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RESEARCH PAPER

Rehydration ability of native dried date (*Phoenix dactylifera* L.) fruits soaked in orange juice

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قدرة ثمار النخيل المجفف (*Phoenix dactylifera* L.) على الترطيب عن طريق نقعها في عصير البرتقال

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Abstract. Algerian date (*Phoenix dactylifera* L., dried variety *Mech-Degla*) fruits (DFs) are of low commercial value. To our knowledge, research on the rehydration of DFs by soaking in citrus or other fruit juices is limited. The present paper reports on the soaking process of naturally dried DFs in orange juice (OJ). The DF rehydration ability was analyzed by applying two levels factorial design with three responses (DF weight gain, OJ °Brix and DF breaking strength) and three factors (soaking temperature "X1", soaking time "X2" and OJ volumetric fraction "X3"). The optimal experimental conditions (X1 = 5 °C, X2 = 24 h and X3 = 0.1) allowed to achieve weight gain ~ 0.5, °brix ~ 16 °Bx and breaking strength of 0.6 N (i.e. against 3.7 N for the initial DFs). In addition, the resulting syrup-infused DFs showed a good heat treatment capability in terms of texture retention. The soaking of dried DFs in citrus juice like OJ could be an alternative to valorize such products.

Keywords: Dried date fruit, orange juice, rehydration, soaking, syrup

الملخص: تعتبر التمور الجزائرية (*Phoenix dactylifera* L) من النوعية الجافة (*Mech-Degla*) ذات قيمة تجارية منخفضة. و على حد علمنا، فإن البحوث العلمية في معالجة (ترطيب) التمر عن طريق النقع في عصائر الحمضيات أو الفواكه الأخرى محدودة. تشير المقالة الحالية إلى عملية نقع هذه التمور الجافة طبيعيا في عصير البرتقال. تمت دراسة قدرة ترطيب التمر من خلال تطبيق التصاميم التجريبية (تصميمات عاملة كاملة) ذو مستويين دون تكرار مع الأخذ بعين الاعتبار لثلاثة متغيرات تابعة (زيادة وزن التمر ، °Brix لعصير البرتقال ، وقوة كسر التمر) وثلاثة متغيرات مستقلة(درجة حرارة النقع «X1» ، مدة النقع «X2» نسبة عصير البرتقال «X3») . الظروف التجريبية المثلى (X1=5 درجات مئوية ، X2 =24 ساعة و X3 =0.1) مكنت بتحقيق زيادة في وزن التمر تقدر بالنصف ، قيمة brix ~ 16° درجة وقوة الانكسار N 0.6 (مقابل N 3.7 للتمور الغير معالجة). بالإضافة إلى ذلك، فقد أظهرت التمور المشبعة بالعصير قدرة جيدة على المعالجة الحرارية من حيث الاحتفاظ بالملمس. يمكن أن يكون اذن نقع التمور المجففة في عصير الحمضيات مثل عصير البرتقال بديلاً لتثمين هذه التمور.

الكلمات المفتاحية: التمور الجافة، عصير البرتقال، النقع، شراب مركز، تصميمات عاملة كاملة دون تكرار.

Introduction

Preservation of genetic diversity of date palm (*Phoenix dactylifera* L.) tree needs valorization of date fruits (DFs) having low commercial value (Acourene et al., 2007). Native dry DF varieties like *Mech-Degla* are known to be a sugar-rich material, attributing to the fruit pulp a sweet taste and non-juicy consistency. Rehydration is a unit operation widely used in food processing (Amami et al., 2006). This is a complex process aimed at the restoration of the food properties, including thermophysical properties (Vega-Gálvez et al., 2009).

Many works have been devoted to rehydration process of different fruits, including DFs, using distilled water as soaking media: hot air-dried DFs (Falade and Abbo, 2007), freeze-dried pineapple, mango, guava, acerola and papaya (Marques et al., 2009), softening of over dried 'Deglet Nour' dates and impact of rehydration on the dried products (Boubekri et al., 2010), osmotic pre-dehydrated, hot-air and microwave-vacuum dried strawberry and apples (Kowalska et al., 2018) , etc. However, to our knowledge, little research has been reported on the rehydration using fruit juices as soaking media.

The present paper reports on the rehydration ability of Algerian native dry DFs (*Phoenix dactylifra* L., *var. Mech-Degla*) using orange juice as soaking liquid. The orange juice could add specific physicochemical, nutritional and organoleptic characteristics to new infused fruit. It is worth pointing out that the possibility of obtaining dried date fruits infused in syrup was initially reported by Amellal et al. (2007) and Benamara et al. (2008). Preservation of fruits in syrup is well known traditional method (Tindall, 1994).

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Materials and methods

Plant Materials

Algerian date (*Phoenix dacylifera* L., dried variety *Mech-Degla*) fruits (DFs) were harvested in the region of Biskra (south-eastern Algeria) and purchased from the city of Constantine (north-eastern Algeria). They were characterized by high sugar content of 64% (wb), low water content of 14% (wb) and relatively high pH of 6.3 as already highlighted by Noui (2007) and Messaid (2008). These are the three most important parameters because they are likely to have a direct influence on the mass transfer and texture. The fruits were sorted and cleaned, then packaged in a polyethylene bag at 6 °C. Before rehydration, the fruits were washed, dried by absorbent paper and then cut longitudinally into two halves.

The orange juice (OJ) used as soaking media was from fruits of late variety Valencia cultivated in the region of Blida (50 km west of Algiers). The oranges were cleaned, washed and dried by absorbent paper. The OJ was extracted immediately prior to use, by manual pressing of orange halves using lemon squeezers. After extraction, OJ was filtrated and centrifuged.

Rehydration by Soaking in Orange Juice

The rehydration of DFs by soaking in diluted OJ was studied using two-level full factorial design as described by Goupy (1996). For this, three factors (variables) were considered, namely temperature of OJ used as soaking media (X_1, level (-) = 5 °C and level (+) = 45 °C), soaking time (X_2, level (-) = 0.5 h and level (+) = 24 h) and volumetric fraction of OJ in the soaking aqueous solution (i.e. mixture of distilled water and natural OJ) (X_3, level (-) = 0.1 and level (+) = 0.9). The temperature was controlled using a refrigerator equipped with a thermostat (i.e. 5° C) and a thermostatically controlled water bath (i.e. 45° C). Three responses were taken into account, namely, DF weight gain (weight fraction, with reference to the initial weight), OJ °Brix and DF breaking strength (N). The DF halves:soaking OJ ratio was 1:3 (w/v), corresponding to 20 g date pieces/60 mL diluted OJ. Data modeling was performed using XLSTAT software.

Instrumental Texture Analysis

It is well established that the texture of foods, together with color and flavor, is one of the most important quality criteria, which determines the consumer acceptability (Andrés-Bello and Barreto-Palacios, 2013). The measurement of the breaking force (expressed in N) was carried out on DFs before and after soaking, using the texture analyzer TA Lloyd (AR2000 TA plus LLOYD instrument, Ametek, UK) with drip tray. Fundamentally, it consisted of three modules, namely drive system, test cell and force measuring and recording system. The plunger used was cylindrical shape with a flat base 12.7 mm in diameter, moving with a speed of 1 mm/s. Several parameters were measured but only the breaking strength, indicative of the DF firmness, is presented. For comparison purpose, commercial syrup-infused pineapple and papaya were subjected to the same analysis.

Pasteurization

This test consisted essentially to check the ability of the processed date fruits to maintain texture during thermal pasteurization. Preliminary, time needed to reach the desired temperature at the center of DF pieces was determined, using a thermocouple (type J Blindi), a heat generator (Lauda type) and a temperature recorder (Type Servogor 210/Goerz). The DFs soaked in the OJ syrup were packaged in a glass jar, which was first sealed with a screw cap and then immersed in a thermostatically controlled heating bath. The pasteurization temperature was kept constant at 78 °C during pre-determined heating time of 4 min.

Results and Discussion

The results of rehydration ability are summarized in Table 1. As it can be seen from the table, the test 3 was the most interesting based on: i) the maximum date fruit (DF) weight gain ~ 0.5, ii) Brix value ~ 16 °Bx, corresponding to a syrup of light type (FAO, 2003), and iii) appreciated DF texture with a tensile strength of 0.64 N (against 3.66 ± 0.6 N for the initial fruits) (i.e. close to that of commercial syrup infused fruits, 0.63 and 1.2 N for papaya and pineapple, respectively). The breaking force of 0.64 N was chosen because among all the values obtained for the breaking force, it was the closest to 0.63 N (i.e. commercial infused papaya). None of the values did show as close to the firmness (1.2 N) of pineapple (i.e. commercial infused fruit). To our knowledge, there was negligible numerical data on the firmness of other infused fruit species. Regarding DFs, soft and chewy moist fruits are commonly preferred (Barreveld, 1993).

Globally, the rehydration ability and firmness of processed DFs seemed to be close to those (2-50% and 0.4 to 2 N, respectively) of infused blueberries (Rodrigues et al., 2015). Infused fruits generally refer to the process of osmotic dehydration. In this present work, the process of soaking of DFs in orange juice (OJ) was visualized as compared to other two processes of rehydration and osmotic dehydration (Figure 1).

The observed enhancement in the texture of rehydrated DF pieces can be attributed to absorbed water (Stanley and Aguilera, 1985). In addition, various substrates, ions and enzymes in OJ can interact with DFs during soaking and heat treatment (Andrés-Bello and Barreto-Palacios, 2013). The color change may also be influenced by the pH value (Andrés-Bello and Barreto-Palacios, 2013). The rehydration ability of DF varieties can be depended on sun-drying of fruits on the tree. Such drying is relatively different from post-harvest drying. In fact, the high temperature of drying involves

Table 1. Experimental design related to soaking of native dried dates soaked in orange juice

No	X1	X2	X3	Weight gain	°Brix*	Breaking strength, N
1	-	-	-	0.211	4.63	2.58
2	+	-	-	0.224	5.03	1.63
3	-	+	-	0.499	16.63	0.64
4	+	+	-	0.521	20.83	0.28
5	-	-	+	0.195	12.00	2.78
6	+	-	+	0.215	12.90	1.81
7	-	+	+	0.483	21.50	0.86
8	+	+	+	0.507	28.00	0.35
Level (-)	5°C ±3	0.5 h	0.1**			
Level (+)	45 °±3	24 h	0.9***			

* Expressed as fraction, based on the initial weight; **10 % (V/V) pure orange juice; ***90 % (V/V) pure orange juice; X1: temperature of soaking juice; X2: soaking time, and X3: volumetric fraction of orange juice.

a more rigid structure, which can lead to a lower rehydration rate (Ramallo and Mascheroni, 2012). Models obtained with the coded variables are given as follows, using XLSTAT software (Goupy, 1996):

$$\text{Weight gain: } Y = 0.357 + 0.010X_1 + 0.146X_2 + 0.007X_3 \quad (1)$$

$$\text{°Brix : } Y = 15.19 + 1.50X_1 + 6.55X_2 + 3.40X_3 + 1.18X_1X_2 + 0.35X_1X_3 - 0.40\ X_2X_3 + 0.23X_1X_2X_3 \quad (2)$$

$$\text{Breakingstrength: } Y = 1.37 - 0.35X_1 - 0.835X_2 + 0.08X_3 + 0.13X_1X_2 \quad (3)$$

The measured and predicted values are shown in Figure 2. For the "weight gain" response (Eq. 1), the factor time

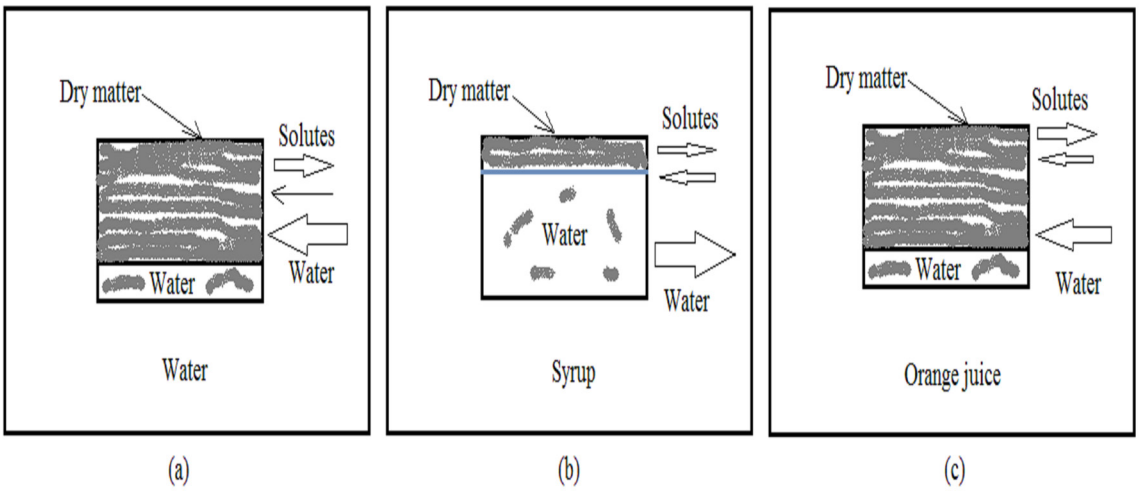

Figure 1. Diagrams of rehydration in water (a), osmotic dehydration (b), and soaking date fruit in orange juice (c). The arrows of different sizes indicate the direction and, for general guidance, the intensity of the corresponding mass transfers.

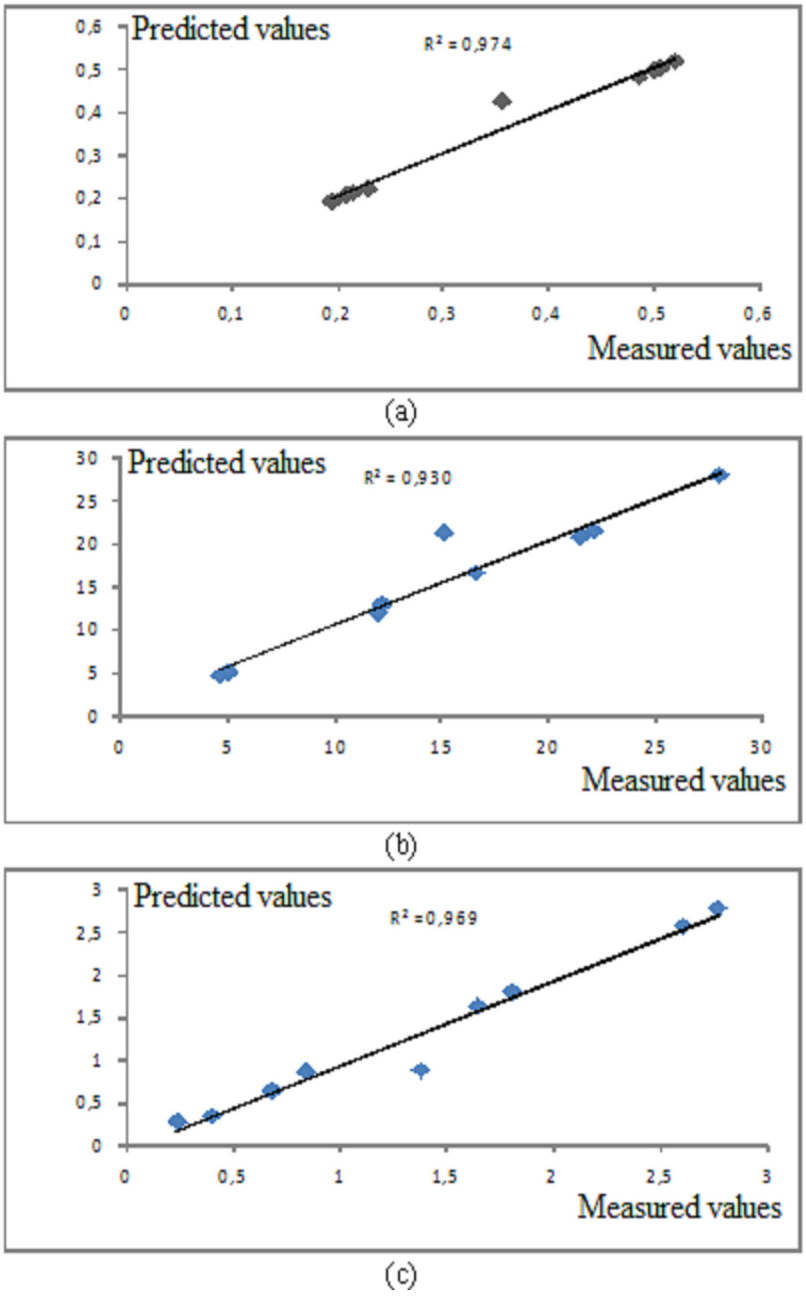

Figure 2. Predicted by the model and measured values of weight gain (a), °Brix (b) and breaking strength (c), (See Table 1 for units).

(X2) has a positive main effect and it seems to be the most influential factor. In the case of "°Brix" (Eq. 2), time and OJ concentration have a positive effect and both factors seem to be more influential than temperature. Regarding the "Breaking strength" (Eq. 3), the soaking time and temperature have a negative main effect and they seem to be more influential as compared to the OJ concentration. Moreover, there is a synergistic interaction between orange juice temperature and soaking time.

The internal and external surface of DF halves at different stages of treatment are shown in the Figure 3. Sugars as essential components of DFs promote water uptake by plant tissue, whereas the fruit minerals could improve the texture firmness of the final product, and potassium being frequently associated with the fruit firmness (Guedes et al., 2013; Cromey, 2012; Watson and Lom, 2008; Neumann 1972). It should be noted that preliminary tests showed that the rehydration of dried DFs

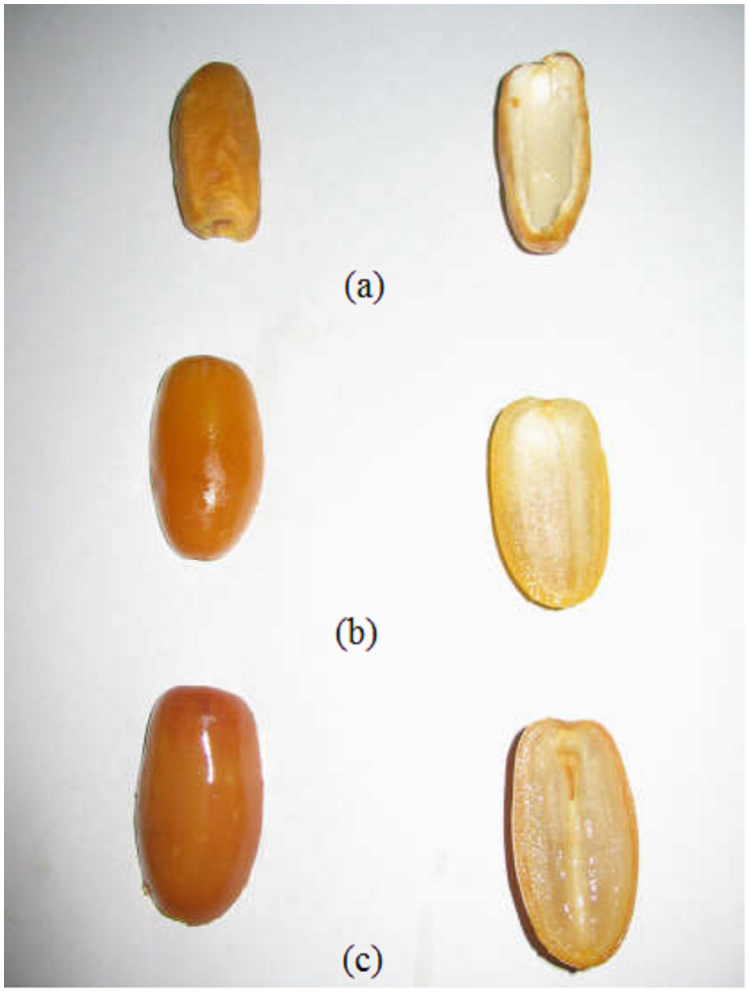

Figure 3. Images of pitted dried date fruits halved longitudinally: a) before soaking, b) after soaking, according to test No 3 (see Table 1), and c) after soaking followed by pasteurization at 78°C during 4 min. On the left: date fruit external side; on the right: date fruit internal side.

by soaking in water was not convenient because of the disintegration of the fruit texture (results not presented here), whereas the citrus juices produced a firm texture.

Conclusion

Naturally dry date fruits (DFs) showed a good ability to rehydration when they were soaked in orange juice. In addition, the thermal pasteurization improved the rehydration ability and surface structure of infused DFs. These findings confirm the possibility of obtaining a new DF product. Additional studies are needed to improve the modeling and optimization of rehydration and pasteurization processes.

References

Acourene S, Allam A, Taleb B, Tama M. (2007). Inventaire des différents cultivars de palmier dattier (*Phoenix dactylifera* L.) des régions de Oued-Righ et de Oued-Souf (Algérie). Sécheresse 18(2): 135-142.

Amami E, Fersi A, Khezami L, Vorobiev E, Kechaou N. (2007). Centrifugal osmotic dehydration and rehydration of carrot tissue pre-treated by pulsed electric field. LWT- Food Science and Technology 40: 1156-1166.

Amellal H, Ait-Ameur L, Benamara S, Noui Y. (2007). Treatment of Mech-Degla date by immersion in the citrus juices, In: Lazos ES, Eds, Proceeding of 5th International Congress of Food Technology, V.1, Thessaloniki, Greece, 2007, pp. 647–652.

Andrés-Bello A, Barreto-Palacios V. (2013). Effect of pH on color and texture of food products. Food Engineering Reviews 5: 158-170.

Barreveld WH. (1993). Whole dates. In: Date palm products: FAO Agricultural Services Bulletin No. 101.

Benamara S, Gougam H, Amellal H, Djouab A, Ben-

ahmed A, Noui, Y. (2008). Some Technologic Proprieties of Common Date (*Phoenix dactylifera* L.) Fruits. American Journal of Food Technology 3 (2): 79-88.

Boubekri A, Benmoussa H, Courtois F, Bonazzi C. (2010). Softening of over dried 'Deglet Nour' dates to obtain high-standard fruits: Impact of rehydration and drying processes on quality criteria. Drying Technology 28 (2): 222-231.

Cromey, D. W. (2012). Digital images are data: and should be treated as such. In Cell Imaging Techniques (pp. 1-27). Humana Press, Totowa, NJ.

Falade KO, Abbo ES. (2007). Air-drying and rehydration characteristics of date palm (*Phoenix dactylifera* L.) fruits. Journal of Food Engineering 79: 724-730.

FAO. (2013). Directives pour les milieux de couverture des fruits en conserve, CAC/GL51-2003. Food and Agricultural Organization, Rome, Italy.

Goupy J. (1996). La methode des plans d'expériences. Dunod, Paris, 303 pp.

Guedes MNS, de Abreu CMP, Maro LAC, Pio R, de Abreu JR, de Oliveira JO. (2013). Chemical characterization and mineral levels in the fruits of blackberry cultivars grown in a tropical climate at an elevation. Acta Scientiarum Biological Sciences 35 (2): 191-196.

Kadam SU, Tiwari BK, O'Donnell CP. (2015). Improved thermal processing for food texture modification. In: Modifying Food Texture, Volume 1: Novel Ingredients and Processing Techniques, pp. 115-131.

Kowalska H, Marzec A, Kowalska J, Ciurzyńska A, Samborska K, Bialik M, Lenart A. (2018). Rehydration properties of hybrid method dried fruit enriched by natural components. International Agrophysics 32: 175-182.

Marques LG, Prado MM, Freire JT. (2009). Rehydration characteristics of freeze-dried tropical fruits. LWT - Food Science and Technology 42 (7): 1232-1237.

Messaid H. (2008). Optimisation du processus d'immersion-réhydratation du système dattes sèches-jus d'orange. Mémoire de magister, Faculté des Sciences de l'Ingénieur, Université M'hamed Bougara, Boumerdès, Algérie, 96p.

Neumann HJ. (1972). Dehydrated celery: Effects of predrying treatments and rehydration procedures on reconstitution. Journal of Food Science 37: 437-441.

Noui Y. (2007). Caractérisation physico-chimique comparative des deux principaux tissus constitutifs de la pulpe de datte Mech-Degla. Mémoire de magister, Faculté des Sciences de l'Ingénieur, Université M'hamed Bougara, Boumerdès, Algérie, 112p.

Ramallo LA, Mascheroni RH. (2012). Quality evaluation of pineapple fruit during drying process. Food Bioproducts Processing 90 (2): 275–283.

Stanley DW, Aguilera JM. (1985). A review of textural defects in cooked reconstituted legumes-The influence of structure and composition. Journal of Food Biochemistry 9 (4): 277-323.

Tindall HD. (1994). Sapindaceous fruits: Botany and horticulture. In J. Janick (Eds), Horticultural Reviews, Volume 5, John Wiley & Sons, pp. 143-196.

Vega-Gálvez A, Notte-Cuello E, Lemus-Mondaca R, Zura L, Miranda M. (2009). Mathematical modelling of mass transfer during rehydration process of Aloe vera (Aloe barbadensis Miller). Food and Bioproducts Processing 87 (4): 254-260.

Watson FL, Lom B. (2008). More than a picture: Helping undergraduates learn to communicate through scientific images. CBE—Life Sciences Education 7: 27-35.