EFFECT OF SOAKING ON SALTING AND MOISTURE UPTAKE OF PISTACHIO NUTS (*PISTACHIA VERA L.*) FROM TURKIYE

ANTEPFISTIKLARINDA (*PISTACHIA VERA L.*) DALDIRMA İŞLEMİNİN TUZ NEM ALIŞI ÜZERİNE ETKİSİ

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ABSTRACT: Effect of soaking on salting and moisture content of pistachio nuts (*Pistachia vera L.*) was studied using salt solutions of 10% 20% and 30% for various time intervals of up to 5 hr. Results showed that soaking time and concentration of salt solutions significantly affected the moisture content of the kernel and shell of pistachio nuts. There was a significant difference between moisture content of shell and kernel for each salt solution. The higher salt concentration resulted in significantly lower moisture uptake throughout the soaking period. Moisture uptake during soaking was modeled using an empirical equation for the salt solutions. Effect of soaking time on salt content of pistachio nut kernels was significant at 20% and 30% salt solutions. There was no significant difference between salt content of pistachio nut kernels at 20% and 30% salt solutions over the soaking period. Moreover, salt contents of pistachio nut kernels did not differ significantly up to 20 min soaking period. Therefore, salt concentration between 20% and 30% and soaking time shorter than 20 min may be used for salting prior to roasting.

ÖZET: Antepfıstığı tuzlama işleminin daldırma yöntemiyle yapılma koşullarının belirlenmesi amaç ile daldırma yönteminin Antepfıstığının tuz ve nem içeriğine etkisi %10, %20 ve %30 tuz çözeltilerinde 5 saate varan daldırma sürelerinde incelenmiştir. Daldırma süresi ile çözeltinin tuz derişimi Antepfıstıklarının kabuk ve tanesinin nem içeriğini önemli ölçüde etkilemiştir. Ayrıca tüm çözeltilerde kabuk ve tanenin nem içeriği önemli ölçüde farklı bulunmuştur. Çözeltinin tuz derişimi arttıkça Antepfıstıklarının nem alışı azalmıştır. Daldırma sırasınndaki Antepfıstığının nem alışı, her bir tuz çözeltisi için empirik olarak modellenmiştir. Tuz derişimi %20 ve %30 olan çözeltilerle yapılan daldırma işleminde daldırma süresi, Antepfıstığı tanelerinin tuz içeriklerini önemli ölçüde etkilemiştir. %20'luk tuz çözeltisi ile tuzlanan Antepfıstığı tanelerinin tuz içerikleri, %30'luk tuz çözeltisi kullanılarak tuzlanan Antepfıstığı tanelerinin tuz içeriklerinden önemli ölçüde farklı değildir. Ayrıca, Antepfıstığı tanelerinin tuz içerikleri ilk 20 dakikalık daldırma sırasında tuz çözeltisine göre önemli ölçüde değişmemiştir. Bu nedenle Antepfıstıklarının kavrulmadan önce %20 veya %30'luk tuz çözeltisinde 20 dakikadan az bekletilerek tuzlanması için mümkündür.

INTRODUCTION

Pistachio nut, *Pistachia vera L.* is native of Asia with 79% of the world's production. Archaeological excavations in Turkiye date the pistachio nut back to 7000 BC (PYNE, 1996). The biggest grower is the Kerman region of Iran with 47% production followed by United States (23%) Türkiye (19%), Syria (8%) and others (China, Greece, Italy, Afghanistan) (ANON, 1997). The production range in Turkiye is 15 000 - 40 000 metric tons. Pitachio nuts grown in Turkiye is a thinner and smaller variety than Iranian pistachio nuts but is considered to have better flavour (GÖKDEMİR, 1990 and ANON., 1997).

Pistachio nuts are highly nutritious with a protein and fat content of 21%-23% and 57%-62% respectively (KURU *et al.*, 1990, YILDIZ *et al.*, 1996). Pistachio nuts provide nutrients for healthy nutrition such as mono and polyunsaturated fats, which reduces the bad (LDL) cholesterol. Turkish pistachio nut varieties are richer in mono unsaturated fatty acids than Iranian pistachio nut kernels, where the unsaturated fatty acids; palmitoleic acid ($C_{16:1}$), oleic acid ($C_{18:1}$) and linoleic acid ($C_{19:2}$) contents are in the range of 82-93% of total fat (YILDIZ *et. al.*, 1998).

Pistachio nuts are mostly consumed as salted in shell (WOODROOF, 1975). Salting is generally done by soaking the pistachio nuts in a salt solution prior to roasting (WOODROOF, 1975, LUH *et al.*, 1981, KASHANI & VALADON, 1984, YANNITOS & ZARMBOUTIS, 1996). However, a salting process of up to 12 hours as in the traditional method may cause microbiological and chemical deteriorative reactions. Fungi and moulds may sporulate during the salting due to the long humid conditions, which may also give rise to te deleterious mycotoxin production as in the floating process (SHATZKI & PAN, 1996).

Fungi present a tremmendous economical treat to pistachio nuts and can grow more rapidly a water activity higher than 0.70 and produce mycotoxin at an water activity greater than 0.80 (LABUZA, 1984). The minimal level for human consumption for mycotoxin was set by the FDA as 20 ng/g (nut plus shell basis) in the United States while European consuming countries set levels at 1ng/g (B_1) and 5ng/g (total) (MAHONEY & MOLYNEUX, 1998, SHATKI & PAN, 1996, SHANCHIS *et. al.*, 1988). Some moulds produce aflatoxins, which can survive in nuts for long periods of time and may not degrade ever after roasting (SANCHIS *et al.*, 1988).

Salting and roasting processes are the main factors affecting the quality of salted pistachio nuts (KASHANI & VALADON, 1984, LUH *et al.*, 1981). Traditionally in Turkiye, the salting process is done by spreading the salt and water on pistachio nuts and mixing thoroughly before the mix is rested over night (KARACA, 1990). However, this long soaking time for salting and the high humidity environment increases the risk for fungi growth that may produce aflatoxin. Neverthless, research on salting of pistachio nuts are limited and contradictory in the literature: soaking of pistachio nuts in 15% salt solution for 5 hr, 15% salt solution for 30 min or 10% salt solution for 15 min (KASHANI & VALADON, 1984, WOODROOF, 1975, YANNITOS & ZARMBOUTIS, 1996). The aim of this study is to determine the optimum salting time and salt solution concentration for salting in-shell pistachio nuts so that quality problems due to long soaking time for salting would be prevented.

MATERIAL AND METHOD

Sample Preparation

Dried pistachio nuts were supplied from the Pistachio Nut Research Institute, Turkiye harvested from the Gaziantep region in 1997 and stored at 4°C until the experiments. The weight ratio of kernel was 52g/100g of split sample. The initial moisture content of whole hulled-split pistachio nut samples were 3.9±0.04% and 7.3±0.08% for the kernel and the shell, respectively.

For the salting procedure, local industrial type salt was used with a moisture content of 0.14%. For the experiments, 60 g of pistachio nuts were soaked in 300 ml of salt solutions at 10%, 20% and 30% concentrations. Salt and moisture content of shell and kernel were analysed at time intervals of 5 min for the first 30 min and 30 min for the following 4.5 hours. Different soaking period ranges were used since the soaking time mentioned in the literature varies between 15 min and 5 hours. After soaking, the salt solution was drained using a strainer and the excess water was removed by a filter paper. The moisture and salt contents of the samples were determined using the AOAC methods of analysis (AOAC, 1984). All analyses were done in triplicate.

Modeling of moisture uptake during soaking

Moisture uptake of kernel and shell were modelled using an empirical equation for 10%, 20% and 30% salts solutions. The model used was evaluated in terms of final loss ([observed - predicted]^2), regression coefficient, normality distribution of residuals, observed and predicted plots.

Statistical Analysis

Analysis of variance (ANOVA) and the Duncan Test were used for istatistical analyis of data obtained with the SPSS (5.0 version) statistical package program.

RESULTS AND DISCUSSION

Moisture Content

Moisture content of both shells and kernels increased as soaking time increased (Fig 1). There were a significant difference between moisture contents of pistachio nuts soaked in 10% ($p<0.001$), 20% ($p<0.001$) and 30% ($p<0.003$) salt solutions for both shell and kernel.

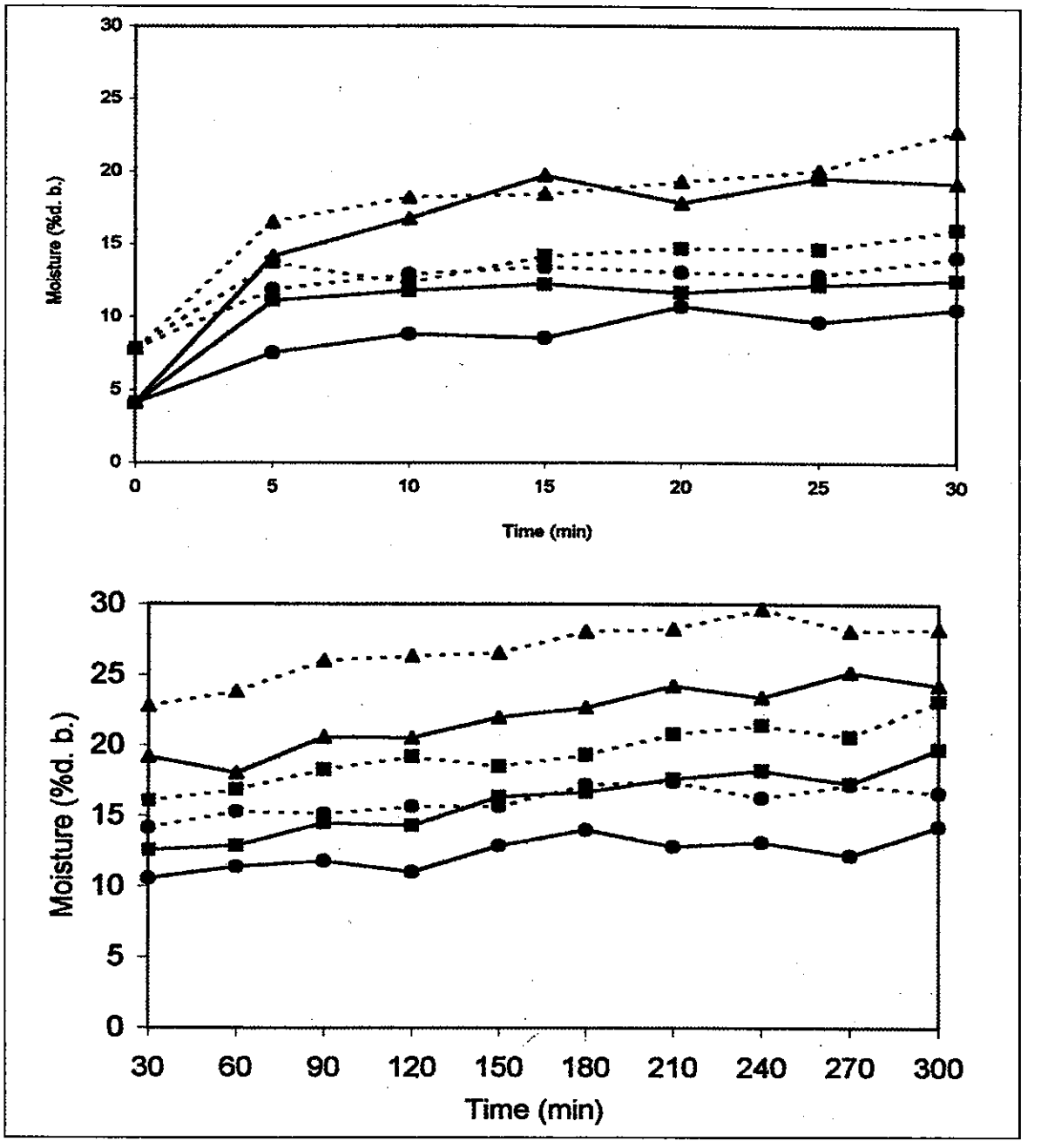

Fig.1. Changes in moisture content of soaked pistachio nut kernels (——) and shells (- - - - -) where ▲, ■ and ● indicates 10%, 20% and 30% respectively. (A) for 0-30 min, (B) for 30-300 min.

Soaking time affected the moisture uptake of both shells and kernels significantly at 10% ($p<0.0001$), 20% ($p<0.0001$) and 30% ($p<0.031$) salt concentrations. Salt concentrations significantly affected moisture uptake of both shell ($p<0.0001$) and kernel ($p<0.0001$) of pistachio nuts. After 20 min soaking, the moisture content of pistachio nut increased from 7.3% to 19% , 15% and 13% (d.b.) for the shells and from 3.9% to 18%, 12% and 11% for the kernels soaked in 10%, 20% and 30% salt solutions, respectively. After 300 minutes the moisture content of pistachio nut kernels reached 3.5-6 fold of their initial moisture content.

The results indicated that pistachio nuts soaked in 20% and 30% salt solution showed considerably lower moisture content compared with 10% salt solutions, because, the concentration of solution is directly

proportional to the osmotic pressure which is also related to vapor pressure or the activity of water (TINOCO, *et al.*, 1978). Adding salt lowers the activity of water resulting in a decrease in driving force for water uptake by the pistachio nuts.

Low moisture uptake of the shell can be explained by their physical resistance to water absorption and the different sorption characteristics of the shell and kernel due to their chemical components as also indicated by LABUZA, 1984 and LOPEZ *et al.*, 1992. High moisture uptake of kernels may cause quality losses during further processes, because, the high moisture content of kernels leads to deteriorative reactions taking place faster. This is especially so, when exposed to high temperatures during processing such as roasting Application of high temperatures at high moisture caused undesired darkening of macadamia kernels (PRICHAVUDHI & YAMAMOTO, 1965). Therefore, it is advisable to pre-dry pistachio nuts to remove moisture taken up during the salting treatment prior to roasting (WOODROOF, 1975, KASHANI, 1983, KARACA, 1990). Moreover, excessive moisture uptake during salting requires higher energy consumption for drying and/or roasting.

Moisture uptake of kernels and shells during salting were also modelled using an empirical model ($m = a+b.\exp(-kt^n)$). Regression coefficients and percent variability explained was above 0.96 and 92%, respectively. Final loss of the model was very low. The normality distribution of residuals, observed and predicted plots were also analysed and gave satisfactory results (plots not shown). Thus, the model satisfactorily described misture uptake of the kernel and shell samples soaked in 10%, 20% and 30% salt solutions, as shown in Fig. 2. Coefficients of the empirical model for the 10%, 20% and 30% salt concentrations are given in Table 1. The predicted models for moisture uptake of pistachio nuts may be useful for design of roasting stages of salted-in-shell pistachio nut processing.

Salt Content

Changes in salt content of kernels are shown in Fig. 2. ANOVA analysis showed that there was a significant difference between the salt contents of pistachio nuts soaked in 10%, 20% and 30% salt solutions

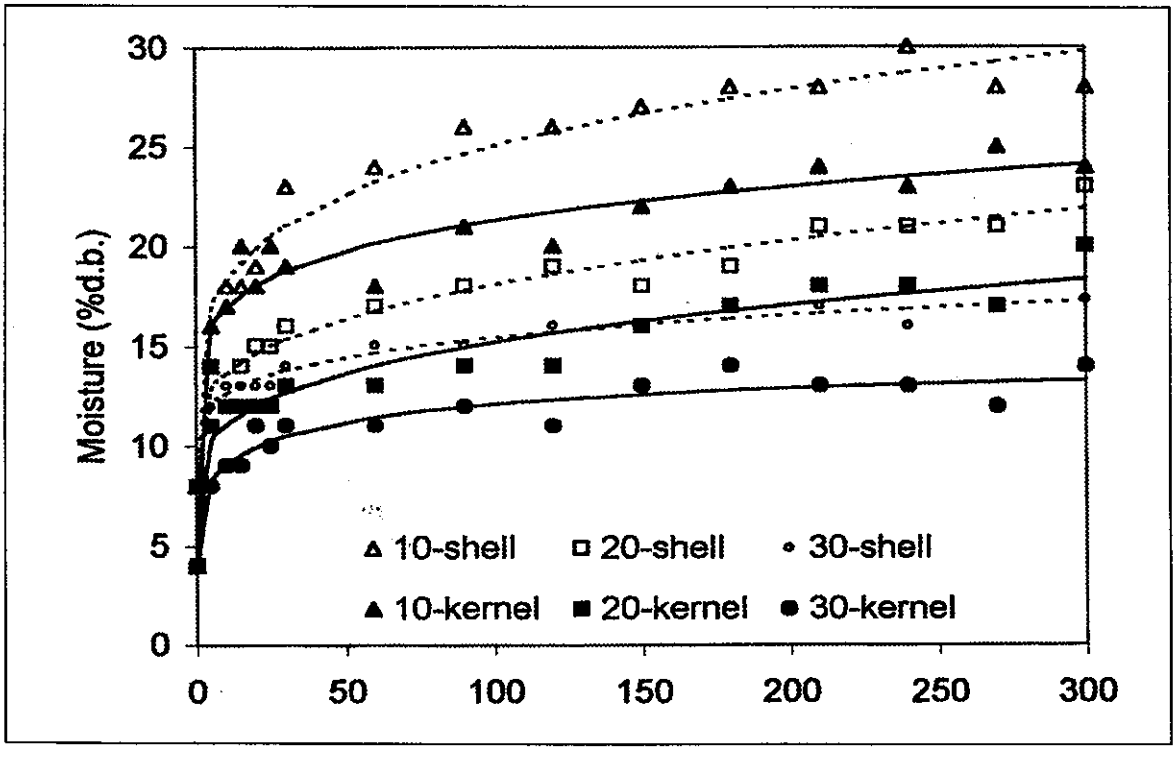

Fig. 2. Changes in salt content of kernels

($p<0.0001$). The Duncan test showed that the salt content of pistachio nuts soaked in 20% and 30% salt solutions did not differ significantly. The effect of soaking time on the salt content of kernels for pistachio nuts soaked in 10% salt solution was not significant ($p>0.310$). The mean of the salt content was 1.55% for 10% salt solution. However, soaking time affected significantly the salt content of pistachio nut kernels soaked in 20% ($p<0.002$) and 30% ($p<0.0001$) salt solutions. The salt content of pistachio nut kernels ranged between 1.95 and 2.97% for 20% salt solution and 1.66 and 3.04% for 30% salt solution. Moreover, the Duncan test revealed that there was no significant effect of soaking time on salt content of pistachio nuts kernels up to 20 min for 20% and 30% salt solutions. The means of the salt content up to 20 min for 20% and 30% salt solutions were determined as 2.32% and 1.87%, respectively which indicated that salt adsorption rate of kernels soaked in 30% salt solution was lower than the kernels soaked in 20% salt solution.

The results of this study indicated that pistachio nuts should be soaked in salt solutions at concentrations between 20% and 30% for less than 20 min, so that excessive moisture uptake is prevented and an acceptable level of salt is ensured. However, the findings should be supported by further research that would be about the effect of the salting process on the quality of roasted pistachio nuts.

CONCLUSIONS

The results indicated that moisture content increased gradually throughout the soaking of pistachio nuts. The moisture content of pistachio nut kernels and shells increased inversely proportional to the concentration of the salt solutions. Salt content of pistachio nut kernels soaked in 10% salt solution did not changed throughout the soaking period. There was no significant difference for salt content of pistachio nut kernels soaked in 20% and 30% salt solutions, which increased gradually throughout the 5 hour soaking period. However, the salt contents of pistachio nut kernels did not change significantly for up to 20 min while the moisture content increased significantly. Therefore, the use of salt solutions with concentrations between 20% and 30% salt solution and soaking times of less than 20 min is recommended to avoid excessive moiture uptake and related quality losses after roasting. Further studes about effect of salting process on roasted in-shell pistachio nuts should be conducted.

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