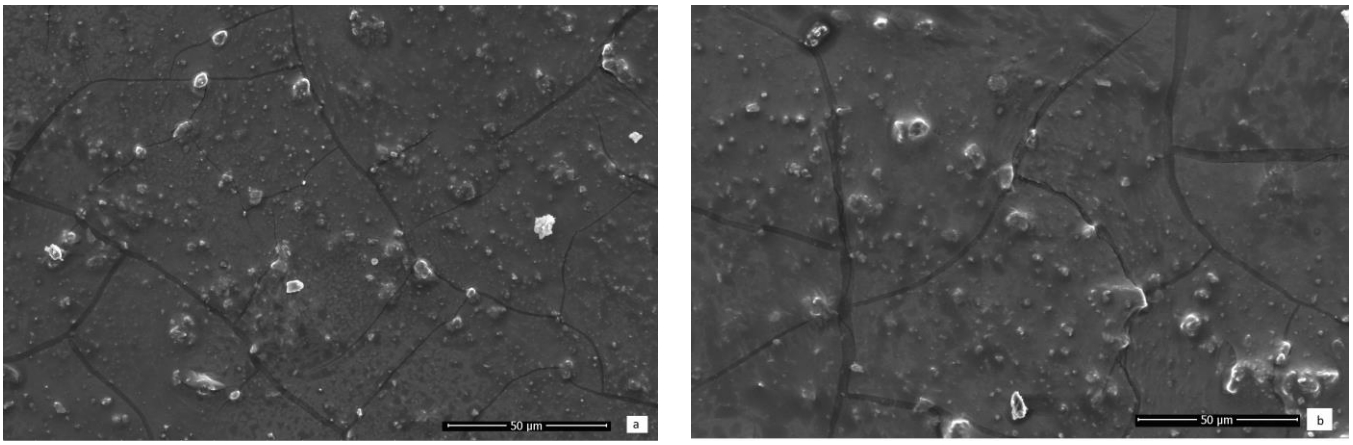

Figure 1. The FEG-SEM images of Bertiz Pekmez Samples in the size of 50 µm.

The peak patterns graph of the 'Energy Dispersive X-Ray Analysis' (EDAX) elemental constituents of the dry pekmez samples was determined using the FEG-SEM for composition modeling as given in Figure 2.

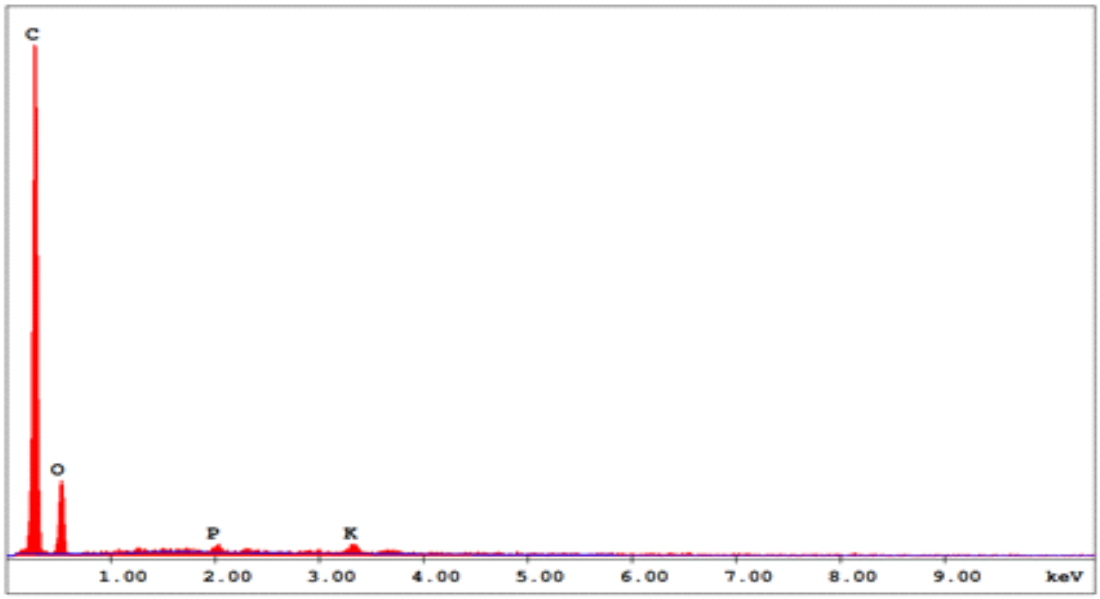

Figure 2. The FEG-SEM EDAX Elemental Peak Patterns Graph of the Dry Pekmez Sample.

The EDAX elemental constituent data of dry Bertiz pekmez samples were shown in Table 1.

Table 1. The elemental constituent data of Bertiz Pekmez Samples.

Elements	Wt%
C	69.89
O	28.14
P	0.69
K	1.28
Total	100

Establishment of significant pekmez nutrition design modeling method development is subject to physical characteristics such as hardness, viscosity, solubility and dissolving ability, and chemical characteristics such as sugar and mineral contents. Texture analysis and formulation modeling studies of the Bertiz pekmez are an effective form of nutrition design modeling method development using electron microscopy to assess improved pekmez and pekmez products production. The traditionally produced Bertiz type kabarcık grape syrup molasses which offers the basic daily nutrients such as sugar, vitamins, amino acids and minerals were used in this study to investigate the physical and chemical properties to accomplish nutrition property design modeling method development.

Pekmez models were performed relying on hardness, viscosity and dissolving ability, sugar and mineral contents in grape pekmez and products that can be accomplished using electron microscopy methods. The FEG-SEM microstructural examinations provided brownie sedimentary surface matrix structural perspective images resulting in certain significant findings in the form of Bertiz pekmez samples as seen in Figure 1. Soil-mineral like, non-crystal, uniform static, solid surface physical appearances were detected in the pekmez sample structural images. No purity and clarity was detected in the structural images of the dried pekmez samples. The elemental analysis peak patterns presented in Figure 2, and composition data shown in Table 1, altogether demonstrate high value of

carbon peaks with abundant carbon (69.89%) and oxygen (%28.14) amounts, and phosphorus (0.69%) and potassium (1.28%) elements which refer to the plentiful carbohydrate and mineral nutrition contents. Indications of high value of carbon peak patterns and observed phosphorus and potassium elements suggest that the pekmez exhibits a sugar and mineral composition model. Appearance of the bioavailable trace elements of iron, selenium, copper, manganese and sodium elements in the investigated pekmez samples were not recorded conceivably due to outstanding carbon value as all were observed in the reputable studies (Batu 1993; Aliyazıcıoglu et al., 2009; Demirci 2006; Demirci & Kayışoğlu, 2006; Tunç et al., 2022).

The solid content of viscous liquid pekmez was measured as 64 °Brix, and remained fresh for six months storage period at room temperature without crystallization and microbial contamination, while conserving the nutritive value, sweetness, odors, flavors and brownie-like texture as stated in related literatures (Alpaslan & Hayta 2002; Yoğurtçu &Kamışlı 2006; Kaya & Gunasekaran 2011). Sensational bitter taste, flavor and caramel color, 6.7 pH and 278 mV values were recorded in the pekmez sample solutions, and weak resistance to pH changes was noted. The soft-solid white and brown solid külek pekmez, with flawless spreading capabilities was shown similar dissolving capability, aroma and taste compared to viscous liquid pekmez. Production of the several nutritious products confirms the expediency of pekmez product. Ice cream, chocolates and choco-nuts were exceptionally produced using pekmez samples as natural sugar, nutrition, taste, odor and color replacement. Potassium and phosphate contents of pekmez indicate electrolyte minerals that supply energetic enhancement in the body. Various carbonated pekmez soft beverages as Pekmez Gazoz containing any additives, Pekmez Cola including caffeine and Pekmez Limon comprising lemon aroma were prepared without any sugar additions.

CONCLUSIONS

The natural pekmez of Bertiz kabarcık (bubble) grape possesses a sedimentary surface structure and carbohydrate and mineral nutrition composition model. Refinement and purification insufficiency were determined in the pekmez samples, and no clear pekmez product was identified in the structural images. The best spreading feature was determined to be the key character of soft solid pekmez. The samples of pekmez were fully dissolved in water and carbonated pekmez soft drink beverages, Pekmez Gazoz without any additives, Pekmez Cola including caffeine and Pekmez Limon containing lemon aroma were produced with no sugar additives. The observed amount of the carbohydrate and mineral nutrition contents of pekmez can be applied to better nutrition design modeling. This developed method proposes a useful tool to differentiate structure and constituents of pekmez of various grape varieties, and the parameters of pekmez and pekmez products production can be well projected to have systematic and methodological manufacturing.

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