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Influence of postharvest treatments on the proximate composition and sugar contents of fresh maize

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Freshly harvested maize is highly perishable and it rapidly losses its sweetness within 3 days of harvest. This study investigated the influence of steeping on the proximate composition and sugar content of fresh maize stored at tropical ambient conditions (28 ± 2°C and 70% RH). The solutions used for steeping were salt (8%), sugar (10%), combination of the salt-sugar solution (2:3 v/v) while the control had no treatment. Standard methods were used for the determination of the proximate composition (moisture, protein, carbohydrate, fat, ash and fibre) and sugar contents as storage progressed. Results obtained showed significant differences (p<0.05) in the proximate composition across the storage period with ash and fat contents increasing while the fibre, protein and carbohydrate decreased as storage progressed. The salt-sugar solution was found to be the best steeping solution as it retained most of the sugar content of the fresh maize, followed by the sugar solution and then the salt solution respectively. There was however a general reduction in sugar contents of all the different treatments as storage progressed. Steeping in the salt-sugar solution was able to retain about 70% of the initial sugar content (sweetness) on the 12th day of storage which was the highest retention obtained. It could therefore be concluded that the salt-sugar steeping treatment given to the fresh maize had significant effect on the proximate composition and sugar content retention in the maize samples and could therefore be a useful method for short term storage of freshly harvested maize.

Key words: Steeping, sugar content, storage, proximate composition.

INTRODUCTION

Maize (*Zea mays*) is one of the most important cereal grains in the world. It is third behind rice and wheat (Mbuya et al., 2011) and serves as a staple food for approximately 400 million people in developing countries. It is used in these countries as food, ingredient and animal feed (Odebode et al., 2008). About half of the estimated 603 million tonnes world production of maize is produced in developing countries (Samapundo et al., 2007). Various types of maize exist and include pop, dent, flint, floury and sweet cultivars (Bibiana et al., 2014). Maize (*Zea mays saccharata*), also known as sweet corn, or green maize differ from all other types of

maize, because it contains the gene *sugary1* (*su1*), which contributes to its high sugar content (Marshall, 1987) and retains large amount of sugar in the kernels, hence it is named 'sweet'. According to Robinson and Treharne (1985), a recessive gene on the fourth chromosome is what slows down the conversion of some of the sugar into starch.

Maize is known always to be sweet when freshly harvested and readily loses its sweetness in less than three days if not properly handled (Robinson and Treharne, 1985). The degradation observed in maize sweetness during storage is attributed to the high respiration rate after harvest; hence this work investigated postharvest treatments that can reduce the loss of sugar and moisture contents so as to retain freshness. The conventional method of storing/ preserving fresh maize include canning, film packaging and freezing methods which is associated with some limitations such as high cost of packaging materials, transportation and high electric energy requirements thus, there is a need for low cost but effective technology like steeping.

Packaging of freshly harvested maize in plastic films stored at ambient tropical conditions (temperature of 28-30°C and relative humidity of 70-80%) have been reported to significantly reduce moisture loss and maintained the appearance and kernel firmness of maize (Oluwalana et al., 2017). However, the method was found not to show any significant effect in sugar content retention and extension of storage life of fresh maize at ambient temperature (Bello and Oluwalana, 2017). Combination of plastic film packaging and storage at low temperatures of 5-10°C have been reported by Bello and Badejo (2017) to significantly preserve the sweetness and other nutritional composition for 8 days.

This study explored the steeping method as an alternative to film packaging and cold storage. Steeping in food, involves immersion of food substance into solutions which have preservative potentials. Natural substances such as salt, sugar, vinegar and diatomaceous earth are used as traditional preservatives. Salt is considered antibacterial since it restricts bacterial growth by lowering the amount of free water molecules in foods as bacteria need high moisture to survive and thrive. Sugar also acts as preservative and maintain desirable appearance, flavour, colour and body in products (Ravneet et al., 2009). Hence the aim of this work was to investigate the effect of steeping in salt, sugar and salt-sugar solutions on the proximate composition and sugar retention of fresh sweet maize.

MATERIALS AND METHODS

Freshly harvested maize was purchased from the Teaching and Research Farm of The Federal University of Technology, Akure and was immediately taken to the Department of Food Science and Technology, The Federal University of Technology, Akure where the studies were carried out.

Sample preparation

The husk and silk of the freshly harvested maize were removed, shelled and well mixed before being portioned 1 kg each into 5 L jars. Two (2) litres of steeping solutions of salt, sugar, salt-sugar was added to the maize in separate jars and each sample were replicated. The jars were then closed with air-tight lids. The control was kept at room temperature without any form of preservation. All the containers (jars) which were 12 altogether were kept in ambient conditions (28 ± 2°C and 70% RH).

Sampling method

Samples for each treatment were taken as described by AOAC (2005) and analyses were carried out at intervals of 7 days and 3 days for proximate composition and sugar content determinations respectively. The treatments were 8% salt solution (SAFM), 10% sugar solution (SUFM), 2:3 v/v salt-sugar solutions (SSFM) and the control with no solution (control).

Chemical analysis

Samples of the maize were analysed for moisture, ash, fat, crude fibre, protein and carbohydrate contents according to the methods described by AOAC (2005). Protein content was determined by the Kjeldahl-Nitrogen analysis procedure, using 6.25 as a conversion factor whiles the crude fat was determined using the Soxhlet extractor. The carbohydrate content was obtained by difference. Sugar content was determined using phenol sulphuric acid method as described by Masuko et al. (2005).

RESULTS AND DISCUSSION

Proximate composition

Table 1 shows the proximate composition of the steeped maize across the storage period. The moisture content all reduced compared to Day zero. This is in conformity with the report of Oluwalana et al. (2017) who reported non-enclosure of fresh maize in plastic films to cause significant moisture loss as storage progresses at tropical ambient conditions. Generally, the ash and fat contents increased with increasing storage time while fibre, protein and carbohydrate decreased as the storage time increases particularly after 7 days of storage. Similar trends were also observed by Oluwalana et al. (2017) in their study of the effects of modified atmosphere packaging on nutritive values and sensory qualities of fresh maize. Values for the proximate composition of the steeped maize samples were higher compared to the control. This could be due to the non preservative/ steeping treatment of the control sample. However, comparing the different treatment methods, the salt-sugar solution (SSFM) had better storage effects on the maize as it had higher proximate composition and sugar retention values. This was followed by the sugar alone, salt alone and the control respectively. The salt solution being the least effective among the steeping solutions could be due to the osmotic pressure exerted on the walls of the maize by the salt solution, thereby gradually

Table 1. Proximate composition of the stored maize.

Parameter	Control			SUFM		SAFM		SSFM	
	Day 0	Day 7	Day 14	Day 7	Day 14	Day 7	Day 14	Day 7	Day 14
Moisture	65.7±1.59	46.94±0.22^a	45.81±0.61^a	55.52±0.20^b	63.19±0.15^d	56.64±0.43^c	51.94±0.00^b	55.80±0.81^b	58.68±0.61^c
Ash	1.27±0.55	1.47±0.00^a	1.89±0.01^a	1.98±0.00^b	2.53±0.56^b	2.92±0.01^c	2.83±0.00^b	1.96±0.00^b	1.89±0.00^a
Fat	4.65±0.29	10.93±0.00^a	14.29±0.00^a	9.27±0.00^a	13.99±0.30^a	12.25±0.00^b	20.95±0.00^b	10.93±0.00^a	19.68±0.55^b
Fibre	1.41±0.00	1.69±0.00^a	1.69±0.00^a	2.59±0.00^b	1.49±0.00^b	2.58±0.00^b	1.29±0.00^c	3.58±0.00^c	1.49±0.00^b
Protein	6.21±0.00	5.33±0.00^a	3.55±0.00^a	5.33±0.00^a	3.55±0.00^a	5.33±0.00^a	5.33±0,00^c	5.33±0.00^a	4.33±0.00^b
Carbohydrate	20.76±1.90	33.65±0.23^d	30.99±0.60^d	25.31±0.20^c	15.20±0.73^b	20.27±0.43^a	19.43±0.00^c	22.40±0.81^b	13.93±0.14^a

Values are Means of triplicate determinations. Mean values in the same column (same number of days) with different superscripts are significantly different at $P<0.05$. Control = Maize sample no treatment; SUFM = maize sample in sugar solution; SAFM = maize sample in salt solution; SSFM = maize sample in salt-sugar solution.

Table 2. Sugar content of the stored maize.

Day	Control	SUFM	SAFM	SSFM
Day 0	23±0.00	23±0.00	23±0.00	23±0.00
Day 3	17.33±0.58^a	20.67±0.58^c	19.33±0.58^b	20.00±0.00^{bc}
Day 6	14.67±1.15^a	18.67±0.58^b	13.33±0.58^a	18.67±0.58^b
Day 9	8.00±1.00^a	16.00±0.00^b	7.67±0.58^a	17.00±0.00^b
Day 12	3.00±0.00^b	12.00±0.00^c	1.33±0.58^a	14.67±0.58^d
Day 15	0.00±0.00^a	0.00±0.00^a	0.00±0.00^a	1.67±0.58^b

Values are Means of triplicate determinations. Mean values in the same row (same number of days) with different superscripts are significantly different at $P<0.05$. Control = Maize sample no treatment; SUFM = maize sample in sugar solution; SAFM = maize sample in salt solution; SSFM = maize sample in salt-sugar solution.

destroying the chemical matrix of the maize (Sandhu and Aggarwal, 2001). The decrease in moisture content observed in the sample immersed in salt solution on the 14th day of storage could be due to the osmotic pressure of the salt (NaCl). This observation agrees with the findings of Ravneet et al. (2009) who worked on baby cob preservation using different salt concentrations. The decrease in ash content of maize immersed in salt solution only could be due to the covalent bond between the salt and other monovalent metals in the samples. Sodium chloride is composed of sodium and halogen group chloride which has potential of binding to monovalent metals to ensure its stability (Mbuya et al. 2011).

Sugar content

Table 2 shows the sugar content of the samples during storage. It was observed that the sugar content of all samples reduced across the storage period. At Day 15, all the sugar had been converted to starch except for sample SSFM, which retained only about 7.3% of the original sugar. This is expected as fresh maize is highly perishable and quickly losses it sweetness immediately after harvest. Brecht (2004) reported that about 60 and 6% of sugar was lost in a single day at storage temperatures of 30 and 0°C respectively. The lesser loss of sugar in sample SSFM can be attributed to the fact that the

combination of salt and sugar has dual preservative or synergistic effect on the fresh maize thus, retaining the sugar content better than the other singular solutions of sugar and salt. As suggested by Sandhu and Aggarwal (2001), there may be penetration of some sugars from the steeping solution into the maize due to the breakdown of the external walls of the grain causing an unnoticeable replacement for sugar lost and resisting penetration of salt into the maize.

Conclusion

The use of salt-sugar solution in this study was found to be more effective in keeping the qualities of freshly harvested maize as it had better retention of the proximate composition and sugar content than the other solutions. However, sugar solution alone showed a better potency for preservation than the salt solution alone. Thus, the salt-sugar solution can be recommended for fresh maize short term storage for sweetness retention.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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