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

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Abstract


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 20000 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-
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 P₂O₅ (100 kg/ha), K₂O (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 I₁, I₂, I₃, I₄, 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-hygrometer 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 T₁, T₂, T₃, and T₄ were selected to be 1 month, 2 months, 3 months and 4 months respectively. The starting values (T₀) 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 (Cemergolu, 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).
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 (I₁) was 4.02%, it was 3.09% in non-irrigated treatment (I₆). 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 S₄. 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 (I₁) reached to the highest...
level (Figure 2). Seasonal evapotranspiration of I1, I2, I3, I4, I5, and I6 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 (Esental, 1990).

**Specific gravity**

Specific gravity increased significantly (P<0.05) by water deficit. It was determined to be 1.069 at the I1 and I2 treatments, while it was 1.078 at the I6 treatment. While the treatments of I1 and I2 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 S3 and S4 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.
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 I2 treatment while the I4 treatment yielded the highest dry matter (19.240%). I3, I4, I5 and I6 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 S4 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 I2 and I4 treatments respectively. I3, I4, I5 and I6 treatments fall into the industr-
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).

**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...
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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Received July, 12, 2006; accepted September, 23, 2006.