Centro Studi e Ricerche sul Nocciolo

ISHS

UNIVERSITÀ DEGLI STUDI DELLA Tuscia

CeFAS
AZIENDA SPECIALE FORMAZIONE E SVILUPPO
Camera di Commercio Viterbo

7th INTERNATIONAL CONGRESS ON HAZELNUT

7° CONGRESSO INTERNAZIONALE SUL NOCCIOLO

PROCEEDINGS OF THE VIIth INTERNATIONAL CONGRESS ON HAZELNUT

Volume 2

Convener

L. Varvaro

Viterbo, Italy

June 23-27, 2008

ISHS Section Nuts and Mediterranean Climate Fruits
ISHS Working Group on Hazelnuts

Acta Horticulturae 845
October 2009

ISSN 0567-7572
ISBN 978 90 6605 712 8, Acta Horticulturae n°. 845
Price for non-members of ISHS: € 164,-
Published by ISHS, October 2009

Executive Director of ISHS: J. Van Assche
Technical Processing: ISHS Secretariat

ISHS Secretariat, PO Box 500, 3001 Leuven 1, Belgium

Printed by Drukkerij Geers Eeckhoutdriesstraat 67, 9041 Gent (Oostakker), Belgium

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1. Landscape of the Monti Cimini hazelnut area (courtesy of S. Gasbarra).
2. Hazelnut in vitro propagation (courtesy of L. Bacchetta).
3. Typical hazelnut orchard in Viterbo area (courtesy of V. Cristofori).
4. Hazelnut harvesting machines (coutesy of D. Monarca).
5. Hazelnut dieback (courtesy of L. Varvaro).
6. Industry hazelnut products (Courtesy of Stelliferi & Itavex Spa).

Effects of Storage Conditions on Hazelnut (*Corylus avellana* L.) Textural Characteristics

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Keywords: textural analysis, hazelnut quality, shelf-life, rupture force, compression loading

Abstract

Texture analysis is a very important new tool to define the characteristics of foods as its responses could be correlated to consumer evaluations. In this work texture analysis was applied to samples of the hazelnut cultivar 'Tonda Gentile Romana' (*Corylus avellana* L.), harvested in 2005 and stored for one year in a refrigerating room, in a freezer and under a nitrogen-enriched atmosphere, in order to define the effect of these treatments on textural characteristics of the products. The analyses were performed on the fresh product and after 4, 8 and 12 months of storage. Raw and roasted products were examined. Rupture force (N), rupture energy (mJ) and nut specific deformation (N/mm) were measured by a Universal Testing machine TA.XT2i® Texture Analyser under three compression loading positions (x, y and z axes). In comparison to the fresh samples, the textural parameters showed the highest differences after four months of storage. After 12 months of storage, the values of the force required to break the nuts ranged from 84.8 to 103.1 N for raw hazelnuts and from 80 to 98 N for roasted. The lowest values of force were generally obtained in raw frozen hazelnuts, while in the same storage conditions roasted hazelnuts had the highest values. The lowest values of rupture force were usually noticed along the x-axis (length), the highest along the y-axis (width). The obtained results showed that rupture force and nut specific deformation were the most discriminating parameters for raw hazelnuts, while rupture energy was the most discriminating parameter for roasted hazelnuts. Finally, rupture force was strongly correlated with both rupture energy (R^2=0.95) and nut specific deformation (R^2=0.94). These results show that texture analysis is a very suitable method for hazelnut analysis and for the study of storage effects on the textural characteristics of this fruit.

INTRODUCTION

The hazelnut (*Corylus avellana* L.) is a very important dried fruit grown in many countries including Turkey, Italy, Spain and the United States. Nearly one million tons are produced each year, ensuring ample supply to meet food industry needs. Annual crop production varies according to the country but generally Turkey supplies 75% and Italy 15% of the world's hazelnuts. Filbert cultivation in Italy involves all the country but in particular the Campania, Lazio, Sicilia and Piemonte regions, where local cultivars are grown.

About 90% of the worldwide production of shelled hazelnuts is used by the food industry as an ingredient of confectionery, biscuit and pastry manufacture, for snacks, creams, nougats and ice creams. The remaining 10% supplies the in-shell consumption market.

For the processing industry and the catering business it is important to check the roasting behaviour and the quality of hazelnuts. The texture of food products is the key to consumer satisfaction and can have a significant influence on food sampling and buying. Texture analysis provides an effective way to monitor the results of changes due to storage and processes such as roasting. Because of its adaptability and simplicity, texture analysis is widely used by the food industry both in new product development and as part of the quality control of processed foods.

In this work, texture analysis was applied to samples of the hazelnut cultivar 'Tonda Gentile Romana', harvested in 2005 and preserved for one year at three different storage conditions, in order to define the effect of these treatments on textural characteristics of the products.

MATERIALS AND METHODS

Samples of 'Tonda Gentile Romana' (kernel size 12-13 mm) hazelnut cultivar (*Corylus avellana* L.) from Lazio (Italy) were used for this work. Raw and shelled hazelnuts were stored for one year in a refrigerating room (+4°C), in a freezer (-18°C) and under nitrogen-enriched atmosphere. Every four months kernels were sampled and roasted (160°C for 20 min). The analyses were performed on the fresh product and after 4, 8 and 12 months of storage.

A TA.XT2i® Texture Analyser (Stable Micro System, Godalming, Surrey, UK) was used to measure kernel resistance to breakage. The device was equipped with a plate probe connected to a 50-kg load cell at 1 mms^{-1} constant speed (Valentini et al., 2006). The nuts were placed on a perforated platform. The force-deformation curve was acquired as a graph and elaborated with Texture Expert® software (Fig. 1). Three replicates of 10 nuts for each storage condition were compressed along the three loading positions: x-axis (length), y-axis (width) and z-axis (thickness) (Güner et al., 2003). The breakage characteristics of hazelnut are expressed according to Braga et al. (1999) as the maximum force required for kernel rupture (N), the energy required to deform the kernel to rupture (mJ) and nut specific deformation (N/mm).

Data were analyzed by SPSS 12.0 software. ANOVA and Tukey's mean comparison test were applied. Linear regression analysis was also performed for the relationship between the parameters.

RESULTS AND DISCUSSION

In comparison to the fresh samples, the textural parameters showed the highest differences after four months of storage. After 12 months of storage, the values of the force required to break the nuts ranged from 84.8 to 103.1 N for raw hazelnuts and from 80.0 to 98.0 N for roasted (Table 1). The lowest values of force were generally obtained in raw frozen hazelnuts, while in the same storage conditions, roasted hazelnuts had the highest. The lowest values of rupture force were usually noticed along the x-axis (length), the highest along the y-axis (width) (Fig. 2). The results obtained showed that the rupture force and nut specific deformation were the most discriminating parameters for raw hazelnuts, while rupture energy was the most discriminating parameter for roasted hazelnuts. Finally, rupture force was strongly correlated with both rupture energy (R^2 = 0.95) (Fig. 3) and nut specific deformation (R^2 = 0.94) (Fig. 4). These results show that texture analysis is a very suitable method for hazelnut analysis and for the study of storage effects on the textural characteristics of this fruit.

Literature Cited

Braga, G.C., Couto, S.M., Hara, T. and Almeida Neto, J.T.P. 1999. Mechanical behavior of macadamia nut under compression loading. J. Agric. Engineer. Res. 72:239-245.

Güner, M., Dursun, E. and Dursun, İ.G. 2003. Mechanical behavior of hazelnut under compression loading. Biosyst. Engineer. 85:485-491.

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Tables

Table 1. Mean and standard deviations (σ) of rupture force (N), rupture energy (mJ) and nut specific deformation (N/mm) of raw and roasted hazelnuts at three different storage conditions. For each parameter the results of Anova and Tukey's tests were reported.

Months of storage	Type	Storage conditions	N		mJ		N/mm	
			Mean	σ	Mean	σ	Mean	σ
4	Raw	Refrigerated	104,05[b]	± 23,8	143,15	± 73,8	42,85[b]	± 9,4
		Frozen	90,16[a]	± 25,7	149,74	± 93,5	33,56[a]	± 8,6
		Under nitrogen	97,99[ab]	± 23,9	130,64	± 69,3	41,66[b]	± 9,2
		Signif.	***		ns		***	
	Roasted	Refrigerated	98,49[a]	± 30,1	112,71[a]	± 65,7	47,02	± 9,1
		Frozen	110,34[b]	± 32,4	139,97[b]	± 91,8	49,02	± 10,5
		Under nitrogen	102,76[ab]	± 29,1	119,01[ab]	± 59,1	48,27	± 11,7
		Signif.	*		*		ns	
8	Raw	Refrigerated	99,30[b]	± 26,5	134,42	± 85,0	42,56[b]	± 9,0
		Frozen	87,87[a]	± 24,0	128,19	± 76,2	37,15[a]	± 9,6
		Under nitrogen	104,68[b]	± 24,0	132,35	± 70,0	46,17[c]	± 10,2
		Signif.	***		ns		***	
	Roasted	Refrigerated	77,75[a]	± 26,4	67,28[a]	± 42,0	47,74	± 10,0
		Frozen	95,73[b]	± 29,1	96,65[b]	± 53,0	49,67	± 11,2
		Under nitrogen	91,77[b]	± 25,7	97,22[b]	± 50,6	54,98	± 10,5
		Signif.	***		***		ns	
12	Raw	Refrigerated	100,45[b]	± 26,1	129,84	± 74,6	43,25[b]	± 10,8
		Frozen	84,82[a]	± 24,1	128,03	± 79,4	32,22[a]	± 7,5
		Under nitrogen	103,09[b]	± 23,1	135,04	± 74,0	43,97[b]	± 10,7
		Signif.	***		ns		***	
	Roasted	Refrigerated	88,60[b]	± 22,4	90,31[b]	± 42,5	45,44[b]	± 8,4
		Frozen	97,98[c]	± 25,2	127,27[c]	± 84,9	41,14[c]	± 10,0
		Under nitrogen	80,04[a]	± 26,2	73,08[a]	± 40,6	45,12[a]	± 10,6
		Signif.	***		***		*	

(* - $p<0.05$; ** - $p<0.01$; ***-$p<0.001$; ns-not significant; mean values with the same letter are not significant different for $p<0.05$)

Figures

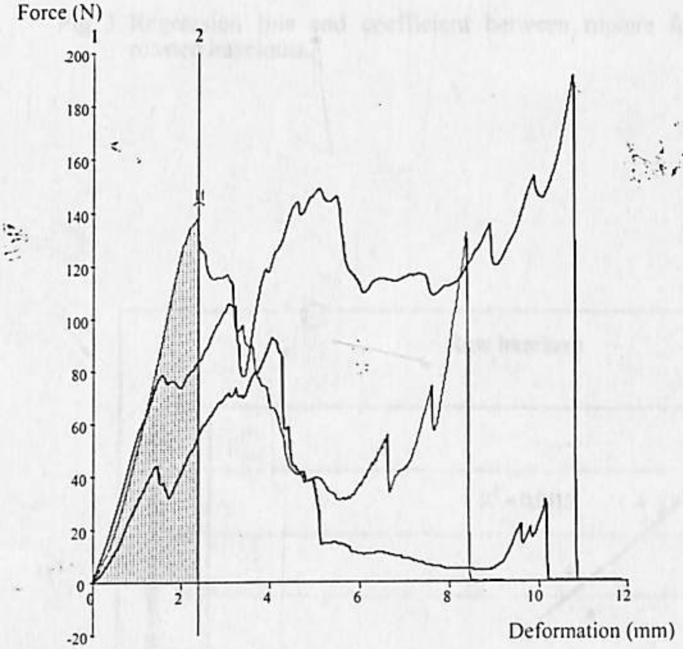

Fig. 1. A typical Force/Deformation graph of texture analysis of hazelnuts.

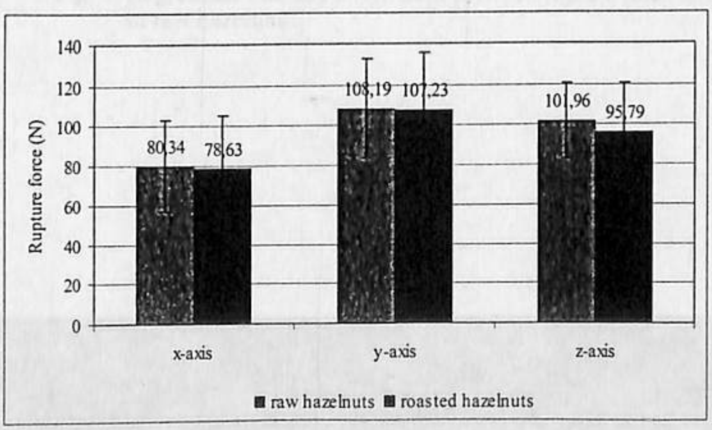

Fig. 2. Behaviour along the three compression axes for Rupture force indices. Reported values are mean of three replicates of 10 nuts while bars show standard deviations.

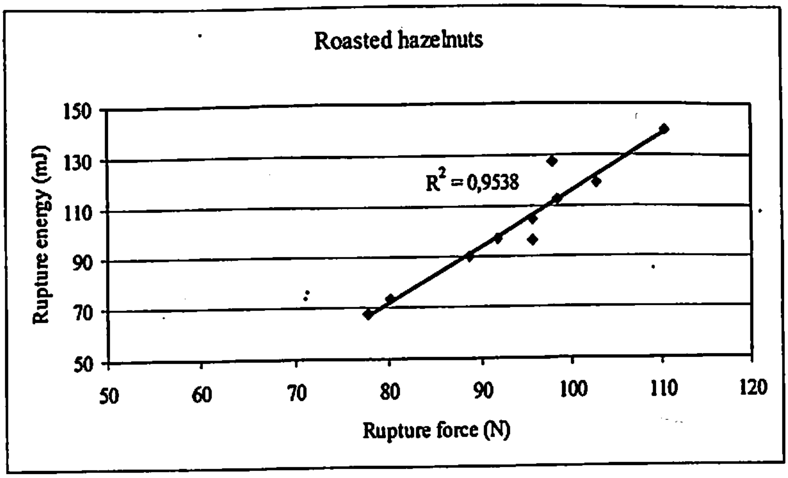

Fig. 3. Regression line and coefficient between rupture force and rupture energy in roasted hazelnuts.

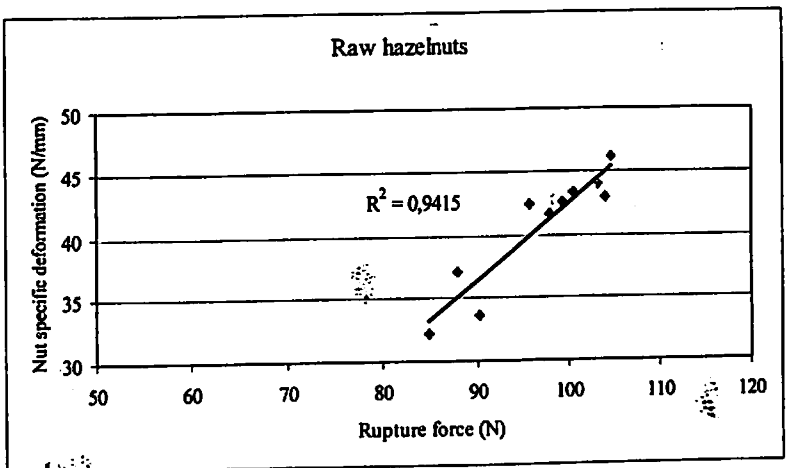

Fig. 4. Regression line and coefficient between rupture force and nut specific deformation in raw hazelnuts.