Kastamonu Uni., Orman Fakültesi Dergisi, 2022, 22(1): 24-32 Research Article
Kastamonu Univ., Journal of Forestry Faculty
Doi:10.17475/kastorman.1095719

Effects of Genotypes and Drying Temperatures on Color and Thin Layer Drying Models of Cherry Laurel *(Laurocerasus officinalis* L.) Fruits

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Received Date: 07.06.2021 Accepted Date: 01.12.2021

Abstract

Aim of study: As in agricultural products, the effect of drying air temperature on the quality and drying properties of black nut fruit is important. In the literature, it is seen that the temperature value of 55 ºC is used for drying the black nut fruit. For this reason, the aim of the study is to investigate the effect of upper and lower temperature values on the drying of black nut, based on the core temperature value of 55 ºC.

Material and methods: In this study, black nut fruits with 54K01 and 55K07 genotypes were dried at 50, 55 and 60 ºC temperatures up to 10-15% humidity range. The most suitable temperature was determined in terms of color and drying models of the product.

Main results: The longest and shortest drying times of the 54K01 genotype black nut fruit were determined as 34.5 and 21.5 hours, respectively. For 55K07 genotype fruit, these values were found as 22.5 and 12 hours, respectively. The drying rates of the products under drying temperatures were processed in Modified Page, Wang Singh, Jena Das and Lewis thin-layer drying equations. With the increase in temperature, the drying time of both genotypes decreased significantly. In case the drying temperatures increased from 50 to 60 ºC, the drying time decreased by 37.68% for the 54K01 genotype and by 46.67% for the 55K07 genotype.

Highlights: Among the models, the Wang Sing model best predicted drying data for both the 54K01 and 55K07 genotypes. The measured and calculated color values of the dried samples were compared with the fresh ones and it was determined that drying at 50 and 60 ºC drying temperatures would be more appropriate for the 54K01 and 55K07 genotypes, respectively.

Keywords: Cherry Laurel Fruit, Drying Duration, Thin Layer Drying Model, Quality

Karayemiş Meyvesinin (*Laurocerasus officinalis* L.) İnce Tabaka Kuruma Modelleri ve Renk Değerlerine Genotip ve Kurutma Sıcaklıklarının Etkisi

Öz

Çalışmanın amacı: Tarımsal ürünlerde olduğu gibi karayemiş meyvesinin kalite ve kuruma özelliklerine kurutma havası sıcaklığının etkisi önemlidir. Literatürde 55 ºC sıcaklık değerinin karayemiş meyvesinin kurutulması için kullanıldığı görülmektedir. Bu sebeple çalışmanın amacı merkez sıcaklık değeri 55 ºC baz alınarak üst ve alt sıcaklık değerlerinin karayemişin kurumasına olan etkisini araştırmaktır.

Materyal ve yöntem: Bu çalışmada, 54K01 ve 55K07 genotipli karayemiş meyveleri 50, 55 ve 60 ºC sıcaklıklarda % 10-15 nem aralığına kadar kurutulmuştur. Ürünün renk ve kuruma modelleri açısından en uygun sıcaklık belirlenmiştir.

Temel sonuçlar: 54K01 genotipli karayemiş meyvesine ait en uzun ve en kısa kuruma süreleri sırasıyla 34.5 ve 21.5 saat olarak tespit edilmiştir. 55K07 genotipli meyve için ise bu değerler sırasıyla 22.5 ve 12 saat olarak bulunmuştur. Ürünlerin kurutma sıcaklıkları altında sergilemiş oldukları kuruma oranları Modified Page, Wang Singh, Jena Das ve Lewis ince tabakalı kuruma eşitliklerinde işlenmiştir. Sıcaklık değerinin artmasıyla her iki genotipin kuruma süresi önemli seviyede azaltmıştır. Kurutma sıcaklıklarının 50'den 60 ºC'ye yükselmesi durumunda kuruma süresi 54K01 genotipi için % 37.68 ve 55K07 genotipi için % 46.67 oranında azalmıştır.

Araştırma vurguları: Modeller arasında 54K01 ve 55K07 genotiplerinin her ikisi içinde en iyi Wang Sing modeli kuruma verilerini en iyi tahmin etmiştir. Kurutulan örneklere ait ölçülen ve hesaplanan renk değerleri tazelerine göre kıyaslanmış ve 54K01 ile 55K07 genotipleri için sırasıyla 50 ve 60 ºC kurutma sıcaklıklarında kurutulmalarının daha uygun olacağı tespit edilmiştir.

Anahtar Kelimeler: Karayemiş Meyvesi, Kuruma Süresi, İnce Tabaka Kuruma Modeli, Kalite

Citation (Atıf): Altuntas, E., Tasova, M., Polatcı, H., & Saracoglu, O. (2022). Effects of Genotypes and Drying Temperatures on Color and Thin Layer Drying Models of Cherry Laurel (*Laurocerasus officinalis* L.) Fruits. *Kastamonu University Journal of Forestry Faculty*, 22 (1), 24-32.

Introduction

Harvested agricultural materials generally have 75-95% moisture contents in wet base (w.b). Just because of such high moistures, physical and quality values could easily be lost. Cold storage or drying processes are commonly used for preservation of agricultural products without any losses in physical and quality attributes (Doymaz, 2011; Ghanbarian et al., 2019). Drying basically includes removal or reduction of moisture to a certain level and reduction of microbial activity. Drying also brings about new products with a high market value. Besides, reduced weight and volumes of dried products facilitate transport of these products (Tellez et al., 2019).

The market for dry products is rapidly growing continuously. While some resistant bacteria, especially *Salmonella*, develop in products not-passed through heat treatments (Enache et al., 2017), several microorganisms develop in products not dried under improper conditions (Chitrakar et al., 2019). Such improper drying conditions (temperature, humidity, air flow rate and etc.) negatively influence quality indicators and lead to development of microbial organisms.

Producers generally lay out the agricultural products over trays or concrete surfaces and use solar energy to remove moisture from the products (Wojdylo et al., 2014; Panagopoulou et al., 2019). Since open space drying (sun-shade) takes long time, nutrients are degraded and lost throughout such long durations (Doymaz et al., 2003; Özgen, 2014; Polatci et al., 2018). On the other hand hazardous gasses may also contaminate the products dried in open spaces (Szulmayer, 1971; Jain & Pathare, 2007). Just to eliminate such negative issues, conventional dryers in which drying conditions could be adjusted separately for each product and drying was performed in closed environments were developed. Convective oven dryers are among these dryers (Bakhshipour et al., 2012; Misha et al., 2013). Figiel (2010), indicated that drying process with these dryers took quite shorter time, conventional dryers yielded quite greater drying rates and healthier products than open-space drying processes. Gamboa-Santos et al. (2014), indicated greater energy consumption than open-space drying as the major disadvantage of conventional dryers. However, conventional dryers are still more appropriate than open-space drying as to get and serve the dry products to markets in a short time. There are several studies in literature about conventional dryers including Purlis (2019), for potato, Majdi et al. (2019), for apple, Mello et al. (2020), for orange peal, Szadzinska et al. (2019), for raspberry. However, there are limited number of studies available about drying kinetics and final color criteria of cherry laurel genotypes under different drying temperatures.

Cherry laurel *(Laurocerasus officinalis* L.) fruits are defined with different names in public and "Taflan" is the common one among the local people. Cherry laurel fruits are consumed either fresh or dried, leaves are brewed as herbal tea. Cherry laurel fruits are also used as neuroleptic, antitussive, digestive and antispasmodic. Fresh or dry fruits are also used in pastry, cakes and compotes (Anonymous, 2019).

In this study, fruits of 54K01 and 55K07 cherry laurel genotypes were dried in a conventional dryer at 50, 55 and 60 ºC temperatures and effects of drying temperatures and genotypes on color, drying models and the other drying performance criteria were investigated.

Material and Method

Drying Material and Moisture (w.b.) Measurements

Cheery laurel fruits to be used in present experiments were supplied from Ordu province in airtight and heatproof containers. Fruits were preserved in a fridge at +4±0.5 ºC at drying laboratory of Biosystems Engineering Department of Tokat Gaziosmanpaşa University until the end of the experiments. Cherry laurel fruits were used as a whole after removing the stems in moisture determination and drying processes. To get wet basis moisture content in w.b., about 30±1.5 g sample was taken, dried in an oven at 70 ºC until a constant mass and reweighed (Yagcioglu, 1999).

Drying Equipment and Process

Şimşek Laborteknik-brand ST-120 type oven was used as the drying equipment. Drying air temperature is adjusted with a PID controller over the device. Samples were dried at 50, 55 and 60 ºC temperature from dry-basis moisture content of 1.67±0.12 g (water).g^{-1} (dry matter) to an average moisture content of 0.15±0.02 g (water).g^{-1} (dry matter). About 20±1.5 g fresh fruits were used in drying processes. Drying processes were carried out in three parallels.

Theoretical Thin Layer Drying Models

Time-dependent dimensionless moisture ratio (MR) released from the products at different drying temperatures was calculated with the aid of Equation 1 (Maskan, 2000);

$$MR = \frac{M - M_e}{M_0 - M_e} \qquad (1)$$

where;
MR: Moisture ratio
M: Instant moisture content (g moisture.g dry matter^{-1})
M_e: Equilibrium moisture content (g moisture.g dry matter^{-1})
M_o: Initial moisture content (g moisture.g dry matter^{-1})

The equations provided in Table 1 were used to model moisture ratios.

Table 1. Equations for drying models

Model	Equation	Reference	No
Jena and Das	MR = h.exp(-j.(t^k))+(m.t)	Jane & Das (2007)	(2)
Lewis	MR = exp(-k.t)	Lewis (1921)	(3)
Modified Page	MR = exp(-(k.t)^h)	Wang & Singh (1978)	(4)
Wang Singh	MR = 1+k.t+h.t^2	Wang & Singh (1978)	(5)

Some models commonly used in the literature were selected. Jena Das, Lewis, Modified Page and Wang Singh equations were used to model drying data of cherry laurel fruits. Among the models used, the most suitable model was determined.

Measured Color Values

The L, a and b color values of fresh and dry materials were measured with the use of Minolta-brand CR300 model color-meter. Fifteen data were recorded for each drying process for color measurements. Of these values; L indicates color lightness and gets values of between 0-100 with 0 indicating the darkest black and 100 indicating the brightest white. The “a” indicates red – green colors and “b” indicates yellow – blue colors. The negative (-) a values indicate intense green color and positive (+) a values indicate intense red color. Zero (0) for a and b values indicates grey color (Mcguire, 1992). Some color parameters such as chroma, hue and total color difference indicating clearer information about product color calculated.

Calculated Color Values

Equations used to calculate chroma, hue and total color difference are provided in Table 2.

Of these values; Croma indicates color saturation or intensity. While pale colors have low chroma values, vivid colors have high chroma values. Hue or hue angle designates the exact position of the colors on 360º color radiant. Of boundary angle values, 0º represent red, 180º: green, 90º: yellow and 270º: blue. Total color difference indicates heat-induced and non-enzymatic changes in product color as compared to initial color.

Table 2. Calculated color parameters

Color parameter	Equation	Reference	No
Chroma, C	$C = (a^2 + b^2)^{1/2}$	Ramallo and Mascheroni (2012)	(6)
Hue, º	$h° = \tan^{-1}(\frac{b}{a})$	Alemrajabi et al. (2012)	(7)
Color difference, ΔE	$\Delta E = \sqrt{(L - L*)^2 + (a - a*)^2 + (b - b*)^2}$	Tan et al. (2001)	(8)

In Table 2, L*, a* and b* values respectively indicate color lightness, redness and yellowness of dry cherry laurel fruits.

Statistical Analysis

Statistical analyses were performed with the aid of SPSS17 software. Significant means were compared with the aid of Duncan's multiple range test.

Results and Discussion

Moisture Content (w.b.) and Drying Performance

Initial moisture contents of 54K01 and 55K07 cherry laurel genotypes were respectively measured as 60.35 and 61.75%. Final moisture contents (w.b.) at the end of drying processes at 50, 55 and 60 ºC drying temperatures are provided in Table 3.

Table 3. Final moisture contents in w.b., and drying durations

Genotypes	Drying temperature	Moisture content (w.b. %)	Drying duration (hours)
54K01	50	10.89±0.27	34.5
	55	12.76±0.33	22.5
	60	12.21±0.26	21.5
55K07	50	10.03±0.02	22.5
	55	14.69±0.53	13.5
	60	10.62±0.46	12.0

As can be seen in Table 3, genotypes and drying temperatures influenced drying performance. The longest drying duration (34.5 hours) to reach desired moisture range in w.b., (10 – 15%) was observed at 50 ºC drying temperature of 54K01 genotype, such a duration was measured as 22.5 hours in 55K07 genotype. The shortest drying durations were achieved at 60 ºC temperature. The shortest durations of 54K01 and 55K07 genotypes at 60 ºC were respectively measured as 21.5 and 12.0 hours. Present findings revealed that 54K01 cherry laurel fruits dried in a shorter time than 55K07 cherry laurel fruits.

Lewandowski et al. (2019), spray-dried maltodextrin powder and reported that drying temperatures influenced drying kinetics. Increasing of GLR (gas/liquid ratio) and initial temperature of drying air produced large and hollow particles with high porosity and low density. Powder bulk density was almost twice lower in comparison to powder density obtained in non-foamed spray drying process. Bantle et al. (2019), dried sweet potatoes at 20, 30 and 40 ºC temperatures and reported significant decreases in drying durations with increaSingh drying temperatures. The dehydration rate in the first drying period of the constant surface temperaturecontrolled methods is about 1.5 to 2.5 times faster than the conventional method where the air temperature is kept constant and the quality parameters are not significant affected. Similar findings were also reported by Yıldız et al. (2019), for crocus plants and by Taşova et al. (2019), for rose berry fruits.

Theoretical Thin Layer Drying Models

The R^2 and p values of thin layer drying models for 54K01 and 55K07 cherry laurel frits dried at different temperatures are provided in Table 4 and Table 5, respectively.

As can be inferred from Table 4 and Table 5 among the thin layer drying models, Wang Singh model the best estimated time-dependent moisture ratios of 54K01 and 55K07 cherry laurel genotypes at 50 ºC drying temperature *($p<0.05$)*. On the other hand as can be inferred from Table 4 and Table 5 Lewis model the worst estimated time-dependent moisture ratios of 54K01 and 55K07 cherry laurel genotypes at 50 ºC drying temperature *($p<0.05$)*.

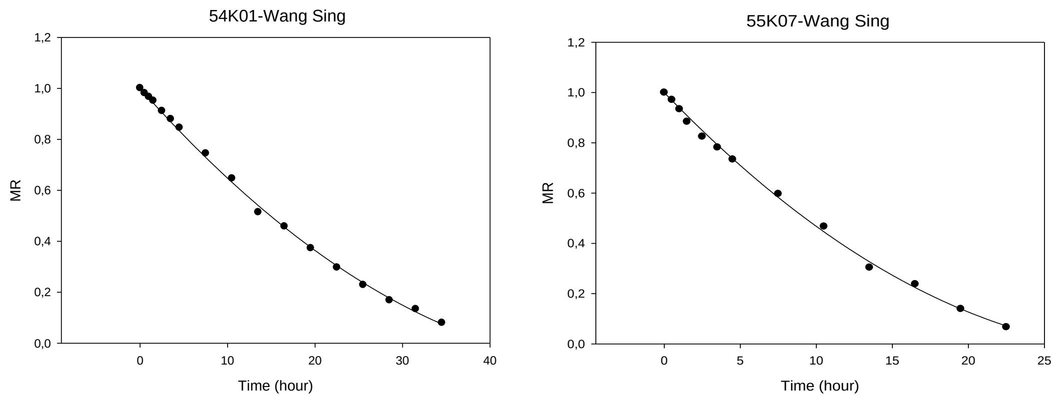
The best models for 54K01 and 55K07 cherry laurel genotypes are presented in Figure 1.

Table 4. Values of drying models for 54K01 cherry laurel fruit

Genotypes	Drying temperatures	Models	Coefficients	R^2
54K01	50 ºC	Lewis	k: -0.0969	0.7640
		Jena Das	k: 1.0236 h: 0.4313 j: 0.7529 m: 0.0187	0.9862
		Wang Singh	k: -0.0387 h: 0.0003	0.9989
	55 ºC	Lewis	k: -0.1273	0.8549
		Jena-Das	k: 1.0650 h: 0.3266 j: 0.9623 m: 0.0860	0.9251
		Wang Singh	k: -0.0658 h: 0.0011	0.9890
	60 ºC	Lewis	k: -0.1309	0.8461
		Jena-Das	k: 1.4024 h: 0.3561 j: 0.9033 m: 0,3587	0.9229
		Wang Singh	k: -0.0774 h: 0.0016	0.9981

Table 5. Values of drying models for 55K07 cherry laurel fruits

Genotypes	Drying temperatures	Models	Coefficients	R^2
55K07	50 ºC	Lewis	k: -0.1225	0.8707
		Jena-Das	k: 0.9976 h: 0.4448 j: 0.7258 m: -0.0082	0.9824
		Wang Singh	k: -0.0628 h: 0.0010	0.9980
	55 ºC	Lewis	k: -0.1665	0.9204
		Jena-Das	k: 1.0156 h: 0.4468 j: 0.7218 m: 0.0104	0.9857
		Wang Singh	k: -0.1009 h: 0.0027	0.9863
	60 ºC	Lewis	k: -0.1764	0.9370
		Jena-Das	k: 1.0083 h: 0.3173 j: 0.9810 m: 0.0272	0.9372
		Wang Singh	k: -0.1016 h: 0.0022	0.9976



a) 54K01-Wang Singh **b)** 55K07-Wang Singh

Figure 1. The best models for 54K01 and 55K07 cherry laurel genotypes. As can be inferred from Figure 1, measured (solid dots) and model estimated data (solid line) were quite close to each other.

Measured and Calculated Color Values

The L, a, b, C, hue° and total color difference values of fresh and dried fruits of 54K01 and 55K07 cherry laurel genotypes are provided in Table 6.

Table 6. Test results for color parameters

Genotypes	Temperature	L	a	b	C	Hue°	ΔE
54K01	Fresh	24.28±1.84a	15.95±4.31a	2.23±1.57a	16.14±4.49a	-42.49±4.82bc	-
	50 ºC	23.05±0.62b	2.49±0.32b	-2.29±0.18b	3.00±1.50b	-43.44±4.57c	20.10±1.68b
	55 ºC	24.64±0.78a	2.71±0.18b	-2.23±0.24b	3.10±1.52b	-39.40±3.35ab	21.89±1.61a
	60 ºC	24.32±0.62a	2.72±0.27b	-2.19±0.15b	3.09±1.51b	-38.96±4.45a	21.57±1.75a
55K07	Fresh	18.17±1.53d	6.06±2.31a	-1.13±0.49a	6.22±2.19a	-13.09±8.27a	13.90±1.51d
	50 ºC	25.56±1.31a	3.03±0.94b	-1.58±0.40b	3.05±1.75b	-27.89±8.71c	22.82±2.31a
	55 ºC	21.44±2.41c	3.44±0.64b	-1.16±0.27b	3.42±1.68b	-25.25±6.95bc	18.50±3.56c
	60 ºC	23.90±1.15b	3.23±0.30b	-1.24±0.23a	3.09±1.48b	-21.20±4.88b	21.16±1.92b

As can be inferred from Table 6, the closest to fresh L values of 54K01 cherry laurel fruits were achieved at 55 and 60 ºC drying temperatures *($p<0.05$)*. For a and b values, it was observed that fruits were not able to preserve fresh values at all temperatures. With regard to hue and total color difference, the best drying temperature of 54K01 genotype *($p<0.05$)* was identified as 50 ºC. Present L and a value of 55K07 cherry laurel fruits revealed that samples were not able to preserve fresh values at all drying temperatures *($p<0.05$)*, but the closest b values to fresh values were observed at 60 ºC temperature *($p<0.05$)*. With regard to chroma, hue and total color difference of 55K07 genotype, samples were not able to preserve fresh values *($p<0.05$)*. It was determined based on entire color findings that the the closest to fresh drying temperature was 50ºC for 54K01 cherry laurel fruits and 60ºC for 55K07 cherry laurel fruits.

Celik et al. (2019), reported significant effects of different drying methods on L, a, b and C color values of cherry laurel fruits *($p<0.05$)*. Although relatively low temperature (55 °C) was applied in vacuum-drying and fan oven drying, LO cherry laurel had significantly higher brightness (L*) and redness (a*) values ($p < 0.05$). The LO cherry laurel had the highest L* (49.84), a* (11.72), and b* (17.48) values while FO cherry laurel had the lowest (L*:39.88, a*:8.71, b*: 12.09). Similar findings were also reported by Gümüsay & Yalcin (2019), Demirkol & Tarakci (2018), Talih & Dirim (2018), Kasim et al. (2011).

Conclusion

The most suitable drying temperatures were determined in terms of drying and color values of 54K01 and 55K07 genotypes belonging to the originality of this study. It was concluded based on present findings that drying air temperatures and genotypes had significant effects on drying performance, thin layer drying models and color parameters of cherry laurel fruits *(p<0.05)*. Significant decreases were observed in drying durations with increasing drying temperatures. Genotypes also generated about 10 hours difference in drying durations. The shortest durations of 54K01 and 55K07 genotypes at 60 ºC were respectively measured as 21.5 and 12.0 hours. Wang Singh model the best estimated moisture ratios at 50 ºC drying temperature. Genotypes and drying temperatures had significant effects on color parameters of cherry laurel fruits *(p<0.05)*. For a and b values, it was observed that fruits were not able to preserve fresh values at all temperatures. It was concluded based on entire color findings that the closest to fresh drying temperature was 50ºC for 54K01 cherry laurel fruits and 60ºC for 55K07 cherry laurel fruits *(p<0.05)*.

Ethics Committee Approval

Due to the scope of the study, there was no need for an ethics committee permission document.

Peer-review

Externally peer-reviewed.

Author Contributions

E.A.; Material supply and determination of the method. M.T.; Conducting laboratory experiments and writing the article. H.P.; Controlling articles and data. O.S.; Assisting in supplying the material and checking the article.

Conflict of Interest

The authors have no conflicts of interest to declare.

Funding

The authors declared that this study has received no financial support.

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