



## Determining The Factors Affecting Fruit Hardness of Different Peach Types with Meta Analysis

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### ARTICLE INFO

#### Article history:

Received 10 July 2014

Accepted 01 September 2014

Available online, ISSN: 2148-127X

#### Keywords:

Effect size

Fisher's Z statistic

Hunter-Schmid

Meta-analysis

Firmness

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### ABSTRACT

The aim of this study is to determine the factor effective in determining the hardness of Caterina, Suidring, Royal Glory and Tirrenia peach types using meta analysis. In the study, the impact force ( $F_i$ ) and the contact time ( $t_c$ ) were detected and the impulse values ( $I$ ) that are expressed as independent variable in the area under the curve were calculated in the measurements performed using the technique of a low-mass lateral impactor multiplied with peach. Using the theory of elasticity, the independent variables were determined as  $F_{max}$  (maximum impact force), contact time ( $t_{max}$ ),  $F_{max}/t_{max}$ ,  $1/t_{max}$ ,  $1/t_{max}^{2.5}$ ,  $F_{max}/t_{max}^{1.25}$  and  $F_{max}^{2.5}$  parameters. The correlation coefficient values showing the relationship between these parameters and the dependent variable Magness-Taylor force (MT) were calculated and were combined with meta-analysis by using the Hunter-Schmid and Fisher's Z methods. The Cohen's classification criterion was used in evaluating the resulting mean effect size (combined correlation value) and in determining its direction. As a result of the meta-analysis, the mean effect size according to Hunter-Schmid method was found 0.436 (0.371-0.497) positively directed in 95% confidence interval, while it was found 0.468 (0.390-0.545) according to Fisher's Z method. The effect sizes in both methods were determined "mid-level" according to the Cohen's classification. When the significance level of the studies was analyzed with the Z test, all of the ones that taken into the meta analysis has been found statistically significant. As a result of the meta analysis in this study evaluating the relationship of peach types with the fruit hardness, the mean effect size has been found to reach "strong level". Consequently, "maximum shock acceleration" was found to be a more effective factor comparing to the other factors in determining the the fruit hardness according to the results of meta analysis applied in both methods.

Türk Tarım – Gıda Bilim ve Teknoloji Dergisi, 3(2): 98-102, 2015

## Meta Analiz İle Farklı Şeftali Türlerinin Meyve Sertliğine Etki Eden Faktörün Belirlenmesi

### MAKALE BİLGİSİ

Geliş 10 Temmuz 2014

Kabul 01 Eylül 2014

Çevrimiçi baskı, ISSN: 2148-127X

#### Anahtar Kelimeler:

Etki büyüklüğü

Fisher's Z istatistiği

Hunter-Schmid

Meta-analizi

Sertlik

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### ÖZET

Bu çalışmanın amacı, Caterina, Suidring, Royal Glory ve Tirrenia şeftali türlerini sertliğinin belirlenmesinde etkili olan faktörün meta analizi ile belirlenmesi üzerinedir. Araştırmada, düşük kütleli bir yanal impaktörün şeftaliye çarptırılması tekniği kullanılmasıyla yapılan ölçümlerde, çarpma kuvveti ( $F_i$ ) ve temas zamanı ( $t_c$ ) algılanmış ve eğri altında kalan alandan bağımsız değişken olarak ifade edilen impuls ( $I$ ) değerleri hesaplanmıştır. Elastisite teorisi kullanılarak, bağımsız değişkenler,  $F_{max}$  (maksimum çarpma kuvveti), temas zamanı ( $t_{max}$ ),  $F_{max}/t_{max}$ ,  $1/t_{max}$ ,  $1/t_{max}^{2.5}$ ,  $F_{max}/t_{max}^{1.25}$  ile  $F_{max}^{2.5}$  parametreleri olarak belirlenmiştir. Bu parametreler ile bağımlı değişken Magness-Taylor kuvveti (M-T) arasındaki ilişkiyi gösteren korelasyon katsayı değerleri hesaplanarak meta analiz ile Hunter-Schmid ve Fisher's Z Yöntemi kullanılarak birleştirilmiştir. Ortaya çıkan ortalama etki büyüklüğü (birleştirilmiş korelasyon katsayı değeri) ve yönünün değerlendirilmesinde ise Cohen'nin sınıflandırılma ölçütü kullanılmıştır. Meta analiz sonucunda, Hunter-Schmid yöntemine göre ortalama etki büyüklüğü %95 güven aralığında pozitif yönlü 0,436 (0,371-0,497) olarak bulunurken, Fisher's Z yöntemine göre etki büyüklüğü 0,468 (0,390-0,545) olarak bulunmuştur. Etki büyüklükleri her iki yöntemde de Cohen'nin sınıflandırılmasına göre "orta düzeyde" olduğu belirlenmiştir. Çalışmaların anlamlılık düzeyi Z testi ile incelendiğinde de meta analize alınan çalışmaların hepsi de istatistiksel olarak anlamlı bulunmuştur. Şeftali türlerinin meyve sertliği ile olan ilişkisinin değerlendirildiği bu çalışmada meta analiz sonucunda ortalama etki büyüklüğünün "güçlü seviyeye" ulaştığı tespit edilmiştir. Sonuç olarak, her iki yöntemde de uygulanan meta analiz sonuçlarına göre meyve sertliğini belirlemede, etkisi diğer faktörlere nazaran daha güçlü olan faktör "maksimum çarpma ivmesi" olarak saptanmıştır.

## Introduction

Meta-analyses is a statistical method that makes the results more reliable by increasing the sample size by combining the studies conducted on different people, places and times for the same purpose (Wolf, 1986; Cohen et al. 2007). This notion was first introduced by Glass (1976) and it started to be used in different disciplines over time. Knapp et al. (2009) reported that they developed a method for extracting a possible range of the precision of the horticultural experiment using meta-analysis.

Tokamin and Yesilyurt (2013) emphasized that the effect size of previously obtained data (a common unit of measurement) could be attainable in the meta-analysis method which brings together the statistical data of different studies conducted for the same purpose.

When the studies for determining the effect size of averages examined in meta-analysis, it has been observed that these studies were applied more frequently compared to the studies done with correlation coefficients. Kaplan et al. (2013) took the effect size of the average as basis in bringing together the results obtained from the studies done for the effectiveness of teaching material use independently of one another.

Many examples are available for Meta-analysis that it is widely used in many disciplines (medicine, economics, social, etc); however the use of literature in this area has not been encountered yet.

The aim of this study is to determine which fruit is the harder fruit with Hunter-Schmid and Fisher's Z methods using various correlation values from different studies on Caterina, Suidring, Royal Glory and Tirrenia peach varieties using meta-analysis and to determine the variable effective in determining this hardness; also, to determine new common correlation values belonging to these fruit varieties.

## Material and Method

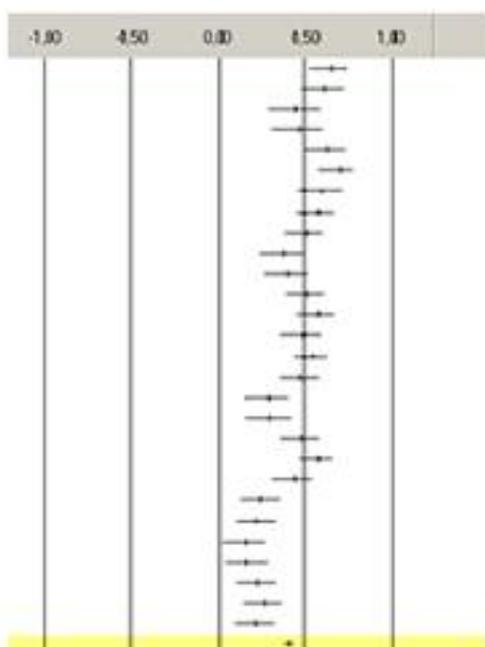
### Material

In this study, the data of Caterina, Suidring, Royal Glory and Tirrenia peach varieties were used. The correlation coefficient values ( $r$ ) were calculated separately for each variety to determine the relationship between the low-mass shock technique which is one of the undamaged measurement methods and the hardness.

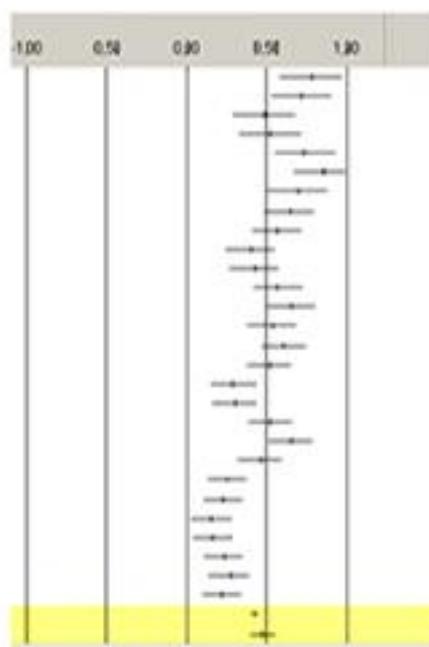
In the calculations, in the measurements performed using the technique of a low-mass lateral impactor impacted with peach, Impact force ( $F_i$ ), and the contact time ( $t_c$ ) were detected and impulse values ( $I$ ) expressed as independent variable in the area under the curve were calculated (Vursavus et al. 2012). The independent variables were determined as the parameters of  $F_{max}$  (maximum impact force), contact time ( $t_{max}$ ),  $F_{max}/t_{max}$ ,  $1/t_{max}$ ,  $1/t_{max}^{2.5}$ ,  $F_{max}/t_{max}^{1.25}$  and  $F_{max}^{2.5}$ .

### Method

First, using the information obtained from other studies, the correlation values affecting peach fruit hardness were obtained according to the types and the average effect size of the data set were taken into consideration by Cohen's criterion (Fig. 1). The methods of Hunter-Schmid and Fisher's Z, respectively were used to combine the correlation values of the study. As a consequence the average effect size of the data set was attained. The effect size of the study was assessed using the effect size classification criteria of Cohen (Table 2). It was tested with the Q statistic whether prepared data set was homogeneous. Finally, the strongest fruit varieties was determined using independent variables and the most effective factor that reveals the strength of this fruit on were determined (Table 4).



Meta-analysis funnel plot drawn according to Hunter-Schmid, (95% confidence interval)



Meta-analysis funnel plot drawn according to Fisher's Z (95% confidence interval)

Figure 1 The funnel plots of effect sizes according to Hunter -Schmid and Fisher's Z method

Table 1 The criteria of Cohen in classification of the effect size (Kinay 2012)

Effect size	Effects size criteria	Interpretation
Correlation coefficients	r < 0 +/- 0.10	weak impact
	r < 0 +/- 0.30	small impact
	r < 0 +/- 0.50	medium impact
	r < 0 +/- 0.80	powerful influence
	r ≥ 0 +/- 0.80	very powerful influence

Table 2 The distribution of the data set used in Meta-analysis according to the peach varieties.

PEACH VARIETIES	The studies correlation coefficient values taken to Meta-analysis	Peach types taken to Meta-analysis	r <sub>1</sub>	r <sub>2</sub>	r <sub>3</sub>	r <sub>4</sub>	r <sub>5</sub>	r <sub>6</sub>	r <sub>7</sub>
			Pearson correlation Coefficient values	Royal Glory	0.576**	0.477**	0.290**	0.300**	0.482**
	Caterina	0.699**	0.618**	0.454**	0.479**	0.631**	0.654**	0.602**	
	Tirrenia	0.266**	0.225**	0.158**	0.169**	0.230**	0.247**	0.218**	
	Suidring	0.575**	0.513**	0.382**	0.401**	0.516**	0.572**	0.489**	

r<sub>1</sub>: the relationship between M-T and F<sub>max</sub> (maximum impact force); r<sub>2</sub>: the relationship between M-T and contact time(t<sub>max</sub>); r<sub>3</sub>: the relationship between M-T and F<sub>max</sub>/t<sub>max</sub>; r<sub>4</sub>: the relationship between M-T and 1/t<sub>max</sub>; r<sub>5</sub>: the relationship between M-T and 1/t<sub>max</sub><sup>2,5</sup>; r<sub>6</sub>: the relationship between M-T and F<sub>max</sub>/t<sub>max</sub><sup>1,25</sup>; r<sub>7</sub>: the relationship between M-T and F<sub>max</sub><sup>2,5</sup>; \*\*: P<0.01.

**Hunter and Schmid Method:**

Hunter and Schmid method is based on the direct coupling correlation coefficients method without any transformation of the correlation coefficients. This method enables the amount of variance of the effect of average effect size to be based on such reasons, ranges stenosis, sampling error and low reliability (Kuncel et al., 2005). Borenstein et al. (2009) reported that the approximate variance value for calculating the effect size of correlational data is,

$$V_r = \frac{(1-r^2)^2}{n-1}$$

r: Correlation coefficient obtained from the sample,  
n: Indicates the sample size.

**Fisher Method:**

Unlike Hunter and Schmid method instead of combining the correlation coefficients directly, direct variance calculations and Fisher's z transformation alternatives are preferred in this method.

While in direct combining process unweighted mean correlation coefficients generally preferred to use random effects of the confidence interval, in Fisher's Z method the wider confidence intervals are formed. At the same time it is allowed to generalize average effect size in the studies other than sample (Borenstein et al., 2009). There are combining methods of Fisher method (random and fixed) are available based on two different models. Borenstein et al. (2009) reported that the correlation coefficient obtained from a sample converted into Fisher's Z statistic is calculated as,

$$Z = 0.5x \left( \frac{1+r}{1-r} \right), \text{ the variance } V_z = \frac{1}{n-3}$$

The two-independent sample t-test was used (SPSS, 2006) whether both methods show differences in terms of effect sizes. The average effect sizes obtained by

combining correlation coefficients were evaluated by making use of the classification criteria of Cohen et al. (2007). This classification table is indicated as in Table 1.

Meta-analysis procedures were performed using the demo version of the Comprehensive Meta-Analysis V2 program (Meta, 2013).

**Results and Discussion**

The correlation coefficient values showing the relationship between the independent variables and the dependent variable; Magness-Taylor force (M-T) are calculated separately for four different varieties. 28 correlation coefficient values showing the relationship between the M-T dependent variable and examined seven different variables are given in Table 2.

The Q statistic was used to determine whether the study data is homogeneous (Tokamin and Yesilyurt, 2013). Additionally, the total effect size of this data set is given in Table 3.

The results of the total effect size according to Hunter and Fisher-Schmid methods are given in Table 3. According to the classification criteria of Cohen, as a result of Hunter-Schmid and Fisher's Z combining methods, the variables used in determining fruit hardness has been found "moderately positive" significant, 0.436 and 0.468, respectively (P<0.001). However, no significant difference has been found when comparing the effect sizes of both methods (P>0.05).

Confidence limits of both methods are shown in the funnel plots (Fig. 1). According to the Funnel plot, it has been seen that the data in Hunter-Schmid varies in a narrower range than in Fisher Z. This shows that the correlation coefficients included in meta-analysis exhibit a homogenous structure.

The results found when the correlation values in Table 1 combined within their varieties with meta-analysis are given in Table 4. According to both Hunter- Schmid and Fisher method, Caterina variety has been found to have the highest effect size of all fruit varieties. It can be said that Caterina variety is harder than other types of fruit varieties.

Table 3 The results of total effect size according to Hunter-Schmid and Fisher methods size

Applied methods	Number of studies	Effect size (r)	Lower limit	Upper limit	Z value	Q
Hunter-Schmid	28	0.436	0.371	0.497	11.808***	192.855***
Fisher's Z	28	0.468	0.390	0.545	11.808***	
Significance level	ns.					

ns: P&gt;0.05; \*\*\*: P&lt;0.001

Table 4 Combining the correlation coefficients of Peach varieties within themselves with meta-analysis

Peach varieties	Methods	Effect size	Lower limit	Upper limit	Z value	p
Caterina	Hunter-Schmid	0.597	0.503	0.677	9.799	***
	Fisher's Z	0.689	0.553	0.824	9.979	***
Royal Glory	Hunter-Schmid	0.450	0.342	0.547	7.370	***
	Fisher's Z	0.485	0.356	0.614	7.370	***
Suidring	Hunter-Schmid	0.496	0.373	0.601	7.046	***
	Fisher's Z	0.544	0.392	0.695	7.046	***
Tirrenia	Hunter-Schmid	0.216	0.102	0.325	3.680	***
	Fisher's Z	0.220	0.103	0.337	3.680	***

\*\*\*: P&lt;0.001

Table 5 The correlation changes calculated according to Fisher's Z for the peach fruit varieties affecting fruit hardness

Varieties	Correlation Coefficients according to Fisher's Z	Previous correlation value	Increased amount of proportional correlation (%)	
Caterina	r <sub>1</sub>	0.865**	0.699	19.19
	r <sub>2</sub>	0.722**	0.618	14.40
	r <sub>3</sub>	0.490**	0.454	7.35
	r <sub>4</sub>	0.522**	0.479	8.24
	r <sub>5</sub>	0.743**	0.631	15.07
	r <sub>6</sub>	0.782**	0.654	16.37
	r <sub>7</sub>	0.696**	0.602	13.51
Royal Glory	r <sub>1</sub>	0.676**	0.576	14.79
	r <sub>2</sub>	0.519**	0.477	8.09
	r <sub>3</sub>	0.299	0.290	3.01
	r <sub>4</sub>	0.310	0.300	3.23
	r <sub>5</sub>	0.526**	0.482	8.37
	r <sub>6</sub>	0.616**	0.548	11.04
	r <sub>7</sub>	0.470**	0.438	6.81
Tirrenia	r <sub>1</sub>	0.273**	0.266	2.56
	r <sub>2</sub>	0.229	0.225	1.75
	r <sub>3</sub>	0.159	0.158	0.63
	r <sub>4</sub>	0.171	0.169	1.17
	r <sub>5</sub>	0.234	0.230	1.71
	r <sub>6</sub>	0.252	0.247	1.98
	r <sub>7</sub>	0.222	0.218	1.80
Suidring	r <sub>1</sub>	0.655**	0.575	12.21
	r <sub>2</sub>	0.567**	0.513	9.52
	r <sub>3</sub>	0.402**	0.382	4.98
	r <sub>4</sub>	0.425**	0.401	5.65
	r <sub>5</sub>	0.571**	0.516	9.63
	r <sub>6</sub>	0.650**	0.572	12.00
	r <sub>7</sub>	0.535**	0.489	8.60

\*\*: P&lt;0.01

The changes of the variables affecting the hardness of peach fruit varieties before and after getting combined with meta-analysis is given in Table 5. Since the results are in Fisher Z higher than in Hunter-Schmid, they are evaluated according to Fisher given in Table 5.

Of these four different varieties, Caterina variety is a harder fruit than other varieties, and it has been determined that the most important correlation affecting fruit hardness within these fruits is the relationship

between Magness-Taylor force and the maximum shock acceleration. When the studies combined with meta-analysis, the increases of 7.35-19.19% in Caterina type, 2.56-14.79% in Royal Glory type, 0.63-2.56% in Tirrenia type and 4.98-12.21% in Suidring type were achieved in the newly obtained correlation values. As a result of studies conducted by Diezma-Iglesias et al. (2006) the correlation between the maximum impact acceleration and the Magness-Taylor force was determined high.

These new correlation values show the common effect of other studies. These effects vary according to the varieties.

This study was conducted to determine which fruit is the harder fruit with Hunter-Schmid and Fisher's Z methods using various correlation values from different studies on Caterina, Suidring, Royal Glory and Tirrenia peach varieties using meta-analysis and to determine the variable or variables effective in determining this hardness; also, to determine new common correlation values belonging to these fruit varieties.

As a result, a sample application of meta-analysis started to be widely used in various disciplines, was performed in the field of agriculture, and the availability of this method has been shown in the agricultural field.

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