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Analysis of Physiochemical Changes in Potato Varieties during Reconditioning for Processing Applications

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Abstract: ***This study investigates the physiochemical changes during the reconditioning of three potato varieties— Destiny, Mustang, and Kuroda—stored at 10°C and 73 - 78% RH for 25 days. Results indicate a significant reduction in sugar content, yet levels remained unsuitable for processing. No adverse effects on dry matter content or chip yield were observed. Destiny variety exhibited superior sensory qualities. Extended reconditioning or higher temperatures are recommended to achieve optimal sugar levels for processing.***

Keywords: potato varieties, reconditioning, reducing sugars, processing quality, chip yield

1. Introduction

The potato is the fifth most produced agricultural product with 388 million tons, behind sugarcane (1.84 trillion tons), corn (1.13 trillion tons), wheat (771 million tons), and rice (769 million tons) [1]. It can be consumed fresh, dehydrated, or fried as a snack. Around the world, the potato crisp is a particularly popular snack. At the industrial level, the preparation of chips requires particular attention to the formation of acrylamide. This chemical compound is suspected of being carcinogenic to humans, and its evolution in industrial products is closely monitored. During cooking, reducing sugars and asparagine interact can lead to browning on the outline and sometimes the whole of the chips, as a result of the reaction of Maillard [2]. The more the potato is rich in reducing sugars (glucose, fructose, and sucrose), the more the browning is visible. Whether for health or commercial reasons, the industry seeks to limit this browning. To limit the formation of acrylamide in food products, Food Drink Europe [3] has published tools in the form of "toolboxes" that are intended for the food industry. Among the first recommendations is the need to use potato varieties with low levels of reducing sugars. Some studies have already shown that there is a strong link between the reducing sugar content and the final level of acrylamide [4, 5].

It is well known since the experiments of MiJller - Thurgau [6] that temperatures above 10~ change biochemical processes in the potato tuber tissue towards resynthesis of starch from free sugars. This phenomenon is nowadays known in industrial practice as 'reconditioning' and is a necessary treatment of cold - stored potatoes, especially in those cases, where frying is one of the steps in the processing of the potatoes. The length of reconditioning depends on the one hand on the level of sugars accumulated during cold storage and on the other hand on the susceptibility of different potato varieties to lose sugar during this treatment. From the practical as well as the theoretical point of view it is also interesting to know what qualitative changes occur during reconditioning in the reducinazg sugar content. Increasing the reconditioning temperature by 10 °C - according to van 't Hoff's rule - should accelerate the reactions involved in sugar loss twofold or even more, so this aspect should also be taken into consideration.

High - reducing sugar concentrations result in undesirably darkened potato chips and fries. Some varieties recondition better from low temperatures than others. Norchip potato variety, for example, reconditions better from 7 °C. storage temperatures than does Kennebec.

The processing quality of tubers stored at 8 - 10°C could be improved further by reducing the level of reducing sugars through appropriate reconditioning of the tubers after removal from the stores [7, 8].

This study addresses the critical issue of reducing sugar levels in potatoes to improve their suitability for processing, contributing to the optimization of industrial practices and consumer health.

The purpose of this study is to analyze the effect of reconditioning on the physiochemical properties of potato varieties [9] to determine their suitability for industrial processing.

2. Materials and Methods

About 200kg from the potato varieties Destiny, Mustang and Kuroda which have been stored for 3months at (4^0C) were selected randomly from a commercial cold store located in Omderman. The varieties were kept later at 10^0C (73 - 78% RH) in cold store at Food Research Center for 25 days for tuber reconditioning.

Dry matter:
Dry matter content was measured in all tested tubers using the potato hydrometer (APH Group.,. Holland). Method of Smith [10]. Tubers were selected for absence of defects and uniformity of size a random sample (3.660 kg, potatoes) was placed in wire basket and all were dipped into thirty - gallon container of water, and the reading of dry matter content was

taken as soon as the hydrometer came to rest while floating in the water. The readings were triplicates for each treatment.

Reducing sugars:

Tissue extraction: Thirty grams of potatoes tubers from each variety were homogenized in 100 ml. of distilled water for one minute using a blender, and centrifuged at 6, 000 rpm for 10 mints in a gallon Camp portable centrifuge (CF400) the volume of the supernatant, which constituted the extract, was determined.

Reducing sugars determination:

The reducing sugars were determined in the tuber extract from each treatment according to the technique described by Nelson [11] as modified by Somogyi [12] reducing sugars were expressed as percent of fresh weight.

Potato chip yield and organoleptic quality:

The tubers were taken randomly from each variety, washed, weighed in (g) individually and hand peeled. The tubers were then cut into 1.75 mm thick slices using automatic slicer. The slices were washed in running tap water at room temperature (30±5 ºC) and then dried. About 300 g dried slices were fried in sunflower seed oil at 170ºC in a deep fryer till the bubbling stopped (about 6 min). The fried chips were drained off to remove excess oil and then weighed to determine the tubers chip yield (%) [13]. Twelve semi - trained assessors were provided chips and asked to evaluate the general appearance, Flavor (odor & taste), texture, after taste and overall quality in the 25 days of reconditioning duration by the ranking method [14].

Statistical analysis:

Data generated was subjected to Statistical Analysis System (SAS), using one factor analysis of variance (CRD); and then means were tested and separated using Duncans Multiple Range Test (DMRT) [15].

3. Result and Discussion

Table (1) illustrates the effect of reconditioning for 25 days at 10˚C (73 - 78% RH) on the reducing sugars content (%) in Destiny, Mustang and Kuroda potato varieties. There were highly significant ($P \leq 0.05$) differences among tested potato varieties with respect to the changes in reducing sugars level with time. After 25 days of reconditioning, Destiny, Mustang and Kuroda tubers showed a considerable reduction in reducing sugars content by 75, 66 and 61% respectively, although the content of reducing sugars still high and it did not reach the desired levels for processing 0.25% for making chips and 0.5 % for making French fries [16, 17]. Extension in reconditioning period may be needed for diminishing the reducing sugars to the recommended level for processing or applying higher temperature may be useful for conferring sugars to starch.

Table (2) shows the effect of reconditioning for 25 days at 10˚C (73 - 78% RH) on the dry matter (%) in Destiny, Mustang and Kuroda potato varieties. Generally no significances difference was observed in dry matter ($P \leq 0.05$) content in all potato varieties during the reconditioning period. Although there was a slight decrease in dry matter content with the time of reconditioning till the day 25th which recorded the lowest dry matter content in all varieties Destiny, Mustang and Kuroda (23.6 - 21.00 and 20.20 %) respectively. Destiny potato variety recorded the highest content of dry matter compared with the other two Mustang and Kuroda potato varieties. The recommended range of dry matter content for processing is 20 - 24% [18]. When the storage temperatures are too high respiration losses can outstrip evaporative losses, with a resultant decrease in dry matter. On the other hand humidity levels in storage can also affect dry matter level [19].

Chips yield (%) in Destiny, Mustang and Kuroda potato varieties during 25 days at 10˚C (73 - 78% RH) is shown in table (3) No significant differences ($P \leq 0.05$) were observed in chips yield among tubers of Destiny through the reconditioning period. Mustang and Kuroda potato varieties showed a significant ($P \leq 0.05$) decrease in potato chips yield in day 25 from 40.37 to 31.4 % and 35.53 to 30.67% respectively.

Table 4 shows the sensory evaluation of potato chips prepared from Destiny, Mustang and Kuroda tubers reconditioned for 25 days using the ranking method [14]. Destiny potato tubers were significantly ($P \leq 0.05$) superior in appearance, crispness, after test and overall quality compared to Kuroda which was superior in chips flavor. No significant differences ($P \leq 0.05$) were observed in appearance, crispness, after taste and overall quality between Kuroda and Mustang potato varieties.

Table 1: The effect of reconditioning for 25 day at 10˚C (73 - 78% RH) on the reducing sugars (%) in Destiny, Mustang and Kuroda potato varieties

Varieties	Storage period (days)					
	1	5	10	15	20	25
Destiny	4.57^{a} (±1.68)	2.93^{bc} (±0.10)	1.63^{def} (±0.12)	1.57^{def} (±1.12)	1.23^{f} (±0.31)	1.13^{f} (±0.06)
Mustang	4.43^{a} (±1.40)	2.33^{cdef} (±0.06)	1.90^{cdef} (±0.35)	1.90^{cdef} (±0.35)	1.67^{def} (±0.67)	1.50^{ef} (±1.65)
Kuroda	3.67^{ab} (±1.07)	2.30^{cdef} (±0.00)	1.83^{cdef} (±0.29)	1.97^{cdef} (±0.45)	1.97^{cdef} (±0.45)	1.4^{f} (±1.25)
$Lsd_{0.05}$	0.9981					
SE±	0.3488					

Any two mean±SD values bearing different superscript are significantly different (P≤0.05).

Table 2: The effect of reconditioning for 25 day at 10˚C (73 - 78% RH) on the dry matter (%) in Destiny, Mustang and Kuroda potato varieties

Treatments	Storage period (days)					
	1	5	10	15	20	25
Destiny	25.93^{a} (±0.74)	25.80^{ab} (±0.20)	25.60^{abc} (±0.20)	25.03^{abcd} (±1.57)	24.67^{abcd} (±0.58)	23.60^{cd} (±0.53)
Mustang	24.53^{abcd} (±0.35)	25.23^{abcd} (±1.46)	23.30^{de} (±0.96)	21.60^{ef} (±2.34)	21.20^{f} (±0.53)	21.00^{f} (±0.85)
Kuroda	24.63^{abcd} (±1.81)	23.80^{bcd} (±0.53)	21.50^{ef} (±0.10)	20.97^{f} (±0.76)	20.73^{f} (±2.76)	20.20^{fg} (±0.46)
$Lsd_{0.05}$	1.788					
SE±	0.6288					

Any two mean±SD values bearing different superscript are significantly different (P≤0.05).

Table 3: The effect of reconditioning for 25 day at 10˚C (73 - 78% RH) on the chips yield (%) in Destiny, Mustang and Kuroda potato varieties

Treatments	Storage period (days)					
	1	5	10	15	20	25
Destiny	34.17^{ab} (±4.57)	32.34^{bcdefg} (±0.32)	33.30^{bcdef} (±1.74)	35.27^{b} (±1.29)	33.77^{bcde} (±3.35)	34.83^{bc} (±0.53)
Mustang	40.37^{a} (±2.67)	32.83^{bcdefg} (±1.74)	35.00^{b} (±1.91)	29.73^{efghi} (±2.34)	32.270^{bcdefg} (±0.72)	31.40^{bcdefg} (±1.65)
Kuroda	35.53^{b} (±1.07)	30.40^{defghi} (±0.87)	29.87^{efghij} (±0.17)	26.47^{ij} (±2.31)	31.33^{bcdefg} (±0.49)	30.67^{cdefgh} (±1.25)
$Lsd_{0.05}$	3.579					
SE±	1.259					

Any two mean±SD values bearing different superscript are significantly different (P≤0.05).

Table 4: The effect of reconditioning for 25 day at 10˚C (73 - 78% RH) on the acceptability of potato chips prepared from Destiny, Mustang and Kuroda potato varieties

Varieties	Appearance	Flavor	Crispness	After taste	Over All Acceptance
Destiny	36b	77a	41b	41b	40b
Mustang	53a	51a	57a	57a	54a
Kuroda	48a	41b	47a	44a	47a

- Any two sum of ranks having similar superscript letter (s) in each column have no significant difference (P<= 0.5).
- 12 reps, 4 varieties rank total (28 - 56).
- Range from Ihekoronye and Ngoddy (1985) Table was 28 - 56.

4. Conclusion

The study concludes that reconditioning for 25 days at 10°C significantly reduces reducing sugar levels in Destiny, Mustang, and Kuroda potato varieties, but the levels remain unsuitable for processing. Adjustments in reconditioning duration or temperature are recommended to achieve optimal processing quality.

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