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Changes in Some Quality Properties after Different Storage Periods of Potato Tubers Grown under Well and Deficit Irrigation Conditions

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Abstract

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In present study, the effect of different storage periods (1, 2, 3 and 4 months) on some quality parameters of potato tubers grown under well and deficit irrigation conditions was examined. Irrigation water levels were selected as 100% (well-irrigated), 80%, 60%, 40%, 20% and 0% (non-irrigated) of usable soil water, respectively. Potato tubers stored under dark including air temperature and relative humidity control units. Increasing water deficit levels significantly increased the specific gravity, dry matter and starch ratio of potato tubers. However, weight loss of potato tubers significantly reduced with water deficit levels. The effects of storage periods on all searched parameters were found significant. Increasing storage period increased the water loss, specific gravity, dry matter, starch ratio and pH, while decreased the vitamin C. Significant increases in water loss increasing storage periods were observed for potato tubers under grown well irrigation conditions according to deficit irrigation conditions. After four month storage periods the weight losses were between 6.87% and 9.29% for non-irrigated and well irrigated conditions, respectively.
Key words: Potato, deficit irrigation, storage, weight loss, specific gravity, vitamin C, pH

Introduction

Potato is an important food for mankind throughout the world and it has become major field crops in Turkey as well. According to recent FAO statistics, Turkey has 200000 ha potato production area (FAO, 2004). Almost 4.8 million tone of potato is produced by the country and the storage and marketing become an important issue.

The main subject of potato storage is to maintain both the quality and quantity of marketable tubers throughout the stor-

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age periods in order to maximize economic benefits. During the storage period, some physical and chemical changes in tubers occur depending on cultivar, storage conditions, and also cultivation techniques applied before harvest (Dede et al., 1999).

Storage period has an important effect on weight loss of tubers (Kara, 1996; 2000) which is inevitable during the storage period, since the tubers use water in respiration (Esendal, 1990).

The specific gravity of potato tubers is an important quality criterion in potato processing. Specific gravity varies from 1.055 to 1.095 in potato cultivars (Toolangi, 1995). Along with cultivars, excess or insufficient soil moisture can reduce specific gravity (Hegney, 2001). Storage period has also significant effect on specific gravity. In general, an increase in specific gravity, which is used as an estimation parameter of the solids or dry matter content of tubers (Hegney, 2001; Tawfik et al., 2002; Shetty, 2005), during storage period was determined in previous studies (Kara, 2000; Sengul, 2002; Sengul and Keles, 2005a; 2005b). The tuber dry matter is influenced by a wide range of factors for example environmental, different growing seasons, soil moisture and cultural treatments (van Es and Hartmans, 1987). In previous studies, it was showed that excessive water use resulted in dry matter decrease in tubers (Toolangi, 1995; Bosnjak et al., 2004), and storage also caused relative increases in dry matter content because of water loss from tuber (Sengul, 2002; Sengul and Keles, 2005a; 2005b).

Starch content in potato tubers was almost 3/4 of dry matter (Sengul, 2002), and there is a high positive correlation between specific gravity and starch content (Kumlay et al., 2002; Tawfik et al., 2002; Anon., 2005). Storage and irrigation have diverse effects on starch ratio of the tubers while storage results in an increase (Kara, 2000; Sengul and Keles, 2005a), irrigation causes a decrease in starch ratio (Bosnjak et al., 2004).

Vitamin C content, on the other hand, affected by cultivars used, ecological conditions, cultivation and storage period (Sengul, 2002) and an important vitamin C decrease from 30 to 8 mg/100 g over 8-9 months of storage periods were determined (FAO and WHO, 2002).

Potato is within lower acidity food class. pH increases during storage period due to a decrease in acid because of physiological activity (Cemeroglu and Acar, 1986) and it was reported that irrigation did not effect on pH (Bosnjak et al., 2004).

In this study, it is aimed to determine the effects on some quality properties of different storage period on potato tubers were grown under the well and deficit irrigation conditions.

Material and Methods

The field study was conducted during the growing season of 2004 year, between May and October at the Agricultural Research Station of Ataturk University in Erzurum-Turkey. The coordinate of the experimental area are latitude 39°55' N and longitude 41°16' E, with an elevation 1835 m a.s.l. Plots consisted of raised beds, 5 m long and 3 m wide. A 3 m space was left between the plots in order to prevent water interactions among the treatments.

Texture, pH, electrical conductivity, carbonates and organic matter contents of the soils of the plots were determined to be loamy, 7.25, 566.67 dS/m, 2.12% and 1.07% respectively. cv. Granola was

used as experimental plant material in such study due to its high yield and resist to disease which is previously reported (Kara, 1996). Tubers were planted on 25 May 2004 with a planting density of 70x35 cm between and within rows. All treatments received same amount of P_2O_5 (100 kg/ha), K_2O (50 kg/ha) and N (150 kg/ha) fertilizer during the soil preparation stage before sowing. 150 kg/ha N was also applied to all plots in hilling stage. Hoeing and weed control were performed manually and repeated when required during growing season. No pesticide was applied. Potato tubers were harvested on 5 October 2004.

Irrigation water levels I_1, I_2, I_3, I_4, I5 and I6 were selected to be 100 % of usable soil water in well irrigation treatment and 80%, 60%, 40%, 20% and 0% of usable soil water in deficit irrigation treatments respectively. Plots were irrigated when the available soil moisture was decreased to the level of 30 percent in well irrigated treatment. Effective root depth was accepted to be 60 cm (Kanber, 1999; FAO, 2002). Irrigation water was good quality with electrical conductivity 0.27 dS/m, sodium adsorption ratio 0.41, and pH 7.8.

Harvested potato tubers were kept for three weeks in dim environment with 8 - 10 °C of average temperature and 50 - 60% of relative humidity before storage. Average sizes of healthy potato tubers were selected and put in to the sacks according to treatments. Sacks were divided two groups. 1st groups including approximately 6 kg tubers were used for weight loss determination and 2nd 6 kg for used some analysis. Tuber sacks were placed in storage room where air temperature and relative humidity could be kept at the desired range. Storage air temperature and relative humidity was measured during storage period by a thermo-hygrograph and are given in Figure 1 for each 5 days. Average air temperature and relative humidity were 3.8 °C and 61.8% respectively.

The storage periods T_1, T_2, T_3 and T_4 were selected to be 1 month, 2 months, 3 months and 4 months respectively. The starting values (T_0) were taken as control data. Weight loss, specific gravity, dry matter, starch content, vitamin C and pH values were determined at the end of each period. Weight loss of tubers was determined comparison of weight at the beginning and at the end of each period. Specific gravity, on the other hand, was determined by weight in air/ weight in water method (Shetty, 2005). Dry matter and starch ratio were determined by the high correlation between specific gravity-dry matter and specific gravity-starch ratio (Esendal, 1990), while vitamin C and pH were determined by titration method and pH meter respectively (Cemeroglu, 1992).

Complete randomized block design with three replications was employed in the study (Yildiz et al., 2002). Statistical analyses were made with MINITAB statistical package (release 11.12, 1996; Minitab Inc.). General Linear Model ANOVA was used. Significant means were compared with Duncan multiple range test method by using MSTAT-C package software (MSTAT-C, 1988).

Table 1
Changes in some quality parameters of potato tubers by storage periods and irrigation levels

Treatments		Parameters					
		Weight loss, %	Specific gravity	Dry matter, %	Starch, %	Vitamin C, mg/100 g	pH
Irrigation levels	I_1	4.018a	1.069b	17.593bc	12.047bc	9.373	5.956
	I_2	3.664b	1.069b	17.360c	11.767c	9.661	5.999
	I_3	3.355c	1.075ab	18.553abc	13.087ab	9.749	6.021
	I_4	3.299c	1.077a	19.240a	13.633a	9.925	5.976
	I_5	3.319c	1.078a	19.147a	13.520a	10.363	6.005
	I_6	3.094d	1.075ab	18.700ab	13.093ab	10.54	6.017
	Sig Lev*	P<0.01	P<0.05	P<0.05	P<0.05	NS	NS
	St Dev&	0.042	0.002	0.435	0.427	0.971	0.018
Storage periods	S_0	0.0e	1.050e	13.583d	8.244d	12.222a	5.842d
	S_1	1.463d	1.058d	15.006d	9.611d	10.267ab	5.956c
	S_2	3.033c	1.078c	19.194c	13.506c	9.733ab	6.037b
	S_3	4.966b	1.087b	21.283b	15.500b	9.568ab	6.009bc
	S_4	7.828a	1.096a	23.094a	17.428a	7.885b	6.134a
	Sig Lev	P<0.01	P<0.01	P<0.01	P<0.01	P<0.05	P<0.01
	St Dev	0.039	0.002	0.397	0.39	0.886	0.017

* SigLev: Significant Level

& StDev: Standard Deviation

Results and Discussion

Weight loss

The decreasing of water deficit and increasing storage period significantly increased (P<0.01) weight loss from tubers (Table 1). While the weight loss in well irrigated treatment (I_1) was 4.02%, it was 3.09% in non-irrigated treatment (I_6). 1.46% and 7.43% of weight losses at the end of the first and the four months of storage respectively suggested that an increase in storage period resulted in increased weight loss. Significant weight losses from tubers in cv. Granola potato variety at the end of a five or six month of storage is expected (Kara, 1996; 2000). Especially, it was observed that there was much more increase in the treatment of S_4. An increase in temperature and a decrease in relative humidity of the storage atmosphere at the end of storage period were affected by these changes (Figure 1).

As longer as the storage period, weight loss increases differed significantly depending on irrigation level. Moreover, weight loss from tubers from well-irrigated treatment (I_1) reached to the highest

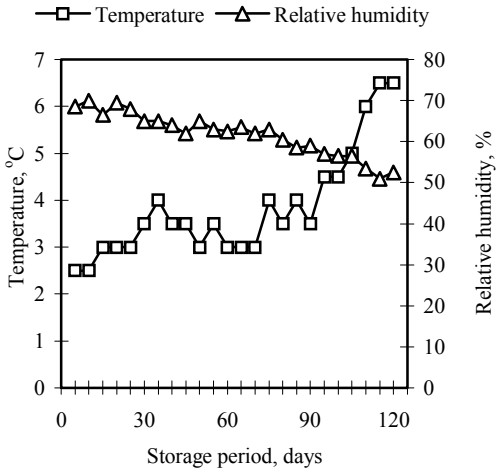

Fig. 1. Changes of air temperature and relative humidity in storage room

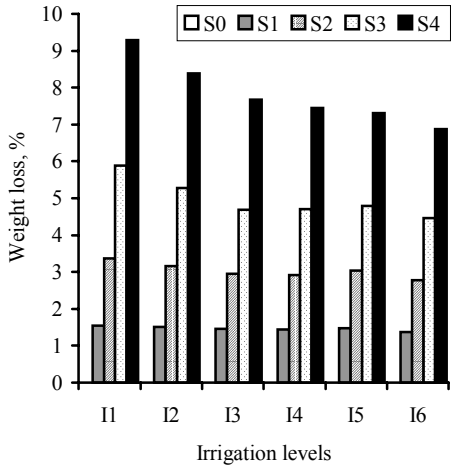

Fig. 2. Weight losses in different storage periods by irrigation levels ($LSD_{0.01}$=0.357; StDev=0.095)

level (Figure 2). Seasonal evapotranspiration of I_1, I_2, I_3, I_4 I_5, and I_6 treatments were determined to be 415.1mm, 361.4mm, 313.0mm, 262.1, 216.2 mm and 167.7 mm respectively. This suggests that the higher levels of irrigation is applied the more weight loss from the tubers during the storage period happens. This also suggests that higher water content means increased metabolic activity leading to an intensive respiration resulting in higher water consumption (Esendal, 1990).

Specific gravity

Specific gravity increased significantly ($P<0.05$) by water deficit. It was determined to be 1.069 at the I_1 and I_2 treatments, while it was 1.078 at the I_5 treatment. While the treatments of I_1 and I_2 were in the lower class, other irrigation treatments were in the middle class regarding specific gravity (Anon., 2001). An increase in soil water content resulted in a decrease in specific gravity (Toolangi, 1995; Hegney, 2001).

The storage period increased specific gravity significantly ($P<0.01$) (Table 1). Specific gravity reached to 1.096 at the end of the four month of storage period with an increase of 4.38% while it was 1.50 at the beginning of storage. The treatments of S_3 and S_4 fall into the much well class regarding specific gravity (Anon., 2001). An increase in the storage period leads to an increase in specific gravity in cv. Granola potato variety (Kara, 2000; Sengul, 2002).

A similar change in specific gravity parallel to the increases in storage periods at all irrigation levels was observed (Figure 3). The highest specific gravity values were determined after four months storage period for all irrigation levels.

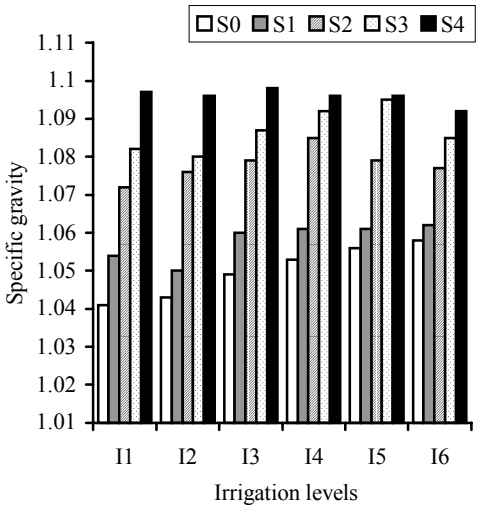

Fig. 3. Specific gravity in different storage periods by irrigation levels (StDev= 0.005)

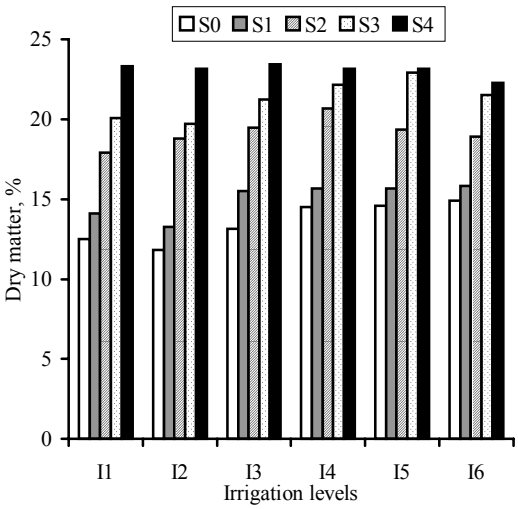

Fig. 4. Dry matter contents of the tubers in different storage periods by irrigation levels (StDev=0.973)

Dry matter

Deficit irrigation resulted in an increase in dry matter content significantly ($P<0.01$) (Table 1). The lowest dry matter (17.360%) was obtained from the I_2 treatment while the I_4 treatment yielded the highest dry matter (19.240%). I_3, I_4, I_5 and I_6 treatments placed in medium class regarding dry matter (Anon., 2001). That is to say, an increase in available water resulted in a decrease in dry matter content. Es and Hartmans (1987), Toolangi (1995) and Bosnjak et al. (2004) all reported similar findings.

The dry matter increased significantly ($P<0.01$) as storage period was longer (Table 1). Dry matter increased to 23.094 % with an increase of 70.02% at end of a four month of storage as it was 13.583 % at the beginning. The S_4 treatment fell into the class of higher dry matter content (Anon., 2001). Kara (1996, 2000) and Sengul and Keles (2005b) reported similar increases in dry matter content of potato tubers through storage. The dry matter content values showed a change dependent on the high positive correlation between the specific gravity and the dry matter content as Esendal (1990), Toolangi (1995) and Shetty (2005) reported.

It was determined similar increases in the dry matter content with an increase in the storage period for all irrigation levels (Figure 4).

Starch ratio

Starch content increased significantly ($P<0.05$) with the higher levels of deficit irrigation. The lowest (11.767%) and highest (13.633%) starch content was obtained from I_2 and I_4 treatments respectively. I_3, I_4, I_5 and I_6 treatments fall into the indus-

trial and cooking groups with regard to starch content (Anon., 2001).

Starch Ratio increased significantly ($P<0.01$) with an increase in storage period (Table 1). Starch content reached to the highest point (17.428%) at the end of a four month of storage period while it was 8.244% at the beginning. This finding, suggesting an increase in starch content parallel to an increase in storage period, is consistent with the results reported by Kara (2000) and Sengul and Keles (2005a). Considering starch content, potato tubers belonging to the cooking group at the beginning, fell into the industrial group at the end of the four months of storage period (Anon., 2001). Starch content values varied depending on the high positive correlation between specific gravity and starch ratio (Esendal, 1990; Toolangi, 1995).

Similar increases were observed in starch content with increasing storage period at all irrigation levels (Figure 5).

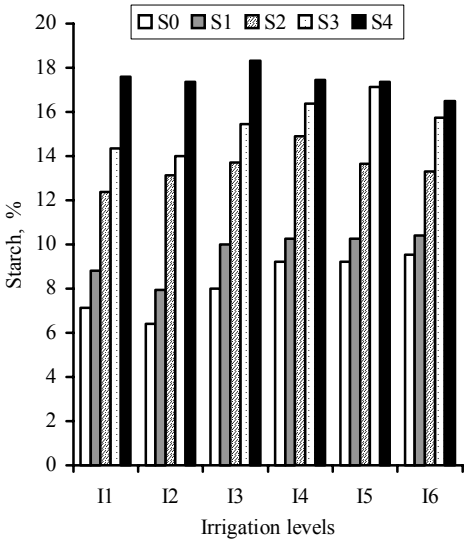

Fig. 5. Starch contents at different irrigation levels by storage period (StDev=0.956)

Vitamin C

Water restriction resulted in an increase in Vitamin C content, but this change was not significant (Table 1). Vitamin C content increased from 9.373 mg/100g in I_1 treatment (well irrigated control plots) to 10.540 mg/100g in I_6 treatment (no irrigation) as significant decreases ($P<0.05$) in Vitamin C content was recorded due to storage (Table 1). Vitamin C content of the tubers changed throughout the storage period from 12.222 mg/100g to 7.885 mg /100g with a decrease of 35.49% in a four month of storage period. This result is common and was reported by many authors (Wills et al., 1984; Wills

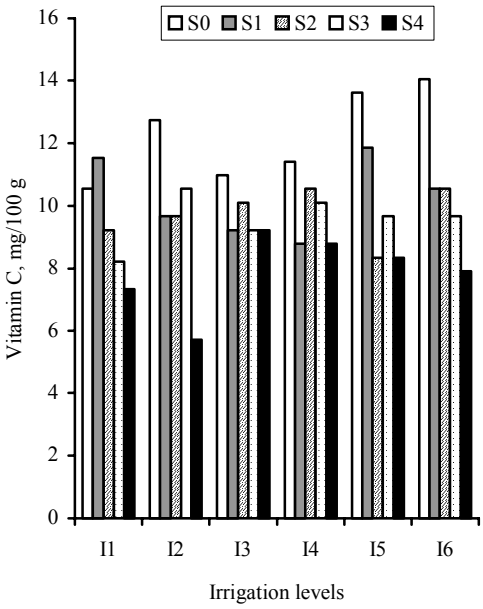

Fig. 6. Vitamin C contents at different irrigation levels by storage period (StDev=2.171)

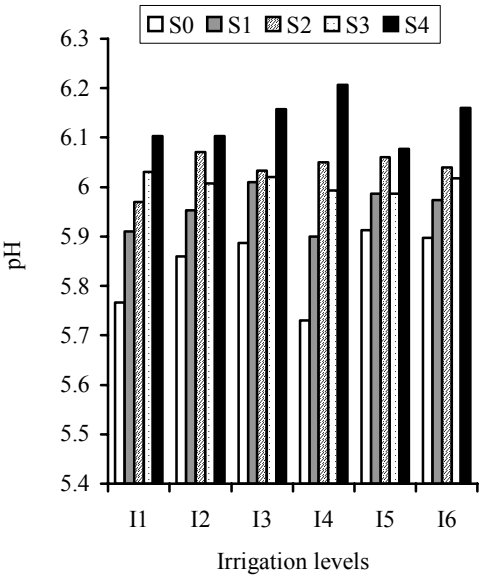

Fig. 7. pH degrees at different irrigation levels by storage period (StDev=0.040)

and Silalahi, 1990; Kaya, 1999; FAO and WHO, 2002; Sengul, 2002; Sengul and Keles, 2005a, 2005b). Similar decreases were observed as storage period got longer at all irrigation levels (Figure 6). The lowest vitamin C values were determined after four months storage period for all irrigation levels.

pH

Irrigation level caused insignificant changes in pH (Table 1). This was reported by Bosnjak et al. (2004) as well. Storage period, on the other hand, increased the pH significantly ($P<0.01$) (Table 1). While it was 5.842 at the beginning, it reached to 6.134 at the end of four months of storage period. Similar increases in pH were observed at all irrigation levels with an increase in storage period (Figure 7). This may be explained with a decrease in acidity due to physiological activity in storage (Cemeroglu and Acar, 1986). According to the pH degrees determined in the study, potato fell into the low acidity group (Sengul, 2002).

Conclusions

It can be concluded that storage weight losses from the potato tubers grown under lower deficit irrigation conditions was greater than that grown under higher deficit conditions. It can also be concluded that storage increased the dry matter and starch content as a result of an increase in specific gravity similarly at all irrigation levels. Storage also resulted in a decrease in Vitamin C but an increase in pH.

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