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Research Article

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Effect of blanching time, temperature and potato tuber bruises on the reducing sugar levels of potato tubers sold in market outlets within Abakaliki metropolis, Ebonyi State, Nigeria

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Abstract Studies were carried out to evaluate the effect of blanching time, temperature and potato tuber bruises on the reducing sugar levels of potato tubers sold in market outlets within Abakaliki metropolis, Ebonyi State, using dinitrosalicyclic assay. The mean reducing sugar levels in the tuber samples with no bruise, light bruises and heavy bruises were 2.86±0.21, 3.22±0.18 and 4.69±0.52mg/g respectively. The presence of bruises in the tuber samples caused a percentage increase in the tuber samples' reducing sugar level from 12.5 to 63.90%. Thus the mean levels of the reducing sugar in the no bruised, scantily bruised and heavily bruised tuber samples were statistically significant. 2.85±0.46, 2.53±0.12, 2.27±0.08, 2.14±0.06 and 3.31±0.42 mg/g were the mean levels of reducing sugar in the potato tuber samples blanched at temperatures and times of 45^{o}C, 55^{o}C, 65^{o}C, 80^{o}C and 0^{o}C and 4min, 8min, 12min, 16min and 0min respectively. Increase in blanching temperature and time from 45 to 80 ^{o}C and 4 to 16min respectively caused a 9.81 to 32.91 % reduction of the mean reducing levels of the potato tuber samples. From the physical observation of the tuber samples after blanching, the ideal range of blanching temperature and time for decreasing the reducing sugar levels in potato tubers prepared for quality crisp production was at 55 to 65^{o}C and 8 to 12 min respectively.

Keywords Reducing sugar, Blanching, Potato tubers and Potato tuber bruises

Introduction

Potato (*Solanum tuberosum* L) is one of the most vital tuber crops utilized worldwide for both human and animal consumption. It is one of the world's major staple crops, that produces more dry matter and protein per hectare than the major cereal crops [1]. Potato is a rich source of carbohydrate and has considerable amounts of proteins, vitamins, essential and trace elements.

Potato tubers contains about 75% water, 21% carbohydrate, 2.5% protein and less than 1% fat [2]. Potato plants are subjected to a variety of biotic and abiotic stresses that impacts the plant's health, marketable tuber yields and final tuber quality [3]. The quality of a potato crisp is a product of the quality of the tubers used in the manufacture of the potato crisps. The quality of the tubers at harvest time is affected by cropping conditions. Hence , tubers with high dry matter content(20-22%), specific gravity of 1.08-1.09%, high amylase to amylopectin ratio, small cell size and

low reducing sugar are preferred for quality potato chips production [4]. According to [5], reducing sugar content is used to predict tuber suitability for crisp production because it is an indicator of colour development in the processed tubers. Accordingly, [6] stated that increased reducing sugar content in potato tubers results in increased browning when the tubers are processed. In other words, [7] observed that if tubers are stressed during harvesting, handing, transportation and storage, the reducing sugar levels in such tubers increases causing a non-enzymatic browning when such tubers are processed. Colour development in potato crisps is produced by Maillard reaction and the colour of a potato is an indicator of the levels of formation of compounds such as acrylamide, a known food genotoxicant [1].

No acrylamide has yet been found in raw or unheated foods, thus, suggesting that a reaction of cooking (frying, roasting or baking) of mainly carbohydrate-rich foods is responsible for the formation of acrylamide [8]. [9] observed that reducing sugar level in potato tubers is the limiting factor for the formation of acrylamide during chips making processes. The health impairment caused by acrylamide hinges on its carcinogenic and genotoxic impact [10].

Reduction /mitigation of acrylamide formation in processed potato products can be achieved by reducing the levels of reactants (such as reducing sugar and asparagines) in the raw potato tubers before frying processes and one of the ways of achieving this is by blanching the potato tuber slices. Blanching is a process that is used to partially cook tuber slices prior to frying. This requires the submersion of the tuber slices into a vessel containing hot water for a determined period and on removal the sliced tubers becomes partially cooked [1]. According to [12], blanching helps to reduce oil absorption in the tuber slices, improve texture and crispness of the fried potato slices and this occur by two mechanisms. Firstly, a film is created between the tuber slice and the oil, that acts as a barrier to oil penetration into slices and secondly, during the blanching, sliced tuber pores are sealed intercellularly by the mechanism of cell expansion.

According to [12,13] , blanching helps to inactivate enzymes responsible for browning when potato tubers are fried. Also [14] stated that the efficacy of blanching process on the reduction of reducing sugar, acrylamide formation and colour development is primarily dependent on blanching temperature and time.

Ebonyi State is one of the few States in Nigeria, where potato is grown for commercial purposes. This precious agricultural produce is in rich quantity at various market outlets within Abakaliki metropolis and thus handling, transportation and storage has left the sold potato tubers with different degrees of bruises and hence prone to senescent sweetening.

The inhabitants of the metropolis mostly fry potato tubers bought from the market to make snack or to support diets while many especially women, sale the fried potato slices as chips to earn a living. The impact of reducing sugar level on the potato tubers occasioned by post-harvest conditions could negatively affect the quality of the fried potato tubers and could increase the formation of acrylamide in the processes potatoes. Hence, this study was carried to investigate the impact of potato tuber bruises, blanching temperature and time on the reducing sugar levels of potato tubers sold in market outlets within Abakaliki metropolis in Ebonyi State.

Materials and Methods

Samples of potato tubers were purchased from market outlets within Abakaliki metropolis in Ebonyi State, packaged properly and taken to the laboratory for preparatory and analytical procedures.

Preparation

For the reducing sugar analysis with the bruised potato tuber samples, the tuber samples were sorted for analysis based on the degree of bruises ranging from none to light to heavy tuber bruises. The samples were properly labeled and sliced to 3mm and washed with water. It was subsequently freeze dried and ground to fine powder prior to analysis.

Equally, selected potato tuber samples were sliced and blanched at water temperatures of 45, 55, 65, 80 and 0^{o}C for 4, 8, 12, 16 and 0min respectively. The samples were each freeze-dried and ground to fine powder.

Analysis

The extraction and quantification of reducing sugar levels in the tuber samples was carried out as described by [15]. 1g of the freeze-dried, powdered potato samples was added to 50ml of distilled water and shakened for 1 hour. The supernant was centrifuged at 3000rpm for 30min. 2ml of dinitrosalicyclic acid was added to 1ml of the centrifuged aliquot in a glass tube and incubated at 99^{o}C in a water bath for 10min. After cooling, the absorbance was measured at 550nm in a microplate reader. The experiment was repeated four times for each investigated tuber sample and samples were analyzed against standards of known concentration for reducing sugar levels.

Statistical Analysis

The data obtained were expressed as mean± standard deviation and subjected to one way analysis of variance (ANOVA) at 5% confidence level using SPSS version 22.0.

Results and Discussion

Table 1: Mean reducing sugar levels of the potato tuber samples at varying levels of bruises

Parameter / Sample	Bruise level	Mean reducing sugar level (mg/g)	% Increase in reducing sugar level	F test p value
A	None	2.68±0.21	-	0.01
B	Light	3.22±0.18	12.59	
C	Heavy	4.69±0.52	63.99	

Result of Table 1 shows that 2.86±0.21, 3.22±0.18 and 4.69±0.52 mg/g were the mean reducing sugar levels of the tuber samples A to C at no, light and heavy bruise levels respectively. The samples contained mean reducing sugar levels in the following decreasing order; sample C> sample B>sample A as shown in Fig. 1.

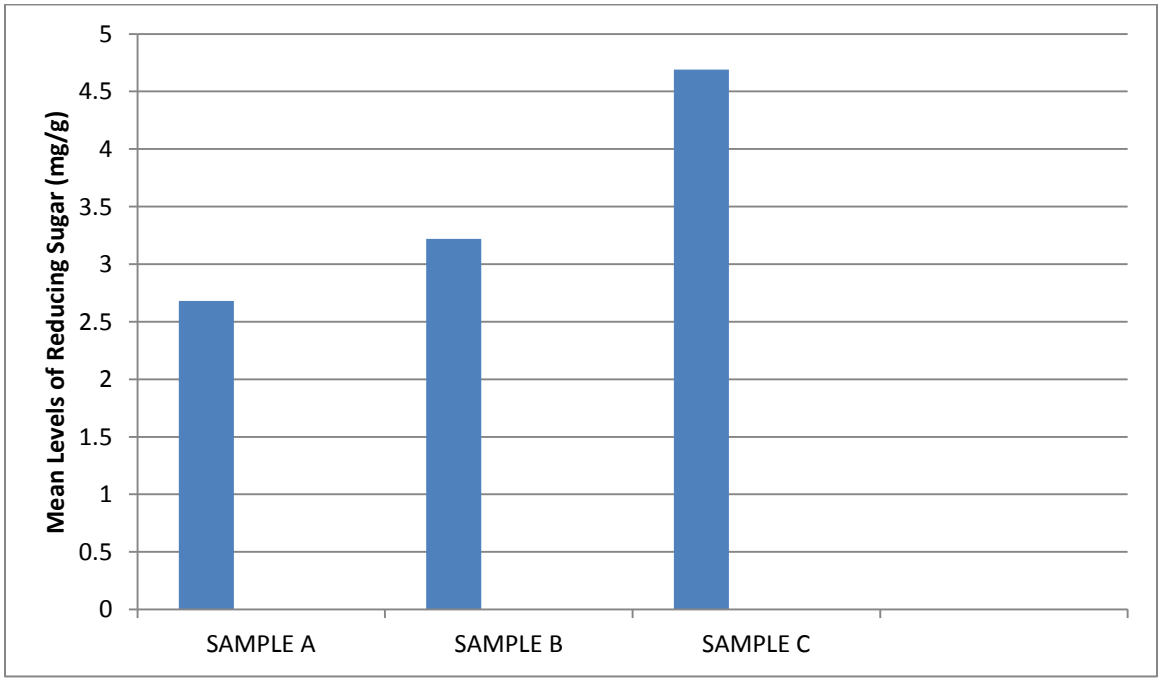

Figure 1: Bar chart representation of the mean reducing sugar levels of the tuber samples at varying levels of bruises

The mean values of reducing sugar in the potato tuber samples with different bruise levels were statistically significant at $p<0.05$. Result of Table 1 shows that increase in scars or bruises in the potato tuber samples greatly increased the reducing sugar level in the studied tuber samples. This is because when potato tubers are bruised during harvesting or post-harvesting processes and such tubers are not cured or consumed immediately, there could be microbial attack on the bruised surface, which could lead to increase in respiration, loss of moisture by the tubers and finally trigger senescent sweetening of the tubers before final consumption. Hence, the potato tuber samples that were not bruised or were scarcely bruised were less prone to microbial attack, loss of moisture and enhanced respiration and thus gave low to moderate levels of reducing sugar compared to the very high mean value obtained for the heavily bruised tuber samples. As the level of bruises in the potato tuber samples increased from light to heavy, the reducing sugar level in the tuber samples increased from 12.59 to 63.99%. [16,17] observed that the rupture of potato tuber skin as a result of mechanical damage during post harvest operations can provide an entry for infection , stimulate physiological deterioration and dehydration and thus trigger senescent sweetening of the tubers. [18] stated that weight loss and entry of micro-organisms occurs through bruised skin of potato tubers resulting in diseases and rot during storage. Both the lightily and heavily bruised potato tuber samples had mean levels of reducing sugar above 3.0mg/g set by [19].

Table 2: Mean levels of reducing sugar in the potato tuber samples at different blanching temperatures and times

Parameter / Sample	Time (min)	Temp. (^oC)	Mean reducing sugar level	% Reduction of reducing sugar	F-test p value
A	4	45	2.85±046	9.81	
B	8	55	2.53±0.12	19.93	
C	12	65	2.27±0.08	28.60	0.01
D	16	80	2.14±0.06	32.91	
E (Control)	Unblanched	3.31±0.42	-		

Result of Table 2 shows that 2.85±0.46, 2.53±0.12, 2.27±0.08, 2.14±0.06 and 3.31±0.42mg/g were the mean levels of reducing sugar in the potato tuber samples blanched at 45, 55, 65, 80 and 0^oC for 4, 8, 12, 16 and 0min respectively. The result therefore indicates that as the blanching temperature and time were increased from 45 to 80^oC at 4 to 16min respectively, the mean levels of reducing sugar in the potato tuber samples decreased from 3.31±0.42 to 2.14±0.06mg/g. The implication of this observation as shown in Table 2 is that increase in blanching temperature and time from 45 to 80^o C at 4 to16min respectively, resulted to a decrease in the levels of reducing sugar in the investigated tuber samples from 9.81 to 32.91%.

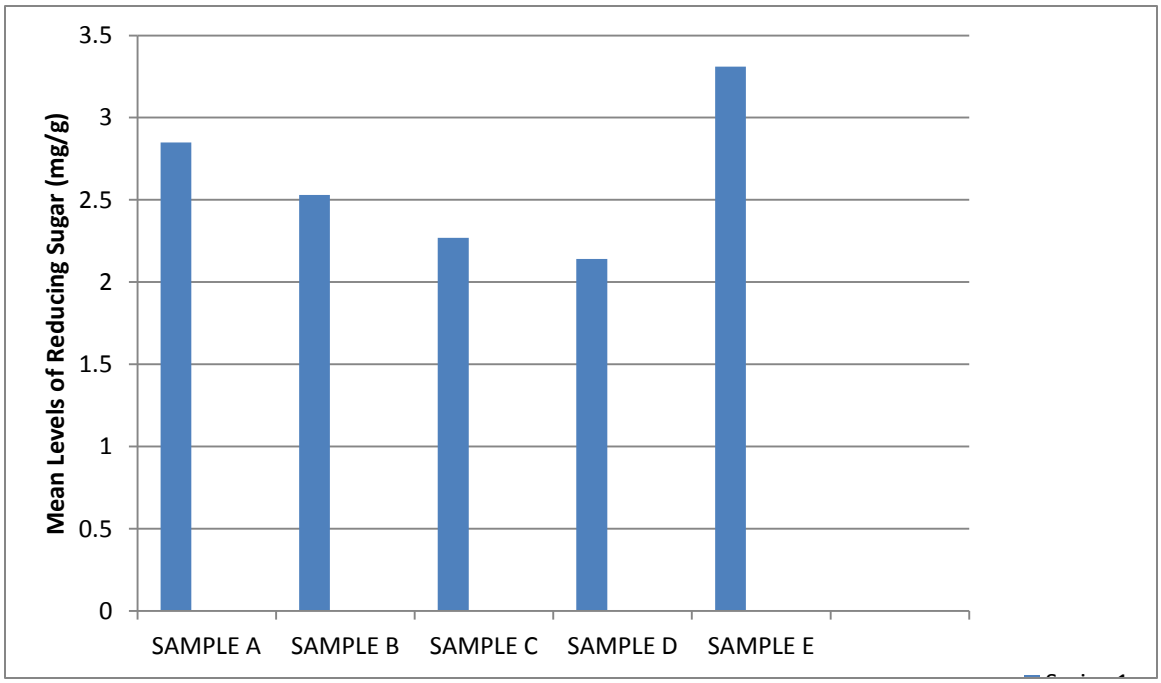

Figure 2: Bar chart representation of the mean levels of reducing sugar in the potato samples at different blanching temperatures and times

However, it is pertinent to state that at a blanching temperature and time of 80^{o}C and 16min respectively, the investigated sliced potato tuber samples became cooked to a larger extent and lacked firmness and so, using such blanched tubers for frying processes would result to poor quality crisps that retains a lot of moisture and hence prone to rapid decay. At blanching temperatures and times range of 55 to 65^{o}C and 8 to 12 min respectively, the blanched tuber samples were partially cooked and still firm and thus indicates that frying such tubers would yield pleasantly coloured and crispy products, with low levels of acrylamide formation.

The mean levels of reducing sugar in the blanched and non-blanched potato tuber samples differed significantly. The reports of [20] on the effect of blanching temperature and time on the reducing sugar and acrylamide levels of potato crisps meant for commercial use, in which they stated that blanching beyond 75^{o}C at a duration of 25min reduces the quality of the produced crisps because of increased oil level in the tuber slices, leading to inferior textural characteristics of the produced crisps was in agreement with the findings of this research. [21] observed that the ideal blanching temperature and time for quality crisps production that yields low acrylamide formation ranges from 55 to 70^{o}C at 10-30 min respectively.

[21] reported a higher percentage reduction of reducing sugar of 56.5 to 64.2% in potato tuber samples blanched at temperatures and times ranging from 65 to 85 ^{o}C and 2 to 10 min respectively, than what was obtained in the blanched tuber samples of this study.

Conclusion

Bruise or scars in potato tubers greatly influences the reducing sugar level that such tubers would have, and thus increase in scars or bruises in potato tubers significantly increases the tubers reducing sugar level. For such tubers with deep or heavy scars, browning of the fried crisps is usually inevitable.

Blanching of potato tubers at temperatures and times ranging from 45 to 65^{o}C and 8 to 12 min respectively, led to a significant reduction of the reducing sugar levels in the potato tuber samples and also the blanched tuber samples still retain reasonable firmness for the production of quality crisps.

To produce crisps of high quality for private and public consumption, it is therefore important that both harvesting and post harvesting techniques should be improved to lessen the scars or bruises that would result in elevated levels of reducing sugar in the tubers. Owing to post harvesting practices that most times are not within the control of the

final consumers of potatoes especially as crisps, it is therefore recommended that potato tubers purchased in market outlets within Nigerian environment should be blanched at suitable temperature and time, to lessen the reducing sugar levels in the tubers and to enhance the production of potato crisps that meets consumers appeal and have reduced levels of acrylamide.

Conflict of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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