Effect of static loading on quality of potatoes during storage

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ABSTRACT

The authors examined the effect of static loading (20kgf) on the quality of potatoes during storage for three months. Static loading did not influence the weight loss, specific gravity, or sprouting, but increased both moisture and reducing sugar contents.

Key words : potato tubers, static loading, moisture, reducing sugar

INTRODUCTION

Bulk storage of potatoes is a routine practice both on farms and at food processing plants. Typically, potatoes are stacked up to 5m high and stored at 10℃ in a high humid environment[1].

Little is known about the effects of maturation and aging during storage of potatoes on the apparent quality of tubers. In contrast, much is known about apples. For example, time in cold storage has been shown to decrease the elastic modulus in apples by a factor of 2 to 3 over a period of 4 months (Hamann, 1969[2] ; Shahabasi and Segerlind, 1981[3]). For Jonathan apples, failure stress and failure strain also decreased with time in storage.

Static loading of plant vegetative tissue can result in elastic, plastic, viscoelastic deformations, as well as structural failure (McLaughlin and Pitt, 1984[4] ; Pitt, 1989[5]). Rao et al. (1974)[6] compressively loaded samples of sweet potato tissue under creep, stress relaxation, and cyclic regimes, and found that uniaxial modulus decreased as the loading time constant increased. However, there has been no research on the change in quality of potatoes under static loading. This study was conducted in order to evaluate the effects of static loading on the quality of potatoes during storage.

MATERIALS AND METHODS

Source and tuber preparation

Norin-ichigo potatoes were harvested on Sep. 28, 1992. Samples of four potatoes (approximately 150 g in size) were placed into a

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storage chamber (11℃, 90%RH).

Static loading and storage

For static loading storage tests, apparatus were constructed to maintain a constant load on the tubers ; potatoes were compressed between a fixed base and a cylindrical weight (20kgf) held within a P. V. C. (Polyvinyl chloride) pipe (Fig. 1). Static loading potatoes and no-loading potatoes (control) were stored at 13℃, 90%RH from Oct. 6, 1992 to Jan. 13, 1993 for roughly 3 months.

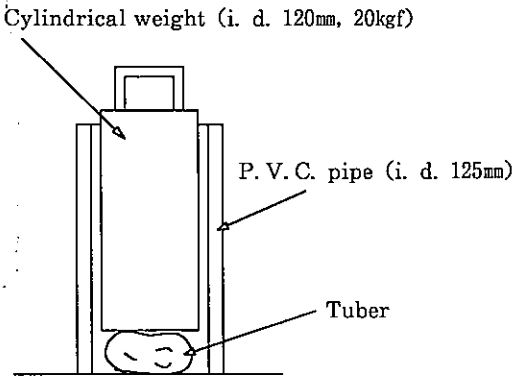

Fig.1 The apparatus used for static loading.

Potato quality evaluation

Weight loss

Two samples from both the static loading and no-loading potatoes were weighed before and after storage.

Specific gravity

Specific gravity was measured on all four tubers using the weight-in-air/weight in water method[7].

Moisture

Two potato tubers were washed, peeled and diced into approximately 5mm cubes. Moisture of the samples (10 g) was determined by predrying at 70℃ for 24 hours and drying at 70 ℃ in a vacuum oven for 2 hours[8].

Reducing sugar

To the 50 g diced tubers above, fifty ml distilled water was added, and the resulting suspension was homogenized with an Osterizer at high speed for 1.5 min, then the homogenats was centrifuged at 2,860×g for 15 min. The supernatant was used for reducing sugar determination by the Somogyi method[9].

Sprouting

The sprout number[10], sprout length (mean of the longest sprout per tuber)[11], and fresh weight of sprouts per tuber[12] were measured on 2 tubers from the 77th day of storage to the 99th day.

All measurements taken twice and results were averaged to obtain mean values. Data obtained on weight loss, specific gravity, moisture, reducing supar, and sprout number, length and weight, was then analyzed. The least-significant difference (LSD) method was used for comparison between means.

RESULTS

Figure 2 shows the weight loss of potatoes during storage. No significant difference in weight loss was found ($p>0.05$) between static loading and no−loading potatoes. In addition, static loading did not influence ($p>0.05$) specific gravity of potatoes (Fig. 3).

Figure 4 shows moisture content of potatoes during storage. Moisture content of both static loading and no-loading potatoes decreased during the first 30 days of storage, but thereafter increased. As illustrated in this figure, static loading potatoes had a higher moisture content ($p<0.01$) than control.

In Fig. 5, reducing sugar contents of both potatoes increased gradually during storage, but in both groups rapid increases occurred after sprouting (around the 77 days of storage). With respect to the effect of static loading on reducing sugar of potatoes, static loading potatoes had a greater reducing sugar content

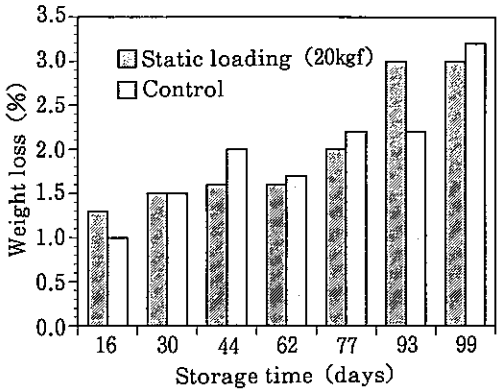

Fig.2 Weight loss of potatoes during storage at 13℃

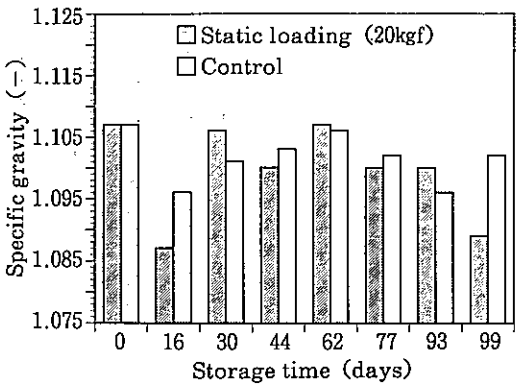

Fig.3 Specific gravity of potatoes during storage at 13℃

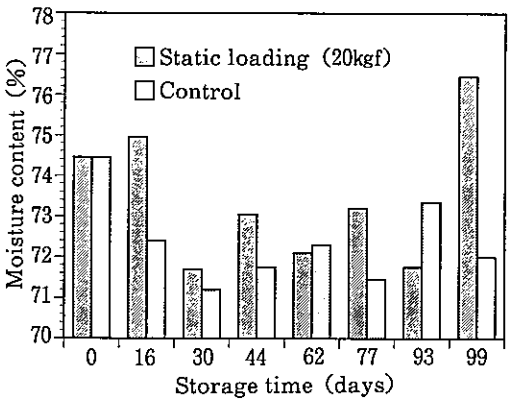

Fig.4 Moisture content of potatoes during storage at 13℃

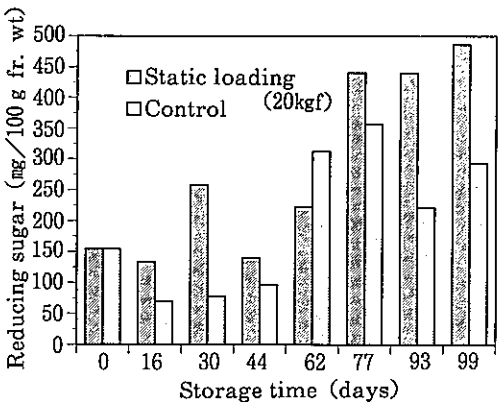

Fig.5 Reducing sugar content of potatoes during storage at 13℃

($p<0.01$) than no-loading potatoes.

With respect to sprouting, static loading did not influence ($p>0.05$) sprout number, length and weight (Figs. 6−8).

A summary of results above is presented on Table 1.

DISCUSSION

Chip color and sugars

The browning of chips (crisps) and French fries at high processing temperatures is due to a typical Mailard reaction between reducing sugars and the α-amino groups of nitrogenous compounds (Schallenberger *et al.*, 1959[13]). In practice, the quantities of amino-N are rerely limiting and the extent of browning is better correlated with the concentration of the principal reducing sugars (hexoses) glucose and fructose (Gray and Hughes, 1978[14]). The ideal reducing sugar content for processing into chips (crisps) is generally accepted to be 0.1% of tuber fresh wt with 0.33% as the upper limit. For French fries the upper limit may be as high as 0.5% (Burton and Wilson, 1970[15]).

Figure 5 shows that no-loading potatoes are suitable for chipping, and static loading

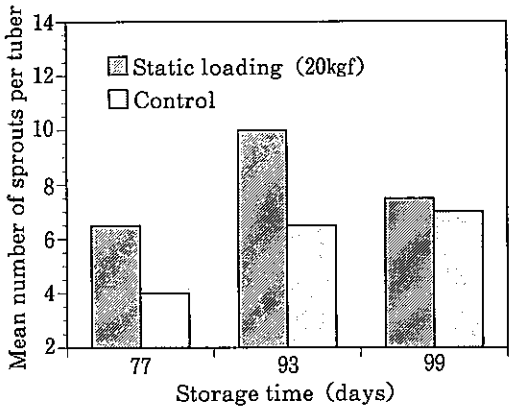

Fig.6 Number of sprouts per tuber during storage at 13℃

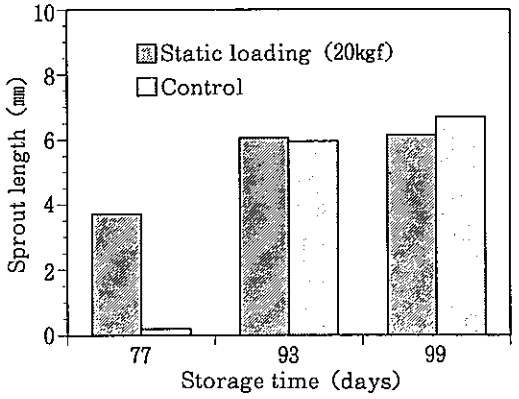

Fig.7 Length of sprouts per tuber during storage at 13℃

ones are also acceptable for French fries in this experiment.

Storey and Davies (1992)[16] showed four types of sweetening in potatoes. The first results from tuber immaturity, the second from rapid sprout growth, the third from senescent sweetening and the fourth from exposure of tubers to low temperatures. Thus, rapid sweetening in both potato samples (Fig. 5) from the 62 days of storage is due to rapid sprout growth (Figs. 6–8).

Sowokinos (1978)[17] has identified sucrose in raw tubers as the major sugar that changes as tubers mature. Schallenberger et al. (1959)[13] indicated hydrolysis of sucrose into glucose and fructose may occur in the presense of hot cooking oil and amino acids typical of chip frying environments. This would result in dark chip

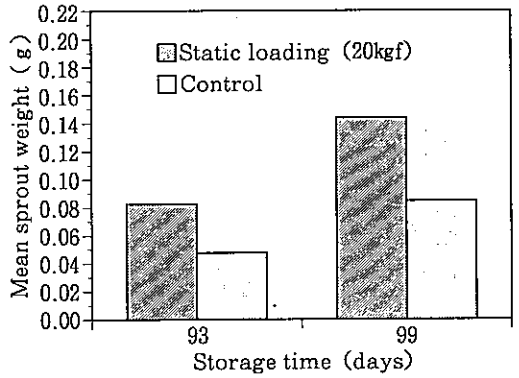

Fig.8 Weight of sprouts per tuber during storage at 13℃

Table 1 Effect of static loading on quality of potatoes during storage

Weight loss	Specific gravity	Moisture	Reducing sugar	Num. of sprouts	Sprout length	Sprout weight
–	–	Sta**>No	Sta**>No	–	–	–

Sta : Static loading No : No−loading

** : Means were significantly different at the 1% level.

– : Not significantly different between static loading and no−loading potatoes.

color if the sucrose consentration is sufficiently high (>0.5% fresh wt). Thus, in this experiment, determination of sucrose content as well as reducing sugar content may also be necessary to evaluate chipping quality.

Stress and sugars

Impact during handling not only increases the likelihood of black spot, but also changes the concentration chemical compounds in the injured area[18]. Sowokinos (1987)[19] found that sucrose concentration exceeded 1 % (fresh wt basis) 10 days after mechanical handling. More than 65% of the maxiaml sugar accumulation occurred within 5 days of handling. The mechanical handling of senescing potatoes resulted in a shift of the plastid membrane to a more disrupted state. This was revealed by electron micrographs examination during storage.

Stresses induced by temperature[20)-22)], moisture[23)-25)], excess nitrogen[26)], infertility[27)], storage[28)] and handling can each lead to an increase in the intracellvlar level of free sugars[29)]. However, sweetening of potato tissue at the molecular level is still unexplained. The level of sugars present is dependent on the net expression of a large number of genes affecting seceral levels of cellular regulation. Levels of cellular regulation which may be influenced by stress include : (a) hormones, (b) membrane structure and function, (c) compartmentalization and concentration of key ions, substrates, enzymes and other effectors and (d) enzyme synthesis and/or enzyme activity (Sowokinos, 1990[30)]). In the present experiment, reducing sugar content of static loading potatoes was high compared with one of no-loading potatoes. the specific reasons for this increase are unknown. Thus, further research is required at the cellular level to understand this increase.

CONCLUSION

Static loading increased moisture and reducing sugar contents of potatoes during storage.

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荷重が貯蔵馬鈴薯の品質におよぼす影響

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和文摘要

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