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Resaerch Application Summary

Levels of glycoalkaloids in potato crisps and French fries sold in Nairobi, Kenya

Omayio, D.G.,[1] Abong, G.O.,[1]* Okoth, M.O.[1] & Muzhingi, T. [2]
[1]Department of Food Science, Nutrition and Technology, University of Nairobi, P.O. Box 29053-00625, Nairobi, Kenya
[2]International Potato Center (CIP), sub-Saharan Africa (SSA) Regional Office, Old Naivasha Road, P.O. Box 25171-00603, Nairobi, Kenya
***Corresponding author:** georkoyo@yahoo.com

Abstract

Glycoalkaloids are natural secondary metabolites occurring in potatoes (*Solanum tuberosum* L.*)* and are stable, remaining unaffected during processing ending up in the final products. Despite the increasing consumption of potato and potato products, safety concerns as a result of glycoalkaloids toxicity have not been determined in Kenya. This study aimed at determining the α-solanine and α-chaconine contents in crisps and French fries sold within Nairobi County in Kenya in order to quantify their total glycoalkaloids (GAs). Crisps were bought from supermarkets and local vendors while French fries were obtained from low, middle and high end outlets. Glycoalkaloids were extracted and quantification done by high pressure liquid chromatography. The GAs ranged from 19.62 to 128.12 mg kg^{-1} dry weight (d.w) and averaged 56.29 mg kg^{-1} d.w for crisps. The GAs levels for branded and unbranded crisps were not significantly different ($p>0.05$). GAs levels in the French fries from street, middle and high end outlets were not significantly different ($p>0.05$) with means for samples being 19.16, 21.40, 19.48 mg kg^{-1} d.w, respectively. The α-chaconine and α-solanine levels had positive correlations - Pearson's coefficient (r) of 0.946 ($p<0.0001$) for crisps and 0.944 ($p<0.001$) for fries. None of the samples exceeded the recommended limit of 1000 mg/kg d.w and therefore consumption of fries and crisps was safe. However, there is need for processors and consumer awareness of post-harvest handling practices for potatoes since these contribute to accumulation of high levels of GAs that contaminate the end products.

Key words: Glycoalkaloids, α-chaconine, α-solanine, safety, *Solanum tuberosum*, toxicity

Résumé

Les glycoalcaloïdes sont des métabolites secondaires naturels présents dans les pommes de terre (*Solanum tuberosum* L.) et sont stables, ils restent inchangés pendant la transformation et se retrouvent dans les produits finaux. Malgré l'augmentation de la consommation de pommes de terre et de produits à base de pommes de terre, les problèmes de sécurité liés à la toxicité des glycoalcaloïdes n'ont pas été déterminés au Kenya. Cette étude visait à déterminer la teneur en -solanine et -chaconine dans les chips et les frites vendues dans le comté de Nairobi au Kenya afin de quantifier leurs glycoalcaloïdes totaux (GT). Les chips étaient achetées dans les supermarchés et les vendeurs locaux tandis que les frites étaient achetées dans les points de vente de différent niveau de points de vente (bas, moyenne et haut de gamme). Les glycoalcaloïdes ont été extraits

et la quantification a été effectuée par chromatographie liquide à haute pression. Les GT variaient de 19,62 à 128,12 mg kg-1 de matière seche (m.s.) et étaient en moyenne de 56,29 mg kg-1 de m.s. pour les chips. Les niveaux de GT pour les chips de marque et sans marque n'étaient pas significativement différents (p> 0,05). Les niveaux de GT dans les frites des magasins d'alimentation de la rue, du milieu et du haut de gamme n'étaient pas significativement différents (p> 0,05), les moyennes des échantillons étant respectivement de 19,16, 21,40 et 19,48 mg kg-1 m.s. Les niveaux de -chaconine et -solanine avaient des corrélations positives - le coefficient de Pearson (r) de 0,946 (p <0,0001) pour les chips et de 0,944 (p <0,001) pour les frites. Aucun des échantillons n'a dépassé la limite recommandée de 1000 mg / kg de poids corporel et, par conséquent, la consommation de frites et de chips était sûre. Cependant, les transformateurs et les consommateurs doivent connaître les pratiques de manutention après récolte des pommes de terre, car celles-ci contribuent à l'accumulation de niveaux élevés de GT qui contaminent les produits finaux.

Mots-clés: Glycoalcaloïdes, -chaconine, -solanine, innocuité, *Solanum tuberosum*, toxicité

Introduction

Potato (*Solanum tuberosum* L.) plays a significant role in Kenya's food security besides contributing to poverty reduction through creating employment and income earning throughout the potato value chain. The potato industry, however, faces various challenges including lack of high quality seeds, persistent pests and diseases, poorly managed marketing systems and inadequate regulations on proper packaging (Riungu, 2011). Potatoes are healthy food crops since they provide essential amino acids, vitamins, minerals and antioxidants besides valuable polyphenolic nutrients. Potatoes, however, contain significant levels of glycoalkaloids that are both harmful to humans and animals but helpful in plant protection against pests and pathogens as well as imparting flavor (Friedman, 2006; NPCK, 2017).

There has been increasing consumption of French fries and potato crisps in most countries including Kenya. The French fries and crisps are quite popular due to their tasty flavor as well as quick, convenient preparation and consumption both at home and retail points (Tajner-Czopek *et al.,* 2008). Steroidal glycoalkaloids are heat-stable toxicants that are not affected by temperatures up to 300 ^{0}C. During production of potato products, the GAs may decrease (e.g., during peeling) since the highest concentration is usually on the peels although levels may increase if there is interruption in the processing of raw products before cooking. Peeling and slicing reduces the total glycoalkaloids significantly (Tajner-Czopek, 2008).

There are concerns in relation to glycoalkaloids when in high concentrations, since they result to health risks besides teratogenicity although the latter has not been well researched on (Friedman *et al.,* 1997). It has been shown that an intake of 1– 3 mg GA kg^{-1} of body weight may result to intoxication. Although human susceptibility to GA poisoning is both high and variable, the symptoms for health complications due to ingestion are mainly

gastroenteritis, gastrointestinal discomfort, diarrhoea, vomiting, fever, low blood pressure, fast pulse rate besides neurological and occasional death in human and farm animals if intake exceeds 3 - 6 mg/kg body weight (Hellenäs *et al.,* 1992).

In Kenya demand for potato snacks is on an increasing trend. Potato post-harvest handling and transportation practices in the country are poor (Abong and Kabira, 2015) and therefore levels of GAs in these products may be high. Glycoalkaloids are usually not destroyed during cooking and consequently, the safety of consumers may be at risk. This study therefore aimed at determining the GAs levels in French fries and crisps sold in Nairobi County.

Materials and Methods

This research was conducted in Nairobi County. Forty eight (48) samples of French fries were bought from high, middle and low level fast food outlets in a ratio of 1:3:1 respectively, within the County in duplicates. For this study, low level outlets were ranked as those selling French fries at less than $0.40 per serving along streets and suburbs while high end are those charging more than $1 in well-furnished hotels and middle level sell a packet of fries between $ 0.4 – 1 per serving. Potato crisps sample were bought from supermarkets and local vendors in a ratio of 3:1, respectively due to the high levels of sale by supermarkets selling various brands of potato crisps compared to the unbranded crisps in local shops. Thirty six (36) Branded potato crisps each weighing 50 g were randomly bought from various supermarkets while 12 samples each weighing 30g of unbranded were randomly procured from local vendors. All samples were bought in duplicates.

Determination of glycoalkaloids. The levels of glycoalkaloids were determined by high pressure liquid chromatographic methods using Waters HPLC (Waters 2695- Waters corporation, USA) and detection set at a wave length of 202 nm using photodiode array detector (Waters 2996, USA). Twenty grams (20g) of each sample were oven dried to a constant weight at 135°C. The dry samples were ground and packaged in sealed plastic bottles and stored until further analysis.

Extraction of glycoalkaloid*s*. Dried samples (2 g) were mixed with 20 ml extraction solution comprising of water, acetic acid and sodium hydrogen bisulfite (100 + 5 + 0.5, v/v/w) and shaken for 15 minutes by Burrell vertical shaker (Burrel Corp, Pittsburg, UK). Clarification was done by centrifugation for 30 min at 3500 rpm using Labofuge A (Heraeus, Germany). Defatting was completed by using 2 ml petroleum ether (Analytical grade) and the supernatant collected and stored at 4°C until further analysis. The samples were cleaned using Solid Phase Extraction columns and the final volume collected was adjusted to 5 ml with LC mobile phase filtered through a 0.45 µm filters into vials and frozen ready for injection.

Chromatographic analysis. The HPLC machine (Waters-2595, USA) was fitted with stainless steel LC column.—250 ×4.6 mm, packed with Hypersil ODS (Shandon Southern Products Ltd., Astmoor, UK), 5 µm particle size, C18 phase. The operating conditions included a flow rate of 1.5 ml/min, injection volume of 50 µl, run time of 15 minutes, column temperature of 40 °C and wavelength detection set at 202 nm. Glycoalkaloids were calculated based on external calibration curves generated from standards stock solutions and expressed as mg GAS/kg on dry weight basis. The data were analysed statistically using GENSTAT v 15 software. The results were analysed

using one-way analysis of variance with the application of Tukey's test ($P \leq 0.05$).

Results and Discussion

The crisps samples moisture level ranged from 1.09 to 4.49% with a mean of 2.57%. None of those sampled exceeded the set limit by Kenya Bureau of Standards for crisps, stated at 5% (KSEAS:745, 2010). The moisture content for the branded and unbranded crisps were significantly different ($p>0.05$) with the latter having a higher mean value at 2.41% and 3.03% respectively. This may be as a result of poor packaging after processing resulting in reabsorption of water and lack of standardized processing conditions as compared to the branded which adhere to standards of production. The moisture content for sampled French fries varied significantly ($P<0.05$) from 36.26% to 62.20% with a mean of 50.11%. There were significant differences ($P<0.05$) for samples from the street vendors, middle level and high end outlets and the samples averaged 49.48%, 51.14% and 47.49% respectively. These findings are in agreement with others. The high end hotels had their samples with the least moisture which made their products the crunchiest. The middle level outlet may have their fries with highest level of moisture contents as most people buy from their outlets therefore the fries are not given enough time to dry during processing.

The total glycoalkaloids levels varied significantly among samples ($P<0.05$) ranging from 19.62 to 128.12 mg kg^{-1} and averaged 56.29 mg kg^{-1} for crisps. On average the GAs contents for branded crisps was 58.08 mg kg^{-1} while 50.94 mg kg^{-1} GAs for unbranded crisps was obtained. The concentrations of α-solanine and α-chaconine for crisps samples varied significantly and ranged from 9.22 to 79 mg kg^{-1} and 8 mg kg^{-1} to 67.52 mg kg^{-1}, respectively. The total glycoalkaloids levels for the branded and unbranded crisps were not significantly different ($p<0.05$) although unbranded samples had lower levels of GAs compared to branded ones. This can be as a result of long storage periods before processing for branded crisps as most are processed in bulk in factories compared to unbranded crisps whose processing takes place in smaller quantities by small scale processors. The findings showed far much higher levels of GAs compared to in other studies. Liu *et al.* (2014) reported a range of 13.7 - 46.60 mg kg^{-1} for α-chaconine, and 2.7 - 13.9 mg kg^{-1} for α-solanine. Other similar studies have shown lower levels reported for the GAs, 3.5-5 mg kg^{-1} dry weight by Tajner-Czopek *et al.* (2008) and 2-29 mg kg^{-1} dry weight by Smith *et al.* (1996).

The total glycoalkaloids for French fries ranged from 3.28 to 65.00 mgkg^{-1} dry weights with a mean of 20.57 mg kg^{-1} d.w GAs. The GAs levels in the French fries from street vendors, middle level and high end outlets were not significantly different ($P>0.05$). Therefore the risk of exposure to consumers may be the same regardless of the place of purchase. The GAs content for the sampled French fries were equally higher compared to other findings such as 0.8 - 8.4 mg/kg^{-1} d.w reported by Friedman (2006), 0.4 – 8.0 mg/kg^{-1} dry weight by Friedman and Dao (1992) and 3.49-5.57 mg/kg^{-1} dry weight by Tajner *et al.* (2014). This difference may indicate poor postharvest handling of potatoes n Kenya that result in high GAs levels in the raw tubers.

The ratio of α-solanine to α-chaconine averaged 1:1.14 for crisps and 1:1.13 for fries. Since α -chaconine is more toxic compared to α -solanine, it is necessary to have the ratio as low as possible The α-chaconine and α-solanine quantities from the samples had a significant (P <0.0001) positive correlation, with Pearson's coefficients (r) of 0.946 for the crisps and 0.944 (P <0.001) for fries. This is an indication that both GAs occur simultaneously in the potato flesh and are both insignificantly affected during processing.

Conclusions

The levels of glycoalkaloids in the sampled products were lower than the recommended limits although, the levels were much higher compared to in other findings, an indication of the poor post-harvest handling practices by farmers and vendors. There is need to carry out consumer, farmers and processors awareness on the need for ensuring good post-harvest practices for potatoes in order to guarantee safe potato products by minimizing GAs occurrence in raw tubers. Constant monitoring of potatoes used in making products as well as carrying out analysis of sold products to ensure that the safe limits are not exceeded is also essential.

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