

Sweetpotatoes in processing of doughnuts: Feasibility and acceptability in rural areas¹.

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ABSTRACT

Sweetpotatoes (*Ipomoea batatas*) storage roots with a high dry matter content, either in steamed and mashed, raw and grated or flour form, were used to partially substitute wheat flour in processing of doughnuts. The feasibility, consumer acceptability, and cost of production of the product in Lira Municipality, Uganda, have been studied. It has been found that doughnuts containing sweetpotato are highly acceptable and competitive, and small-scale businesses of such fried processed products incorporating sweetpotato are starting in the area.

INTRODUCTION

Sweetpotato (*Ipomoea batatas*) is an important subsistence crop in East Africa, and it 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 utilization is very narrow: it is essentially consumed boiled in fresh form. The limited range of ways and availability of adapted processing technologies in which sweetpotato is utilized in the region seriously undermine the potential benefits of the crop to farmers and consumers.

However, there are myriad of products that can be made using sweetpotato as a major ingredient (Ge et al., 1992). Gatumbi and Hagenimana (1995) have shown that sweetpotato roots are starchy and are quite suited to deep-frying during the production of crisps (called "chips" in the United States). Gakonyo (1993), Omosa (1994), and Hagenimana et al. (n.d.) have shown that sweetpotato either in fresh grated, boiled and mashed, or flour form could, with high potential of success, can partially replace wheat flour in processing of fried and baked products. Furthermore, Hagenimana and Owori (1996) have reported that wheat flour is too expensive in a such manner that the cost of a 2-kg pack is equivalent to a 3-day salary of a casual worker in Lira Municipality, Uganda.

Small-scale businesses of such fried processed sweetpotato products, especially mandazis (doughnuts) constitute an important economic activity for women on the most markets of East Africa. However, little has been done up to now to improve the quality and cost of the production of those important food products.

The purpose of this work is to determine the feasibility and acceptability of processing doughnuts where wheat flour has been partially substituted by sweetpotato.

MATERIALS AND METHODS

Plant material

Fresh sweetpotato roots (a mixture of local varieties) were bought from Lira Municipal market.

Sweetpotato flour

Sweetpotato flour used in this study was processed out of dried sweetpotato slices purchased from a farmer in Lira, Uganda. They were from a mixture of white-fleshed varieties and processed according to the general schema described in Figure 1. After harvesting, sweetpotato storage roots are usually kept in the sun for 2-3 days, hand-peeled, sliced, and sun-dried. After peeling, they are often crushed instead of slicing and dried. Sun-dried sweetpotato slices are reportedly very sensitive to attack by storage weevils. To prevent such damage, some farmers in Tanzania parboil or blanch the slices at the boiling temperature of water for 3-5 min and then dry them for 2-3 days before storage (Dr. Kapinga, personal communication). After parboiling, a hard protective layer forms during the sun-drying period because of gelatinized starch at the surface of the slices. This hard layer seems to prevent storage weevils from penetrating into the slices.

Sweetpotato slices used in our trial were ground in a posho mill at Dokolo International Inc. in Lira.

Wheat flour

The wheat flour used was that generally used for mandazi-making at Lira market. It was milled by UNGA Limited, Commercial Street, P.O. Box 30386, Nairobi, Kenya.

Mandazi processing

Mandazis were made from the following recipe: 1.5 kg of boiled and mashed or raw and grated sweetpotato roots (Kemb 10 variety, also called "Tanzania"), 1.5 kg of wheat flour from UNGA Ltd., Nairobi, Kenya (when sweetpotato flour is used the ratio is 3:7 sweetpotato flour to wheat flour), 250 g of sugar, 2 tablespoons (about 10 mL) of baking powder, 5 tablespoons (about 25 mL) of "Elianto" corn oil, and 2 1/4 cups (about 500-600 mL) of water.

Dry ingredients were mixed together and a well was made in the centre where the oil was placed and mixed. Sweetpotato was added and then water was added slowly and gradually. The mixture was hand-kneaded until a soft dough was formed. The dough was left to relax for 10-15 min and was then rolled on a floured pastry board to the thickness of 1.25 mm as reported by Oyunga (1994). It was then cut into approximately equal pieces that were deep-fried until brown. A control was processed using only wheat flour.

The oil content of samples was determined in triplicate as described by Lulai and Orr (1979). Samples were finely ground in a blender, a 5-g mixture sample was put into a thimble, and a 6-h Soxhlet extraction conducted using petroleum ether. Data were analysed using the MSTAT-C program (MSTAT-C, 1991).

RESULTS AND DISCUSSION

Oil content in mandazis incorporating sweetpotato

Figure 2 shows oil content of mandazis containing sweetpotato. The effect of incorporating boiled and mashed, raw and grated sweetpotato in a quantity of 50% or sweetpotato flour (30%) in the mixture of chapati was not significant at the 5% level. The effect of incorporating sweetpotato in the mandazi mixture was significant (Figure 2). Substituting 50% of the wheat flour with boiled and mashed sweetpotato reduced oil in mandazis significantly (Figure 2). When this substitution was in the form of raw and grated sweetpotato, oil uptake increased threefold. There was no difference in oil uptake between substitution of 30% wheat flour with sweetpotato flour and no substitution.

The reduced oil uptake in mandazis containing boiled and mashed sweetpotato may be related to a decrease in roughness, a possible change in mixture porosity, and different water binding affecting water diffusion rate conferred by sweetpotato. In addition, Duxbury (1989) reported that the nature of batters and breadings could influence oil absorption. Batter coating apparently functioned to reduce water loss during frying, which, in turn, lessened oil absorption. Incorporation of long-fiber cellulose, powdered cellulose, or cellulose derivatives into batters or doughnut mixes also reduced oil uptake during frying (Ang, 1990; Ang et al., 1991; Henderson, 1988). It is possible that the properties of sweetpotato root cellulose are suitable for reducing oil uptake; however, much more research is still required to confirm that. We recently reported that the oil content in such products fried in "Elianto" brand (oil) and those in "Kasuku" brand (fat) was not significantly different (Hagenimana et al., 1996) which is particularly relevant in the choice of oil type for use in sweetpotato frying, especially when there are as many as 39 different brands of oils and fats in Nairobi supermarkets (Hagenimana and Oyunga, 1995).

Consumer acceptability

Acceptability was evaluated by comparing sweetpotato mandazis (substituting wheat flour for sweetpotato flour or cooked and mashed sweetpotato) with the mandazis the

consumer has just bought from the market or usually buys. Attributes such as sweetness or sugary taste, colour, filling, appearance (grain, texture, crust and crumb colour), apparent freshness, taste, and oiliness were judged subjectively by mandazi consumers.

Figure 3 gives the characteristics of acceptability for 3 different types of mandazis at Lira main market. In total 42 mandazis consumers were interviewed to comment on different characteristics of the product. Mandazis with cooked and mashed sweetpotato ranked as the first choice for the most of consumers. It had the best sugary taste, appearance, and freshness (Figure 3); its colour and oiliness were adequate, and the general taste was good. Mandazis with sweetpotato flour was classified as the second choice for most of characteristics especially for its freshness, appearance and sweet taste. They almost tied with the mandazis usually bought. Their oiliness aspect was high.

Price

Some 80% of consumers interviewed at the main market in Lira said that they would pay the same price for the mandazis made from ingredients including cooked and mashed sweetpotato as for mandazis usually bought (Figure 4), 10% would pay more and the rest would pay less. For the mandazis with sweetpotato flour, 65% of consumers expressed their willingness to pay the same price as for mandazis usually bought, while 30% said that they would not pay. 5% suggested to pay more for mandazis containing sweetpotato flour.

Costs of production for mandazis

The production costs illustrated in Table 1 use the cost of ingredients and other inputs of the mandazi recipe as a comparison with the product incorporating sweetpotato. Cost and labour inputs for mandazi were collected from Konya-Adong Women's Group, and were readjusted with the data collected when we were processing the mandazis for our trials at New Lango Restaurant, Lira, Uganda.

The comparison of cost production shown in Table 1 indicated that using cooked and mashed sweetpotato or flour increase the net revenue per piece of mandazi by 9.4 UShs (68%). There is an increase of 55.8 in the % net revenue cost ratio of the

product by using cooked and mashed sweetpotato and 56.3% increase by using sweetpotato flour.

Apart from wheat flour, the other expensive ingredient is the oil. The data clearly indicate that it is cheaper to produce sweetpotato mandazi than to produce 100% wheat mandazis. This is mainly due to the reduction in wheat cost and sugar. The cost related to water and firewood in case of washing and cooking sweetpotato have been found to be very minor, and the cost due to oil consumption should slightly decrease according to above mentioned findings.

CONCLUSION

The technology of sweetpotato use (either in cooked and mashed, or flour form) in processing mandazis has been refined and the feasibility adapted to the level of the small processor conditions with no major change in equipment and materials. The activity of trading mandazis in Lira Municipality is significant and employs more than 40 women. Fried products having sweetpotato as an ingredient are highly acceptable by the community from Lira Municipality, and the cost of production indicates that the use of sweetpotato in mandazis is profitable. Cooked and mashed sweetpotato as an ingredient improve the taste, freshness, appearance, sweetness and colour of mandazis. It is recommendable to use orange and yellow fleshed sweetpotato which are rich in pro-vitamin A to replace food colour currently used in the product.

LITERATURE CITED

Ang, J.F. 1990. Reduction of fat in fried foods containing powdered cellulose. Paper presented at the conference on "*Fat and Fiber: Practical Implications for the Calorie Reduced Products*", George Washington School of Medicine and Calorie Control Council, Washington, D.C., Feb. 13-14.

Ang, J.F., Miller, W.B., and Blais, I.M. 1991. Fiber additives for frying batters. *U.S. patent 5,019,406*.

Bashaasha, B., Mwangi, R.O.M., and Ocitti p'Obwoya, C.N, and Ewell, P.T. 1995. *Sweetpotato in the farming and food systems of Uganda. A farm survey report.* NARO and CIP, Kampala, Uganda.

Duxbury, D.D. 1989. Oil water barrier properties enhanced in fried foods, batters. *Food Proc.* 50, 66-67.

Ewell, P.T. 1993. Sweetpotato in Africa: Research priorities to stimulate increased marketing. Paper presented at the *International Workshop on Methods for Agricultural Marketing Research*, 16-20 March 1993, IARI Campus, New Dehli, India.

Gakonyo, N. 1993. Processed sweetpotato: responding to Kenya's urban food needs. *Working papers in Agricultural Economics.* Cornell University, Ithaca, New York.

Gatumbi, R.W. and Hagenimana, V. 1995. Women's role in local sweetpotato crisps processing in Nairobi-Kenya. Paper presented at the *Sixth Triennial Symposium of the International Society for Tropical Root Crops-Africa Branch (ISTRAC-AB)*, Lilongwe, Malawi, 22-28 October 1995.

Ge, L.W., Xiuqin, W., Huiyi, C., Rong, D. 1992. Sweetpotato in China, pp. 41-50. In Scott, G., Wiersema, S., and Ferguson, P.I. (Eds). *Product Development for Root and Tuber Crops. Vol. I-Asia.* Proceedings of the International Workshop, held April 22-May 1, 1991, at Visayas State College of Agriculture (VISCA), Baybay, Leyte, Philippines. CIP, Lima, Peru.

Hagenimana, V., Hall, A., and Low, J. n.d. *Sweetpotato processed products in Kampala, Uganda.* (report in preparation). NRI and CIP, Nairobi, Kenya.

Hagenimana, V. and Owori, C. 1996. *Feasibility, acceptability, and Production costs of sweetpotato baked products in Lira Municipality, Uganda. A study report.* NARO and CIP, Nairobi, Kenya.

Hagenimana, V., Karuri, E.G., and Oyunga, M.A. 1996. Oil content in fried sweetpotato processed products. *Journal of Food Processing and Preservation* (Submitted).

Hagenimana, V. and Oyunga, M.A. 1995. *Brands of oils and fats available on Nairobi market. A survey report.* International Potato Center, Nairobi, Kenya.

Henderson, A. 1988. Cellulose ethers-The role of thermal gelation. In "*Gums and Stabilizers for the Food Industry 4*", Phillips, G.O., Wedlock, B.J., and Williams, P.A. (ed.), p.265-273, I.R.L. Press, Oxford, UK.

Lulai, E.G. and Orr, P.H. 1979. Influence of potato specific gravity on yield and oil content of chips. *Amer. Potato J.* 56, 379-390.

MSTAT-C Program. 1991. *A software program for the design, management, and analysis of agronomic research experiments*. Michigan State University.

Omosa, M. 1994. *Current and potential demand for fresh and processed sweetpotato products in Nairobi and Kisumu, Kenya*. International Potato Center, Nairobi, Kenya.

Oyunga, M.A. 1994. Sweetpotato product development course outline. In: *Seminar to promote processed sweetpotato products in Uganda*, held Sept. 10-17, 1994, at Mukono, Uganda. KARI, Kenya.

Table 1. Production costs for sweetpotato and pure wheat mandazi in Lira Municipality (UShs).

Items	Wheat flour			Cooked & Mashed SP			SP Flour		
	Price per unit	Units	Total	Price per unit	Units	Total	Price per unit	Units	Total
Wheat flour (Kg)	750	0.5	375	750	0.25	187.5	750	0.35	262.5
Sweetpotato (Kg)	20	0	0	20	0.25	5	20	0	0
Sweetpotato flour (Kg)	150	0	0	150	0	0	150	0.15	22.5
Sugar (Kg)	1000	0.08	80	1000	0.07	70	1000	0.07	70
Baking powder (Kg)	3000	0.003	9	3000	0.003	9	3000	0.003	9
Water (L)	2.5	0.039	0.09	2.5	0.037	0.09	2.5	0.041	0.1
Oil (L)	1500	0.06	90	1500	0.06	90	1500	0.06	90
Charcoal (Tin)	100	0.1	10	100	0.2	20	100	0.1	10
Labour (person/day)	500	0.02	10	500	0.03	15	500	0.02	10
Depreciation	0.03	16	0.48	0.03	15	0.45	0.03	18	0.54
Market dues	0.3	16	4.8	0.3	15	4.5	0.3	18	5.4
Total costs			579.37			401.45			480
Revenue	50	16	800	50	15	750	50	18	900
Net Revenue			220.6			348.5			420
Net revenue/mandazi			13.8			23.2			23.3
Net revenue cost ratio			0.38			0.86			0.87
% change in net revenue cost ratio			0			55.8			56.3

Assumptions:

1. The processing of sweetpotato mandazis requires the same amount of oil as wheat flour mandazis.
2. The cost of sweetpotato was calculated from the quantity of unpeeled roots and prices in Lira markets for March 1995.
3. Cost of charcoal: we assumed that the processing of 20 mandazis requires a tenth of a tin. Charcoal is used in fresh sweetpotato cooking and deep frying.
4. Cost of oil: we assumed that about 0.5 L of oil is used and 10% of that oil is absorbed by the mandazis during the process of deep frying. Oil is used in dough mixture and for deep frying.
5. Cost of sweetpotato flour: we assumed that the price of dry sweetpotato chips was 100 UShs/Kg, and the milling cost was 50 UShs/Kg. Total cost was 150UShs/Kg flour.
6. Depreciation: The cost of equipment for standard mandazis production was 18800Ushs. Depreciation was estimated @ 20% p.a., 118800 mandazis per year equivalent to 0.03 Ushs/1 mandazi.
7. Market dues: 3000 Ushs per month, 9900 mandazis per month, and 0.3 Ushs per mandazi.
8. Additional labour for sweetpotato: Labour for peeling, washing, mashing, mixing, rolling, cutting, and frying mandazis made with cooked and mashed sweetpotato takes 13.03 min. Labour cost is 500 Ushs/8h (480 min); equivalent of 13.03 min is 0.2 person/day.

Figure 1. Process of producing dried sweetpotato slices and flour.

Sweetpotato Storage Roots



Washing



Slicing



Drying



Dried chips



Milling



Sweetpotato flour

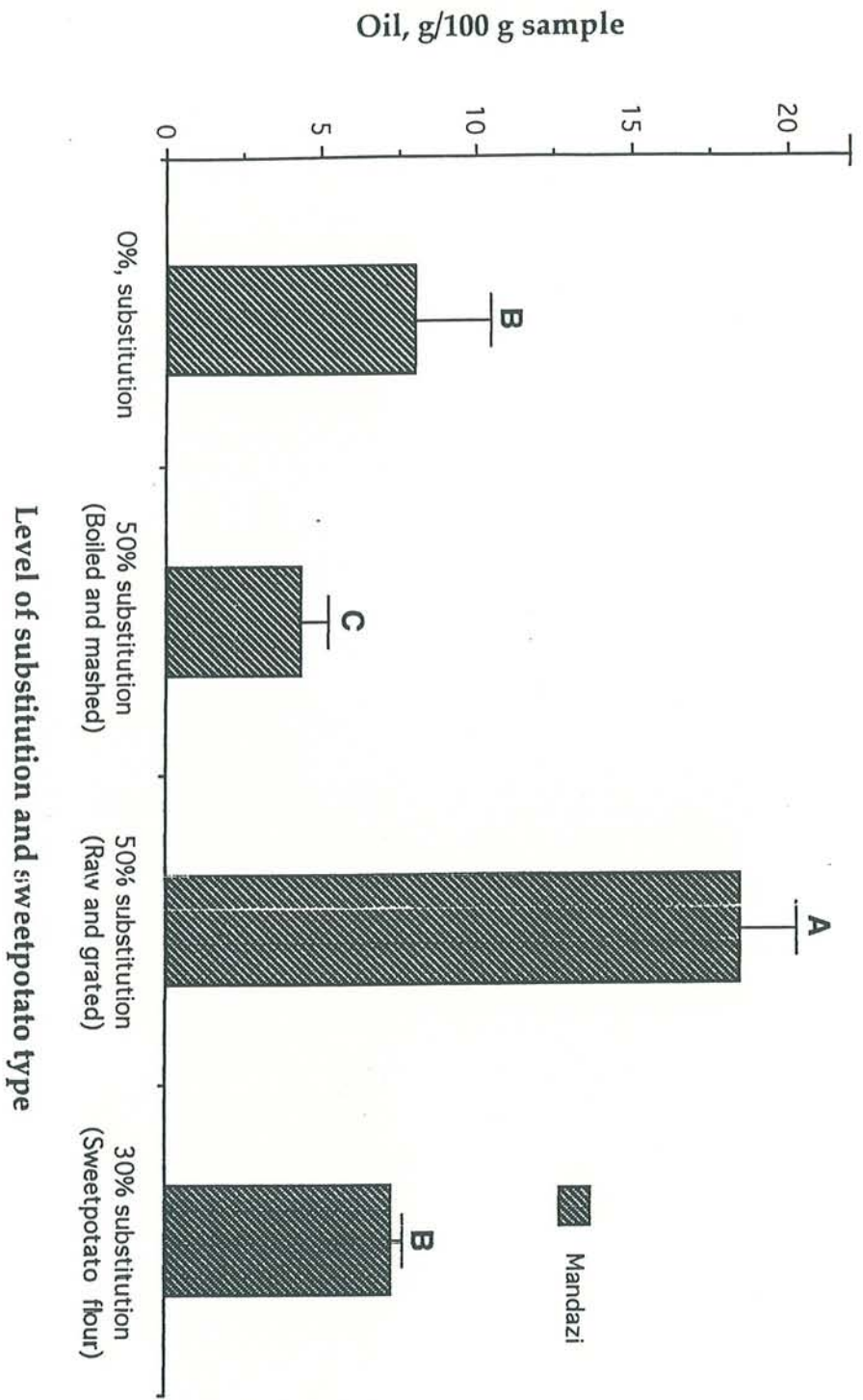


Figure 2. Oil content in sweetpotato mandazis.

(Means followed by common letters for the same processed product are not significantly different at 5% level using LSD test).

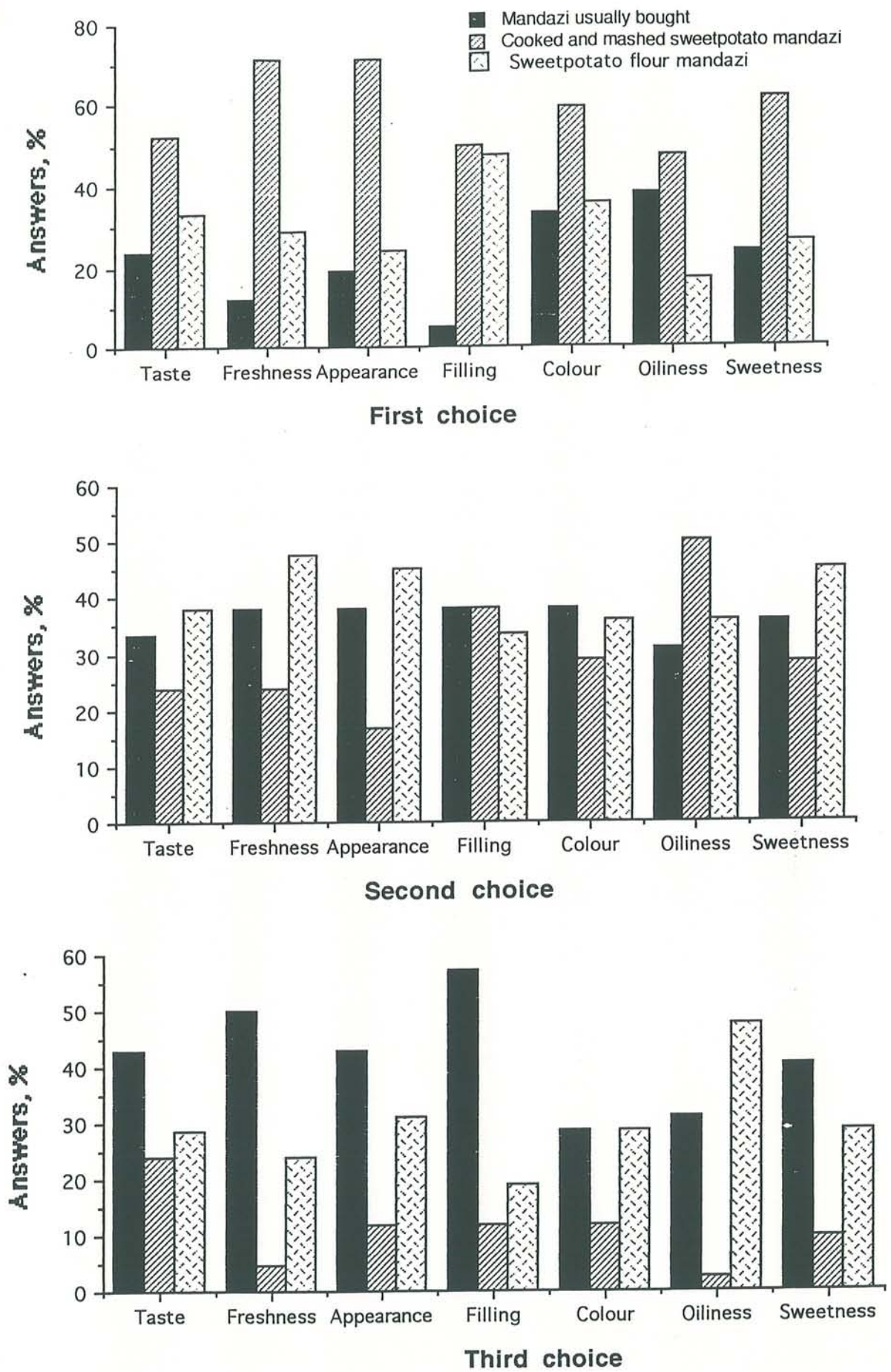


Figure 3. Mandazi characteristic acceptability at Lira main market (sample = 42).

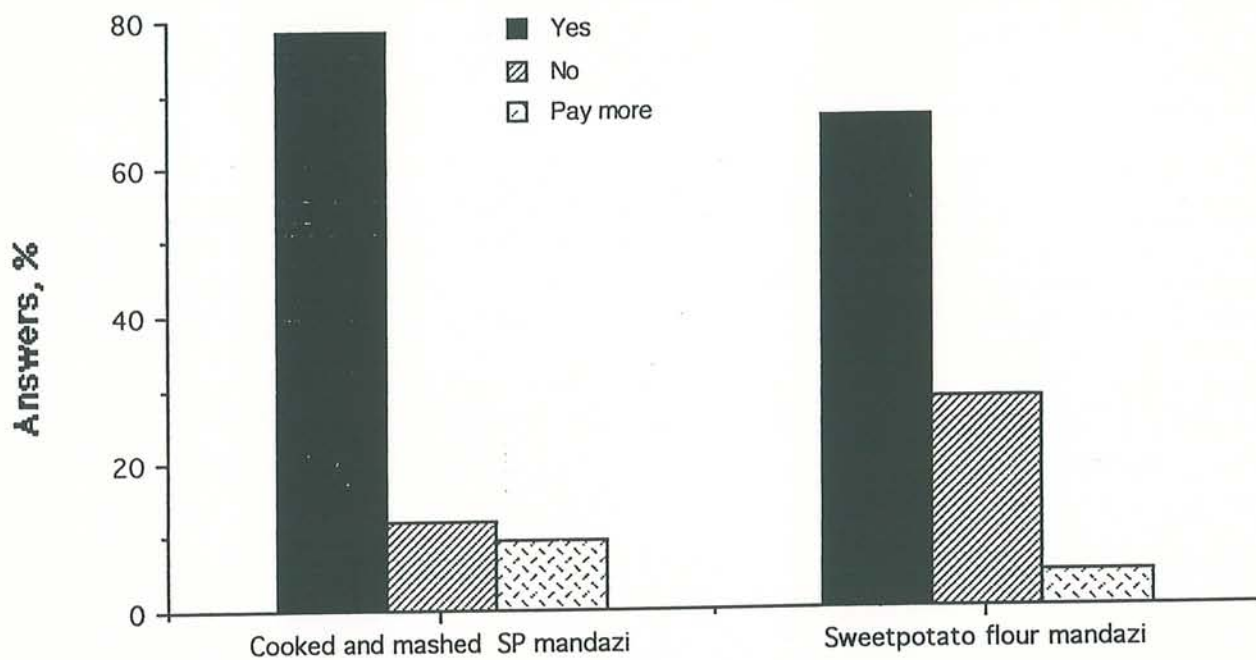


Figure 4. Willingness of consumers to pay the same price as for mandazis just bought at the Lira main market (sample = 42).