Title:

Sweet Potato Ketchup: Feasibility, Acceptability, and Production Costs in Nairobi, Kenya.

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ABSTRACT

Ketchup sauce is increasingly becoming a popular condiment used as a flavouring ingredient in fast-food business of French-fries in East African urban areas. It is one of a myriad of products that can be made by using sweet potato roots. In this report, we assessed the feasibility, consumer acceptability, and cost of production for the ketchup sauce made by substituting tomatoes by sweet potatoes. The final product, where up to 80% tomatoes were substituted by sweet potato, was found to be organoleptically acceptable. The yellow flesh colour of the sweet potato had a good influence on the final consumer preference of the end product. Adding sweet potato in the ketchup formulation had little influence on the final pH, which ranged from 3.8 to 4.1. Titratable acidity values ranged from 0.36 to 0.60 g acetic acid per 100 g sauce. The shelf life test indicated that the ketchup sauce incorporating sweet potato could safely be stored for 2 to 3 months. The addition of sweet potato in the ketchup formulation significantly reduced the production cost of the sauce.

Key Words: East Africa, French-fries, *Ipomoea batatas*, Post-harvest, Sauce, Utilisation.

RÉSUMÉ

En Afrique de l'Est, la sauce "ketchup" devient de plus en plus un condiment populaire pour aromatiser les frites dans les commerces urbains d'aliment prêt-à-emporter; en plus, elle est parmi plusieurs produits dont on peut fabriquer à partir de la patate douce. Dans cet article, nous avons évalué la faisabilité, l'acceptabilité par les consommateurs et le coût de production de cette sauce, fabriquée en substituant de la matière première habituelle, de la tomate, par de la patate douce. La sauce dont le remplacement de la tomate par de la patate douce est allé jusqu'à 80%, a été trouvé acceptable sur le plan sensoriel. L'utilisation de la patate douce à chaire jaune a eu un effet bénéfique sur la préférence du produit par les consommateurs. L'addition de la patate douce dans la formulation de cette sauce a eu peu d'influence sur le pH final du produit, et ce dernier a oscillé entre 3,8 et 4,1. L'acidité titrable a varié entre 0,36 et 0,60 d'acide acétique par 100 g de sauce. Le test de durée de vie du produit a montré que le produit fini pouvait être entreposé pendant 2 à 3 mois sans détérioration ou danger pour les consommateurs. L'addition de la patate douce a réduit sensiblement le coût de production de la sauce.

Mots-clés: Afrique de l'Est, Après-récolte, Frites, *Ipomoea batatas*, Sauce, Utilisation.

INTRODUCTION

There is a relentless increase of population pressure, together with the urgency of environmental conservation, which accelerates the migration of people from countryside to cities. There is a declining rate of increase in yield potentials for higher value commodities such as maize, wheat and rice. This reflects only some of the considerations that call for greater efficiency in the exploitation of what is already available. The problems extend from harvesting through storage and processing to distribution, marketing and final use. These factors have wide implications for poverty alleviation and sustainable production.

Sweet potato (*Ipomoea batatas*) is an important food crop in East Africa, and plays a major role as a famine reserve for many rural and urban households because of its tolerance to drought, short growth period, and high yield with limited inputs on relatively marginal soils (Bashaasha *et al.*, 1995; Ewell, 1993). Its utilisation is currently very narrow; it is essentially consumed boiled in the fresh form. The limited range of ways and availability on the market of adapted processing technologies in which sweet potato is utilised in the region of East Africa seriously undermine the potential benefits of the crop to farmers and consumers (Hagenimana *et al.*, 1998). It is unlikely that further development of the crop will be successful unless full attention is paid to its end uses as food, animal feed and as an industrial raw material.

There are myriad of products that can be made using low priced sweet potato as a major ingredient (Ge *et al.*, 1992). Sweet potato processing into products with a taste and appearance similar to other marketable processed items has proven to be cost-effective enough to make them competitive (Omosa, 1997; Hagenimana and Owori, 1997), and manufacturing of these products would benefit:
-farmers through creation of better markets for their sweet potato and participation in an integrated production-processing-marketing system to add value to their produce;
-food processors through the use of a reliable, low price, abundant and nutrient-rich raw material;
-consumers through the access to low-priced and nutritious products.

Sweet potato is a starchy commodity whose proximate composition, mineral and vitamin content-particularly vitamin A (Woolfe, 1992) is comparable to various fruits. This similarity in composition of sweet potato and fruits served as the basis for development of several food products in Asia like candies, jam, juice, and ketchup sauce (Truong, 1992).

Ketchup is a popular condiment now used in daily meals of many urban East Africans as a flavouring ingredient in various culinary recipes, and goes exceptionally well with one of the fastest growing fast-food industry of French fries in urban areas of East Africa (Walingo *et al*., 1997). Hollingsworth (1997) recently indicated that the sustained growth in the staggering popularity of fast-food cuisine paralleled a long-term trend to eating more meals on the go and behavioural changes almost always tended to be convenience driven.

Traditionally, ketchup is usually prepared from tomatoes. Tomatoes are a very perishable and expensive raw material, mainly grown in East Africa using a heavy input of pesticides (Muroki *et al*., 1997), and their use in processing ketchup dramatically increase the production costs of the sauce. The main characteristics of a fast-food ingredient, however, should be its low price, local availability and be produced in large quantities to meet the high demand.

To overcome the tomato-related problems and reduce the costs of production for the popular ketchup sauce, a study was undertaken to substitute tomatoes by more available and low-priced sweet potatoes in ketchup processing and assess the acceptability of the end product by consumers from Nairobi, Kenya.

MATERIALS AND METHODS

Plant material

Fresh sweet potato roots from Koganesengan (CIP440118) and Chinchano (CIP420051) cultivars were provided by the breeding service of the International Potato Center (CIP), regional office in Nairobi, Kenya. These cultivars were randomly chosen from a list of 80 cultivars and differed in the dry matter content and flesh colour. Sweet potatoes were grown during the short-rain season of 1996 at the farm of the Faculty of Agriculture of the University of Nairobi in Kabete. Medium-sized sweet potato roots were maintained under ambient air conditions, washed, and processed 3 days after harvest. Ripened *Romav* variety tomatoes used in this study were purchased from a local market in Nairobi.

Dry matter determination

Two whole roots were randomly selected from each cultivar, washed, and divided into small cubes. Dry matter content was determined by drying triplicate 20-g samples at 65°C for 72 h in a forced-air oven.

Carotenoid determination

Carotenoid content was determined as described by Imungi and Wabule (1990). Total carotenoids were extracted in acetone from 2-10 gram samples of fresh sweet potato roots or tomatoes until the extract was colourless. The acetone solution was transferred to a separating funnel and the pigment was transferred into petroleum ether (40-60°) and the acetone layer discarded. The petroleum ether extract was brought to 100 ml and then, 25 ml of the extract was concentrated using a rotary vacuum evaporator at 30°C, the residue dissolved in 1 ml of petroleum ether, and the solution introduced onto a silica gel chromatographic column with β-carotene (C-9750, approx. 95%, Sigma, St. Louis, USA) as standard. Separation was run using petroleum ether and the β-carotene fraction collected. Absorbance was read at 440 nm using a spectrophotometer. Concentrations were determined by comparison with a standard curve developed using pure β-carotene from Sigma.

Other measurements

pH, total soluble solids, and total titratable acidity were determined according to standard food analysis methods (Pearson, 1976).

Sensory evaluation

Sensory analysis of ketchup quality was performed by an untrained panel consisting of 20 students and staff of the Department of Food Science and Nutrition, University of Nairobi, in a laboratory designed for sensory testing of foods. The samples of ketchup were evaluated for quality acceptability (taste, flavour, colour, and overall acceptability) on a 9-point hedonic scale of 1=extremely dislike and 9=extremely like. Analysis of variance using the Statistical Package for Social Sciences (SPSS) program was carried out to compare the difference in ketchup quality as affected by the addition of sweet potato.

Shelf life test

The accelerated shelf life test was used. Ketchup samples were held at 55ºC, 75-80% RH, and at this high temperature, each day stability of the pH and total soluble solids was considered to be equivalent to one month stability of the product in the real conditions.

Ketchup preparation

Sweet potato roots were washed, trimmed, peeled and cut into chunks and then boiled. The boiled chunks were pureed using a Philips blender type HR2810 Standmixer, and the sweet potato puree consistency was adjusted to a mash by adding water. The tomato juice extraction involved the heating of tomatoes before breaking in order to inactivate pectolytic enzymes, which would otherwise lower the quality of the juice and reduce the yield. Heated tomatoes were broken up and then mashed to produce a slurry. The slurry was slowly cooked until a homogeneous product was obtained. The homogeneous slurry was filtered to remove seeds and peels, and the total solids of the juice stepped up to 10% using sugar. The tomato juice and sweet potato mashes were then used to make further trials. Table 1 shows the different combinations of tomato juice and sweet potato slurry. Some combinations required addition of colour adjustment with 100% tomato ketchup as a standard.

The sweet potato and/or tomato slurry was placed in a cooking pan together with a tied muslin bag containing spices (pepper, chilli, Cayenne pepper), chopped onions and garlic, and the required amount of water added, and the heat was slowly applied to enable the diffusion of the spices from the cloth to the sweet potato and/or tomato slurry. At 15ºBrix, salt and sugar were added. Cooking continued until 28ºBrix, and vinegar slowly added before the end of cooking. The prepared ketchup was bottled, capped, cooled, and tasted a week after its processing.

RESULTS AND DISCUSSION

Raw material composition

Some characteristics of the raw material are shown in Table 2. Chinchano (CIP420051) sweet potato cultivar had the highest dry matter of 30% and tomatoes, the lowest. The colour of the raw material was respectively yellow, white and red for Koganesengan (CIP440118), Chinchano (CIP420051) sweet potato cultivars, and tomatoes. β–Carotene content was higher in yellow fleshed sweet potato cultivar than in the white, confirming previous results from Ameny and Wilson (1997), K'osambo *et al*. (1998), Low *et al*. (1997), and Takahata *et al*. (1993) that the intensity of orange colour of the flesh sweet potato roots is attributed to high carotenoid content.

Product characteristics

Colour

The colour of ketchup was subjectively determined and ranged between yellow and red. Standard ketchup made from tomatoes was dark orange almost red and similar to that where sweet potato substituted tomato up to 60% (Table 3). The colour of all the products was highly pleasant and was of a dark yellow for ketchup made from 100% sweet potato, cultivar Koganesengan (CIP 440118). The flesh colour of the root had good influence on the end product. We noted that yellow-fleshed sweet potato, cultivar Koganesengan (CIP 440118), required less food colour than the white-fleshed coloured cultivar Chinchano (CIP420051) and this trend was expected to be more pronounced if the colour of sweet potato were deep orange.

pH

The pH of the product was measured using a pH meter (Pye Unicam, model 290 Mk2). pH is an important measurement of eating quality since it contributes to taste. Table 3 shows the pH for the ketchup produced using different combinations of sweet potato and/or tomato. The pH of the ketchup was acidic and ranged from 3.8 to 4.1. Addition of sweet potato in the recipe had little influence on the pH of the product.

Total soluble solids

Total soluble solids were between 29^0 Brix and 35^0 Brix. Table 3 shows the range of total soluble solids in ketchup made using different combinations of sweet potatoes and tomatoes. The total soluble solids according to the Kenya Bureau of Standards regulation should be minimum 28^0 Brix (Kenya Bureau of Standards, 1990).

Titratable acidity

Total titratable acidity was determined in the ketchup by direct titration with NaOH and calculated as % of acetic acid. All the combinations involved an equal amount of vinegar. Titratable acidity values ranged from 0.363 to 0.600 g acetic acid per 100 g ketchup. The variability in the titratable acidity observed within different combination may be due to the initial acidity in the raw material or to the length of cooking time after the vinegar was added. Also, apart from ketchup samples made from 100% tomatoes, all other combinations required colour adjustment by red and/or yellow food colours that had to be done after the vinegar had been added to the product. Vinegar having a pronounced influence on colour, the high value of titratable acidity observed in the ketchup made from 100% tomato could be explained by the fact that in such samples, no colour adjustment was required. Therefore, cooking time after the vinegar was added, was generally less than for other combinations, involving less chemical changes in the product.

The Brix to acid *ratio* reported in Table 3 is an important characteristic for the ketchup since it is an indication of the product sweetness with implications on the taste and the eating quality. When the ratio is very high, that indicates a sweet product. When it is too low, it means an acidic product although the acidic taste might be masked by the sugar.

Our results in Table 3 indicate that ketchup samples having sweet potato had their ratio very high. Samples where up to 60% of tomato was substituted by cultivar Chinchano (CIP420051) sweet potato had a ratio Brix to acidity similar to that of 100% tomato ketchup. However, more substitution of the tomato increased that ratio (Table 3). This was explained by the high sugar content found inherently in the sweet potato, and the sugar content increased when more and more sweet potatoes were used into the recipe.

Sensory evaluation

Consumers sensory response to the various combinations using sweet potato in ketchup formulation was determined using a nine-point scale in the hedonic rating. The main sensory attributes of sweet potato and tomato ketchup are shown in Table 4. Four attributes, taste, aroma, appearance and overall acceptability were assessed, and the data obtained from 20 panellists were analysed. One way ANOVA was used to test for differences in the means of scores for the various sensory attributes as influenced by substitution of tomatoes with sweet potatoes. Where significant differences were found, the Least Significant Difference (LSD) test was run to sort out the homogeneous subsets at $P \leq 0.05$.

Ketchup made from Koganesengan (CIP440118) sweet potato cultivar had generally higher score of acceptability for taste, aroma, appearance, and overall acceptability when the substitution was above 80%. However, at such high level of tomato substitution, the ketchup was not acceptable by most of the consumers. Cultivar Chinchano (CIP420051) made an acceptable ketchup up to the substitution of 70% (Table 4), while Koganesengan (CIP440118) was still scoring high levels of acceptability up to the substitution of 80%. The highest scoring combination was of 100% tomatoes which got a mean of 8.2 as the most preferred ketchup followed by the ketchup made from the substitution of 50% using cultivar Chinchano (CIP420051) sweet potato. Our results suggest that a good choice of sweet potato cultivar could highly enhance the sensory scores, especially the taste and overall acceptability. Using Student t-test, taste and overall acceptability were higher for the yellow-fleshed cultivar at 1% level. We also observed that the yellow colour of the sweet potato flesh had a good influence on the panellist preference for the ketchup.

Shelf life test

The pH and total soluble solids (^{0} Brix) measurements were taken as major indicator for the stability of the ketchup. Figure 1 shows the pH variation during the test of shelf life of ketchup samples where 100, 70, 50, and 0% sweet potato, cultivar Koganesengan (CIP440118), was used in the recipe. There was a clear decrease in pH from the second day indicating an acidification of the product. This may be due to the result of hydrolysis of inherent starch to glucosidic products by acetic acid at high temperatures. The total soluble solids showed a slight increase, which was not significant. The colour of the product tended to darken with the increase of storage days and the consistency of the products slightly changed. These changes were, however, significant for sample made using 100% sweet potato. The changes observed and analysis done during the shelf life test indicated that the ketchup incorporating sweet potato could safely be stored for 2 to 3 months.

Production costs

Table 5 shows the calculated costs of a 200-ml bottle of ketchup made using different combinations of sweet potato and tomato. The prices are only indicative and were found using the raw material bought at the retail stores from Nairobi City Market. The more the concentration of tomatoes used in the combinations, the more expensive the production costs of the ketchup was. The price was Kshs 34.30 (US$ 0.57) for 200 ml of ketchup made out of 100% tomato. When sweet potato was used, the products were much cheaper (Table 5). The substitution of 50% tomato by sweet potato gave a product costing Kshs 22.20 (US$ 0.37) per bottle, for both varieties while that of a 100% substitution gave a ketchup costing only Kshs 10.50 (US$ 0.18) per 200 ml.

CONCLUSION

The study has shown that tomatoes can be substituted with sweet potatoes in ketchup manufacture. The sensory evaluation results indicated that the panellists were unable to distinguish combinations containing sweet potatoes between 50% and 80%. They were, however, able to distinguish ketchup having 100% sweet potatoes from other types of ketchup combinations. The flesh colour of the root has a significant influence on the colour of the final product, the orange colour giving a better product. The study also showed that the concentration of sweet potatoes in the ketchup formulation had a significant influence in the reduction of production costs. More work is still needed in the formulation and adjustment of ketchup texture where 100% sweet potato has been used.

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FIGURE 1. pH variation in the ketchup shelf life test
Samples were incubated at 55°C, 75-80% RH. 100, 70, 50, and 0% represent, respectively, samples where 100, 70, 50, and 0% sweet potato roots, cultivar *Koganesengan* (CIP440118), was used in the recipe.