American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-6, Issue-12, pp-01-07
www.ajer.org
Research Paper Open Access

The Relationship Between Thermal And Electrical Conductivity And Some Physical And Chemical Properties Of Potato During Storage

Serap Kayisoglu[1], BirolKayisoglu[2], Yasemin Sezer[2]
[1]Namık Kemal University, Vocational School, 59030, Tekirdağ, Turkey
[2]Namık Kemal University, Biosystem Engineering Dept., 59030, Tekirdağ, Turkey

ABSTRACT: *In this study, the relations between some physical and chemicalproperties (pH, starch and moisture content) with electrical and thermal conductivity were investigated during storage under the room conditions of potato (Adora variety). The aim of the study, between electrical and thermal conductivity with these properties were to determine the best-fit models and to make accurate predictions with the help these physical and chemical quantities. As the thermal conductivity and moisture content decreased, Electrical conductivity, pH and starch content increased during storage of potato. All of the prediction models determined among these relationships were statistically significant.*

Keywords:*Thermal conductivity, electrical conductivity, potato, moisture contents, starch content*

Date of Submission: 23-11-2017 Date of acceptance: 05-12-2017

I. INTRODUCTION

Knowing the physical-mechanical properties of fruits and vegetables have great importance in terms of designing the machines to be used during the processing and fabrication of these products. Thermal (specific heat, thermal conductivity and thermal diffusion), optical (color, brightness), electrical (electrical conductivity, permeability) and mechanical (structural, shape and tension) properties are the most used properties for this purpose. Many of these engineering features show significant differences due to the different structures of agricultural products. Especially in storage conditions, many properties of products are changing. In this study, the change in temperature and electrical conductivity during storage of the potato was investigated depending on some parameters. The effects of the variation of these parameters on the thermal and electrical conductivity are modeled.

Many researchers have already done research on this topic. A method has been developed by Stela et al.[1] to detect the thermal conductivity of the potato and the volumetric heat capacity. In this method, it is assumed that the potato is a spherical body. This method is an optimization technique in which two thermal properties are estimated and helps to solve the problem analytically. Rahman [2] investigated the relationship between moisture, porosity and thermal conductivity values of apples, potatoes and pear. For this purpose, the researcher examined 122 previously conducted studies and created their own regression model for these products. A probe (line-source probe) has been developed to detect the thermal conductivity of the potato by Wang and Brennan [3]. Measurements were made between 40 and 70 ^{o}C temperature values for different moisture contents with this probe. The thermal conductivity decreased with decreasing of the moisture content of potato. The highest correlation between these two properties was found in the semi-logarithmic regression model. The effect of temperature on the thermal conductivity of potato was minimal. Donsi et al.[4] measured thermal conductivity of potato and apple by Fitchs Method. For measurements made at 30 ^{o}C temperature and different moisture contents, the thermal conductivity decreased with decreasing humidity. The average thermal conductivity was found to be 0.52 W/m.^{o}C in fresh potato and 0.43 W /m.^{o}C in apple.

In recent years, non-destructive physical tests have become more widely used in evaluating the quality of fruits and vegetables. For this purpose, a new device has been developed to determine changes in electrical resistance in order to have knowledge of post-harvest variations. The surface electrical resistivity, surface brightness and weight of the eggplant stored at 20 ° C and 80-84% relative humidity were measured for 96 hours and the relationship between these parameters was determined. During storage the surface electrical resistance increased quatratically. However, there has been a decrease in weight and surface gloss index [5].

II. MATERIALS AND METHODS

Adora variety potatoes from the Netherlands were used in this research. The average tuber weight is 89.9 g, light yellow color and oval shape. The average starch content is 12% and the dry matter content is 18.3%.

Electrical conductivity meter

Electrical conductivity and pH were measured by the same measuring device.The device is MARTINI brand and MI806 model.Electrical conductivity and pH measurement range are 0-20 mS/cm and 0-14 respectively.The sensitivity of the device is ±2%.

Heat conductivity measuring device

Thermal conductivity was measured with the DECACON brand and KD2 Model thermal conductivity device.The device measures thermal conductivity with a sensitivity of 1%, in the range of 0.02 to 4.00 W/mK.

Starch content measuring

Hitachi U2000 UV/Vis brand, 121-002 Model spectrophotometer was used to determine the total sugar content in the product.The starch content was accepted as 94% of the total sugar content [6].

Determination of moisture content

The potato samples were stored in the drying oven until they reached constant weight and their moisture content was determined by the following equation [7];

$$MC = \frac{M_0 - M_f}{M_0} x100$$

Where, M_0 and M_f are initial and final moisture content of samples, respectively.

Harvested potatoes were kept in room conditions and 8 measurements were made in 3 replicates at intervals of 15 days from the first day.Relationships between parameters measured after measurements were investigated.

The relationships between the measured values and the electrical conductivity and thermal conductivity were determined using the SPSS (Ver.18) package program.With these two parameters, the relation between pH, sugar and humidity ratio was tried to be explained with the most suitable models.

III. RESULT OF IMAGE PROCESSING

The values obtained in measurements made in a total of 105 days in 15 day intervals are given in **Figure 1, Figure 2 and Figure 3.**The thermal conductivity and moisture content decreased by 34% and 6% compared to the initial value, respectively. Electrical conductivity, pH and starch content increased by 34%, 11% and 18% compared to the initial value, respectively.Previous studies have also shown that the starch content and pH of the potato increases during storage [8, 9].

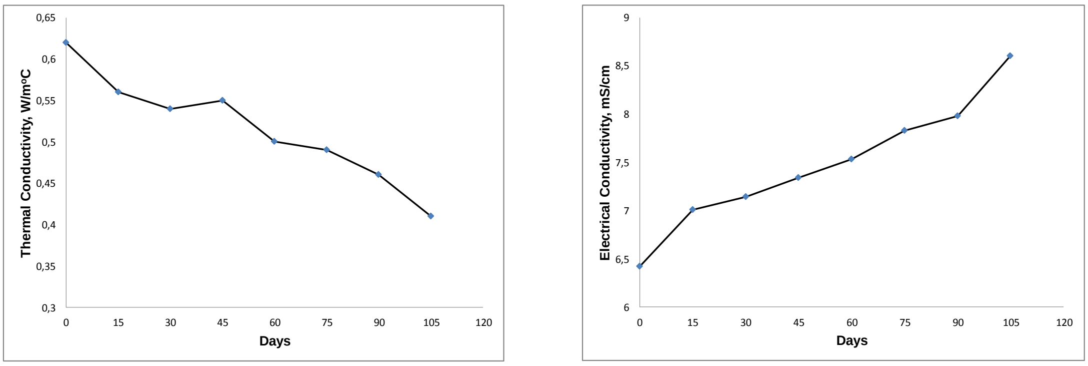

Figure 1.Changes in thermal and electrical conductivity during storage

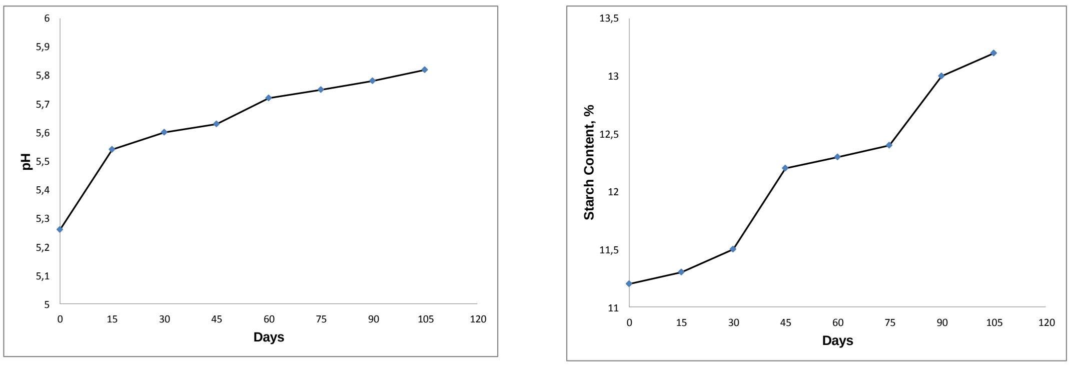

Figure 2.Changes in pH and starch content during storage

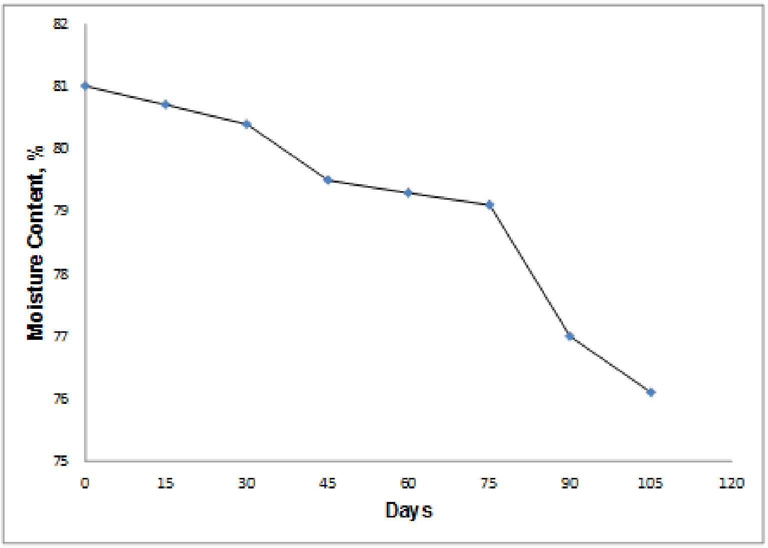

Figure 3.Changes in moisture content during storage

3.1.*Relationship between Thermal conductivity and pH*

The highest regression coefficient between thermal conductivity and pH was found in the Quadratic Model (R^2=0.962). The pH increased as the thermal conductivity decreased**Figure 4.**The relationship between these two parameters was statistically significant (F=63.2; P<0.05).

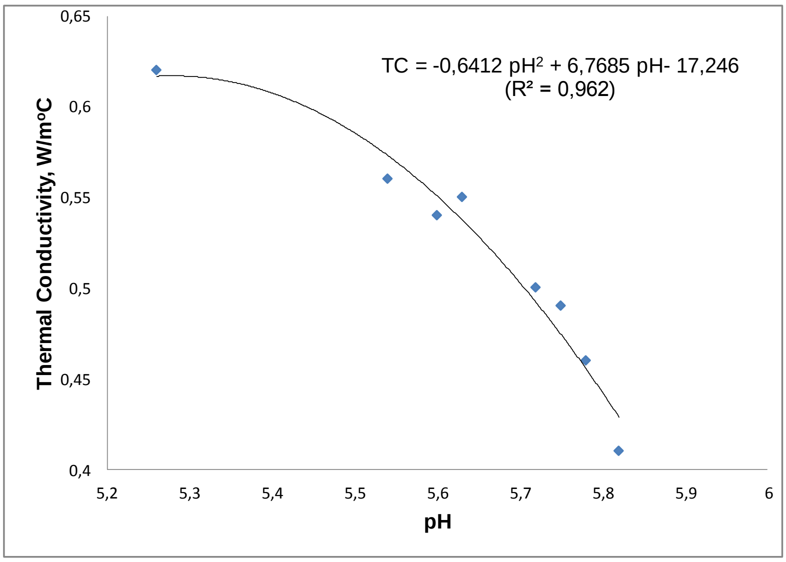

Figure 4. Relationship between Thermal Conductivity and pH

3.2. *Relationship between Thermal conductivity and Starch Content*

The highest regression coefficient between thermal conductivity and starch content was found in the Quadratic Model (R^2=0.864). The starch contentdecreased as the thermal conductivity also decreased **Figure 5.** The relationship between these two parameters was statistically significant (F=15.92; P<0.05).While for some materials (i.e. starch, sucrose, ovalbumin) the predicted values ofthermal conductivity closely matched that of experimentalvalues[10].

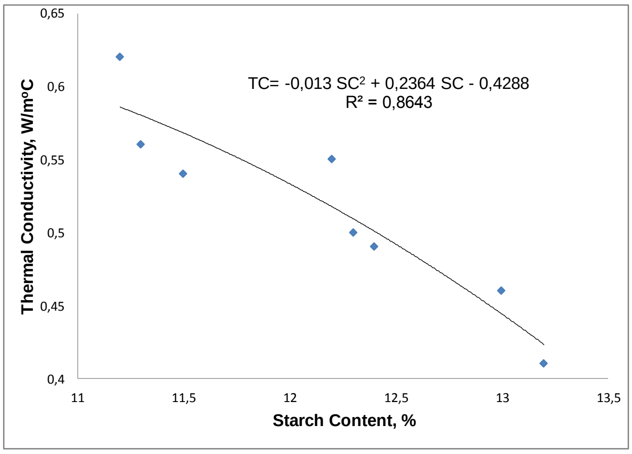

Figure 5. Relationship between Thermal Conductivity and Starch Content

3.3. *Relationship between thermal conductivity and moisture content*

The highest regression coefficient between thermal conductivity and moisture content was found in the Exponential Model (R^2=0.894). The moisture contentdecreased as the thermalconductivity also decreased **Figure 6.**The relationship between these two parameters was statistically significant (F=50.53; P<0.05).Wang and Brennan [3]were determined thermal conductivity of potato at various moisture contents in the temperature range of 40–70°C, using the heated probe method. They also said that as the moisture content of potato decreases, the thermal conductivity decreases. But, Thermal conductivity data were correlated with moisture content by a semi-logarithmic equation by them. They said that temperature have little effect on the thermal conductivity of potato.Kocabıyıket al.[11],found a similar relationship between heat conductivity and moisture content in their work with rape.Kayişoğluet al. [12] reported that there is a significant relationship between the thermal conductivity and the moisture content.Several authors have studied the thermal conductivity of food materials during thermal dehydration processes; a decrease in thermal conductivity with process time and temperature was observed, which in most cases, was related to moisture loss [13, 4, 10, 14].

Wang and Brennan [3] reported that to measure the thermal conductivity of potato, a line-source probe system was developed. The thermal conductivity of potato was determined at various moisture contents in the temperature range of 40–70°C, using the heated probe method. The thermal conductivity of potato decreased with the decrease in moisture content. Temperature had little effect on the thermal conductivity. Thermal conductivity data were correlated with moisture content by a semi-logarithmic equation.

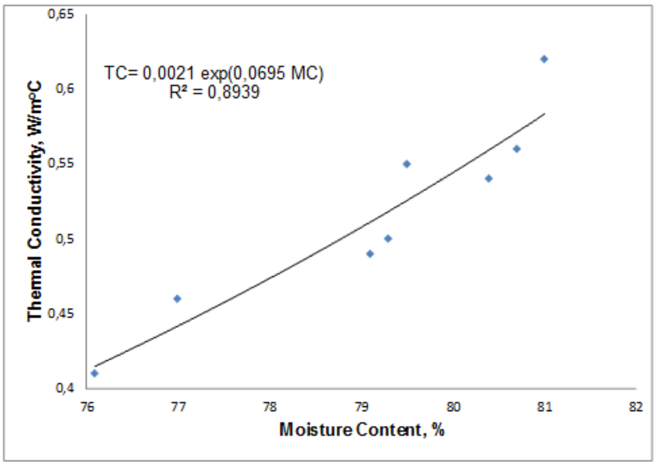

Figure 6. Relationship between Thermal Conductivity and Moisture Content

3.4. *Relationship between electrical conductivity and pH*

The model of the relationship between electrical conductivity and pH is given in **Figure 7.**Quatratic Model has been found to be the strongest correlation, as can be understood from the graph(R^2=0.958).There is a statistically significant relationship between these two parameters (F=56.80; P<0.05). As the pH value of the potato increased, the electrical conductivity value also increased.

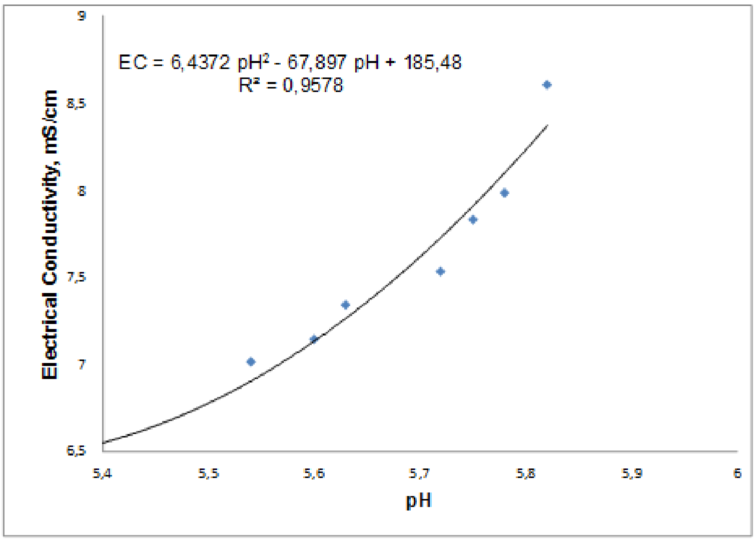

Figure 7. Relationship between Electrical Conductivity and Ph

3.5. ***Relationship between electrical conductivity and starch content***

The highest regression coefficient between electrical conductivity and starch content was found in the Quadratic Model (R^2=0.896). The relationship between electrical conductivity and starch contentwas statistically significant (F=21.53; P<0.05).As the starch content increases, the electrical conductivity value also increases **Figure 8**.

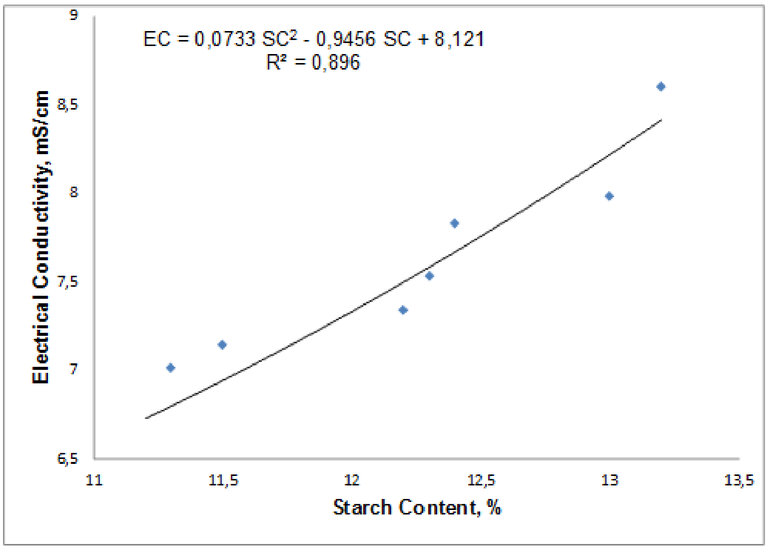

Figure 8. Relationship between Electrical Conductivity and Starch Content

3.6. ***Relationship between electrical conductivity and moisture content***

The best model between electrical conductivity and humidity wasthe Quadratic Model (R^2=0.910).It has been found that there is an inverse relationship between moisture content and electrical conductivity which is statistically significant (F=45.35; P<0.05). The graph of this relationship is shown in **Figure 9.**Pongviratchai and Park [15] also reported that EC is highly dependent on moisture content.

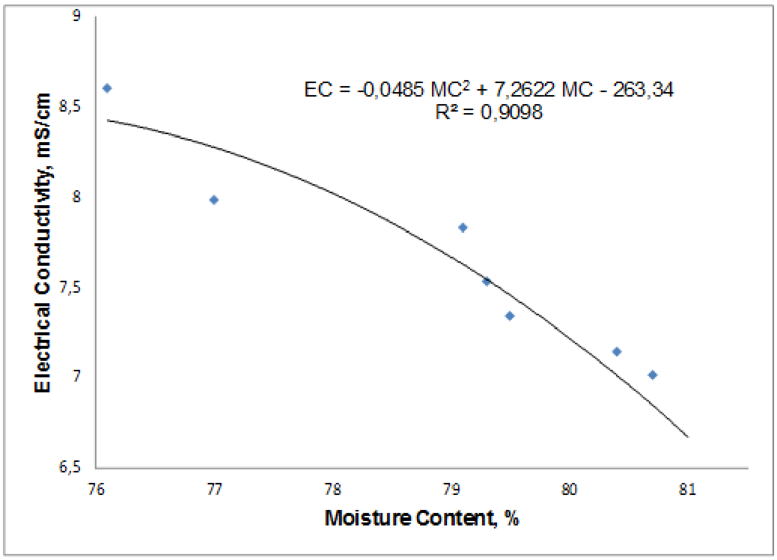

Figure 9. Relationship between Electrical Conductivity and Moisture Content

IV. CONCLUSION

In this study, the thermal and electrical conductivity value was measured during the storage of the potatoes under room conditions and the relation with some properties of it was investigated.Selected models of the relationships are summarized in Table 1.

Table 1. Relations between thermal, electrical conductivity and measured parameters

Parameters	Equation	Model	R^2	Std. Error
THERMAL CONDUCTIVITY				
pH	$TC = -0,6412pH^2 + 6,7685pH - 17,246$	Quadratic	0,962	0,015
Starch Content	$TC = -0,013\ SC^2 + 0,2364\ SC - 0,4288$	Quadratic	0,864	0,028
Moisture Content	$TC = 0,0021\ e^{0,0695\ MC}$	Exponential	0,894	0,045
ELECTRICAL CONDUCTIVITY				
pH	$EC = 6,4372pH^2 - 67,897pH + 185,48$	Quadratic	0,958	0,162
Starch Content	$EC = 0,0733\ SC^2 - 0,9456\ SC + 8,121$	Quadratic	0,896	0,254
Moisture Content	$EC = -0,0485\ MC^2 + 7,262\ MC - 263,34$	Quadratic	0,910	0,246

All models were found to be statistically significant.For this reason, it is possible to reliably estimate the pH, starch and moisture content by measuring the thermaland electrical conductivity during the storage of the potatounder the room condition.

References

[1]. Stela L.R.M, Filho C.R.B, Silva Z.E. (2005). Transient conduction in spherical fruits: method to estimate the thermal conductivity and volumetric thermal capacity, Journal of Food Engineering, Volume 67, Issue 3: 261-266
[2]. Rahman, M.S. (1992). Thermal conductivity of four food materials as a single function of porosity and water content, Journal of Food Engineering, Volume 15, Issue 4: 261-268
[3]. Wang, N., Brennan, J.G. (1992). Thermal conductivity of potato as a function of moisture content, Journal of Food Engineering, Volume 17, Issue 2: 153-160
[4]. Donsi, G., Ferrari, G., Nigro, R. (1996). Experimental determination of thermal conductivity of apple and potato at different moisture contents, Journal of Food Engineering 30, 263–268.
[5]. Jha, S.N., Matsuoka, T.(2004).Changes in Electrical Resistance of EggplantwithGloss, Weightand Storage Period, BiosystemsEngineering, Volume 87, Issue 1: 119-123
[6]. Lees, R. 1968. Laboratory Handbook of Methods of Food Analysis.
[7]. Yağcıoğlu, A. (1999). TarımÜrünleriKurutmaTekniği. EgeÜniv. ZiraatFakültesiYayınları No:536, İzmir.
[8]. Kara, K.(2000).DepolamaSürelerininBazıPatatesÇeşitlerineAitFarklıBüyüklüktekiYumrularınKaliteÖzellikleriÜzerineEtkileri. Turkısh Journal of Agrıculture and Forestry24 ,561-569
[9]. Şen L, Batu A. (2007). Patetesinmodifiyeatmosferdepaketlenerekdepolanması, GıdaTeknolojileriElektronikDergisi. 1, 7-15.
[10]. Sablani, S.S. Rahman, M.S. (2003).Using neural Networks to predict thermal conductivity of food as a function of moisture content, temperature and apparent porosity. Food Research International 36 , 617–623
[11]. Kocabıyık, H., Tezer, D. (2007). Kolzanınısısalözelliklerininbelirlenmesi, Journal of Tekirdağ Agricultural Faculty, 4(1): 65-70
[12]. Kayisoglu, B., Kocabıyık, H., Akdemir, B.(2004). TheEffect of Moisture Content on ThermalConductivities of SomeCerealGrains, Journal of CerealScience, V 39: 147-150.
[13]. Rice, P., Selman, J.D., Abdul-Rezzak, R.K. (1988). Effect of temperature on thermal properties of 'Record' potatoes. International Journal of Food Science and Technology 23, 281–286.

[14]. Muramatsu, Y.,Tagawa, A., Sakaguchi, E., Kasai, T.(2007). Prediction of thermalconductivity of kernelsand a packedbed of brownrice. Journal of FoodEngineering 80, 241–248.

[15]. Pongviratchai, P. Park, J. (2007).Electricalconductivityandphysicalproperties of surimi–PotatostarchunderohmicheatingJ. FoodSci., 72 (9) , 503–507

Serap Kayisoglu The Relationship Between Thermal And Electrical Conductivity And Some Physical And Chemical Properties Of Potato During Storage." American Journal of Engineering Research (AJER), vol. 6, no. 12, 2017, pp. 01-07.