Sweetpotato coalition project
NRIL Number - ZB: 0342

Annual technical report – Analysis of selected chemical components of sweetpotato products
(*MAK-FST coalition partner input)*

2003 – 2004

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1 Introduction

It has been reported that farmers of Central Uganda are failing to capture potential gains from sweetpotato (SP) production and SP related enterprises due to limited market access and high post harvest losses. To partly address this problem a SP coalition project was proposed to provide SP post harvest knowledge and technologies to the farmers while creating an institutional mechanism that incorporates and empowers the farmers. The project operates in three target districts: Kiboga, Luweero and Mpigi. The project is at the end of its 2^{nd} year and the following is a report of findings and achievements by Makerere University – Department of Food and Technology's input, as a coalition partner. The SP coalition is composed of farmers, researchers, the private sector and schools representative.

Makerere University – Department of Food Science and Technology as a partner in the coalition project mainly compiles the composition of selected chemical and nutritional components of products generated from the sweetpotato post harvest technologies. The products characterized were some of the new breeds of SP that have been disseminated to farmers and sweetpotato composite flours. Also and evaluation of the effects of farm storage technologies introduced to farmers aimed at enhancing both the livelihood and their food and nutrition security status.

2 Methodology

A number of SP technologies developed by NARO researchers, CIP, PRAPACE and DFID Crop postharvest programmes were introduced to farmers in the target districts (Kiboga, Luweero and Mpigi). An assessment in terms of the chemical composition of SP and the value–added SP products have been completed.

Selected new SP breeds grown by farmers were measured for beta-carotene, starch, dry matter and sugar content. These parameters were identified for their important role on both nutritional and functional properties of SP value-added products.

An experiment on the storage technologies of fresh SP roots was conducted by FOSRI jointly with the farmers in the target districts. The normal storage conditions of farmer fields prevailed, such that they were able to assess the feasibility of the storage technologies introduced.

2.1 Materials

The SP new breeds released to farmers in three target districts of the project area that were procured are listed in Tables 1 and 2. Drying SP to chips for milling to flour was based on Naspot 1 variety, which has been identified as the variety widely adopted by farmers.

All chemical and microbiological reagents used in the analyses were of analytical grade and purchased from local distribution outlets of BDH Ltd and SCIPHOGEN Ltd.

Table 1. Sweetpotato varieties procured for compositional analysis

District	Farmer	Sweetpotato variety	Maturity age (months)
Kiboga	Farmer site 1 - Kibiga David Kyatule	Naspot 1; New Kawogo SPK004	4.5
	Farmer site 2 - Mulagi Ronald Musisi	Naspot 1; Kala ; SPK004	3.5
Luweero	Farmer site 1 - Zirobwe Seytyabula Rajab	Sudan local*; Kala; Ejumula Naspot 1; Naspot 2; SPK004	5
	Farmer site 2 - Zirobwe Gingo	Dimbuka; Ejumula; Naspot 1 Naspot 2; SPK004	5
Mpigi	Farmer site 1 - Nkozi Semanda	Naspot 1	4
		Semanda (also called *Kasujja)*	"
	Farmer site 2 - Kituntu Jaliya Namusoke	Naspot 1	3
	Farmer site 3 – Nkozi Mary Senyonga	Naspot 1	4
		New Kawogo	5
	Farmer site 4 – Nkozi Fiona Nabanda	New Kawogo	6
	Farmer site 5 – Nkozi Vincent Lwanga	Naspot 1	4
Mpigi	Farmer site 1 – Nkozi	Naspot 1	3
		New Kawogo	4
		Soroti	3
	Farmer site 2 – Nkozi	Naspot 1	3
		New Kawogo	4
		Soroti	3
	Farmer site 3 - Nkozi	Naspot 1	3
		New Kawogo	4
		Soroti	3

*: local farmer variety

Table 2. Sweetpotato varieties used for fresh storage structural experiment

District	Parish / Sub county	Farmer	Sweetpotato variety
Luweero	Vumba / Kalagala	Farmer group 1	Naspot 1; Naspot 2; SPK004
	Kabulanaka / Zirobwe	Farmer group 2	Naspot 1; Dimbuka*; Ejumula
Mpigi	Nnindye / Nkozi	Farmer group 3	Naspot 1; New Kawogo; Semanda (*Kasujja*)

*: local farmer variety

2.2 Analytical methods

Dry matter, starch, beta carotene and sugar contents were the physicochemical parameters measured. Dry matter content of SP samples were measured by drying samples (10 g) in a forced-air oven (Gallenkamp Oven 300 series, UK), at 105°C to constant weight in approximately 20 h and data reported on a dry weight basis (dwb).

Individual weight measurements of roots (four to six root tubers) were obtained and mean weights computed.

Starch content of SP root samples were measured using the phenol-sulphuric method (Dubois et al., 1956), and values reported on a dry weight basis. Total carbohydrate content of SP was corrected for free sugars repeatedly washing the macerated sample (stirring in 40% v/v ethanol at room temperature) and thereafter centrifuged to discard the supernatant. A standard glucose curve (0-1.2 g/ml) was used to compute starch content of samples which were converted to starch content by a factor of 0.9, reported on dry basis. Absorbance readings are read at 470 nm using a spectrophotometer.

Beta-carotene content (mg/ 100 g) of the SP root samples was determined by high-performance liquid chromatography (hplc). The hplc protocol for beta-carotene content analysis as adopted by Government Chemist, Uganda is described.

Sugar content in the SP samples (sucrose, maltose, glucose and fructose) were measured according to Picha (1985) by high-performance liquid chromatography.

Microbiological parameters were determined for the flour products viz. total plate count and yeast and mould counts.

3 Findings based on activity milestones

3.1 Output 2 - Activity milestone 2.1.14 (Samples tested for acceptability by farmers and analyzed in laboratory by end of August 2003)

3.1.1 Dry matter content

Dry matter is an important parameter for processing of SP to chips and is one of the criteria used to evaluate SP varieties. It reflects the amount of dried SP that can be obtained, and the degree of mealiness, an important SP textural property desired by consumers. Figure 1 shows the dry matter contents of SP sampled from 3 districts, which were within the range of dry matter analyzed for these new SP breeds by Ssebuliba et al. (2001) and Owori and Agona (2003). Variation in dry matter content based on variety, district and farmer site was evident (Figure 1). All SP varieties contained dry matter content that ranged between 30-40% (Figure 1). The dry matter content for these is similar to that reported elsewhere and even higher incase of some varieties (Oboh et al., 1989)

3.1.2 Beta carotene content

In order to combat the high vitamin A deficiency prevalent in Uganda, a number of interventions are required. Sweetpotato breeders have bred high beta carotene SP with the intention of using it as a cheap source of vitamin A for the low income earners, and rural farmers. It was therefore important to assess the beta carotene content of these new breeds that have been disseminated to the farmers. Table 3 shows the beta carotene content of the SP varieties procured from the three districts.

Ameny and Wilson (1997) established that the flesh colour of SP correlated with the beta carotene content of SP. This was similarly observed for SP varieties analyzed (Table 3). Variation in beta carotene content of SP varieties could attributed to farmer location and district. Beta carotene is also dependant on the maturity age of the roots, where it has been observed that total carotenoid content of SP increases with root age (Hagenimana et al., 1997-98). Beta carotene content of SPK004 variety procured was similar to that introduced elsewhere in the East African region (Hagenimana et al., 1997-98). A study by Ssebuliba *et al*., (2001) on the potential utilization of orange-fleshed sweetpotatoes to combat vitamin A deficiency in Central Uganda showed that SPK004 variety had much higher (more than 50%) beta-carotene compared to Tanzania, 52, 316 and a local variety they investigated. For the SP varieties procured, Ejumula and SPK004 had much higher (more than ten fold) beta carotene compared to the other varieties (Table 3). However, in comparison to the Asian SP varieties (Dignos et al., 1992), these varieties contained less than half the beta carotene content. This could be attributed different SP varieties and geographical locations.

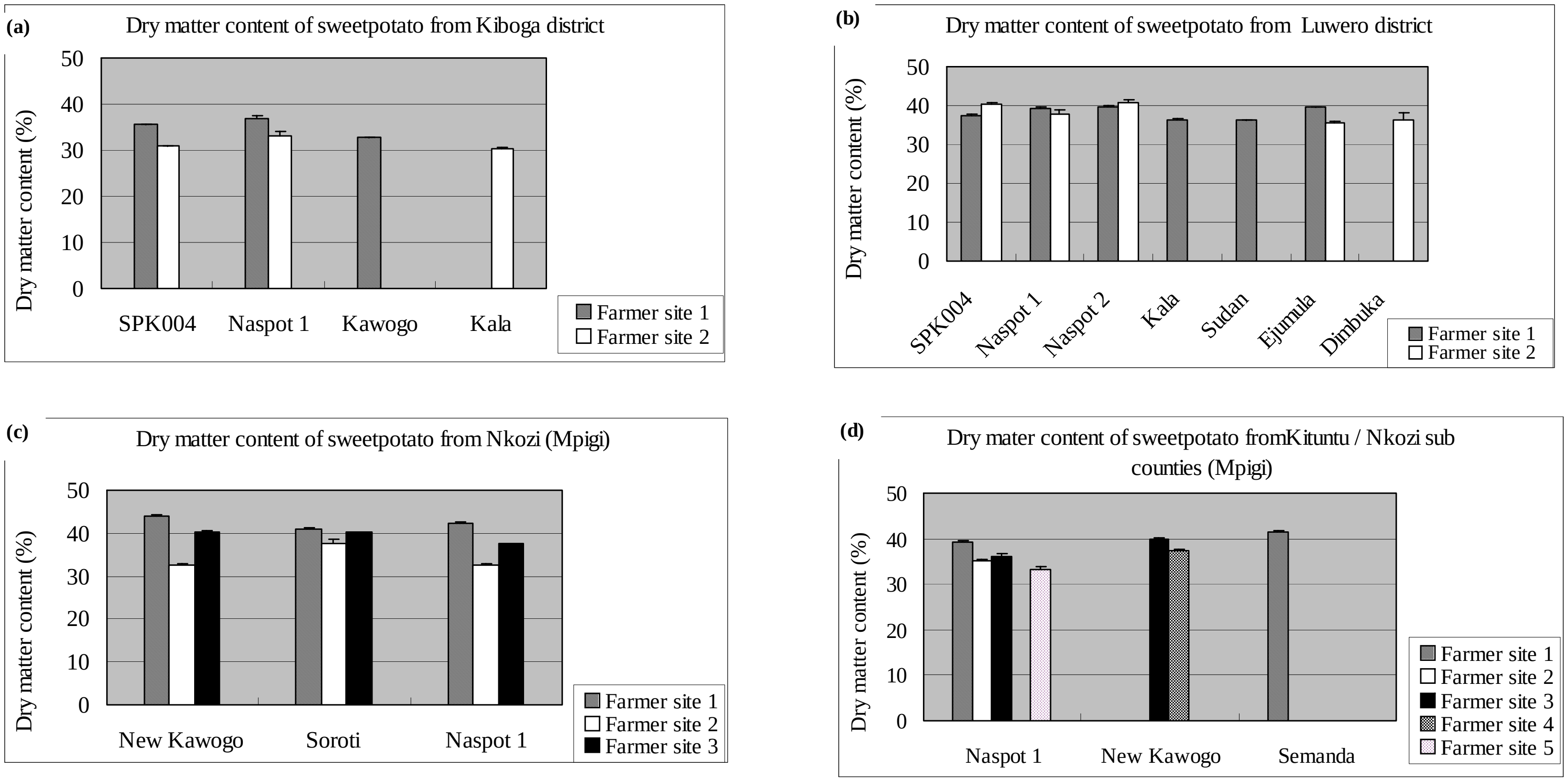


Figure 1 Dry matter content of sweetpotato varieties sampled from three districts of Central Uganda

Table 3 Beta carotene content of sweetpotato varieties sampled from three districts of Central Uganda

District	Variety	Farmer site	Colour of flesh*	Beta carotene content (mg/ 100 g)
Luweero	*Ejumula*	1	Orange	4.07
		2	"	1.35
	Naspot 1	1	Cream	0.26
		2	"	0.16
	Naspot 2	1	Off-white	0.10
		2	"	0.07
	SPK004	1	Pale orange	2.06
		2	"	1.21
Kiboga	*Naspot 1*	1	Cream	0.22
		2	"	0.06
	SPK004	1	Pale orange	0.99
		2	"	1.20
Mpigi	*Naspot 1*	1	Cream	0.13
	New Kawogo	3	Off-white	0.10
Nkozi (Mpigi)	*Naspot 1*	1	Cream	0.20
		2	"	0.18
		3	"	0.72
	New Kawogo	1	Off-white	0.25
		2	"	0.25
		3	"	0.63
	Tanzania	1	-	-
		2	Yellow	0.20
		3	"	0.50

*Colour of sweetpotato flesh evaluation was done by sensorial

Sweetpotato varieties from Luweero district appeared to have higher beta carotene content than Kiboga and Mpigi, for SPK004 variety (Table 3), a similar observation noted by Ssebuliba et al., (2001). It is possible that Luweero with lower annual rainfall, 850-1250 mm, than Mpigi, 1250-1625 mm (Ssebuliba et al., 2001) has SP varieties containing concentrated amounts of beta carotene.

3.1.3 Starch content

Starch in sweetpotato plays an important functional role in both fresh SP and processed products. Figure 2 shows the starch content of SP varieties from framers in three target districts, which were similar to starch contents of other SP varieties (Collado et al., 1997; Wanjekeche and Keya, 1995).

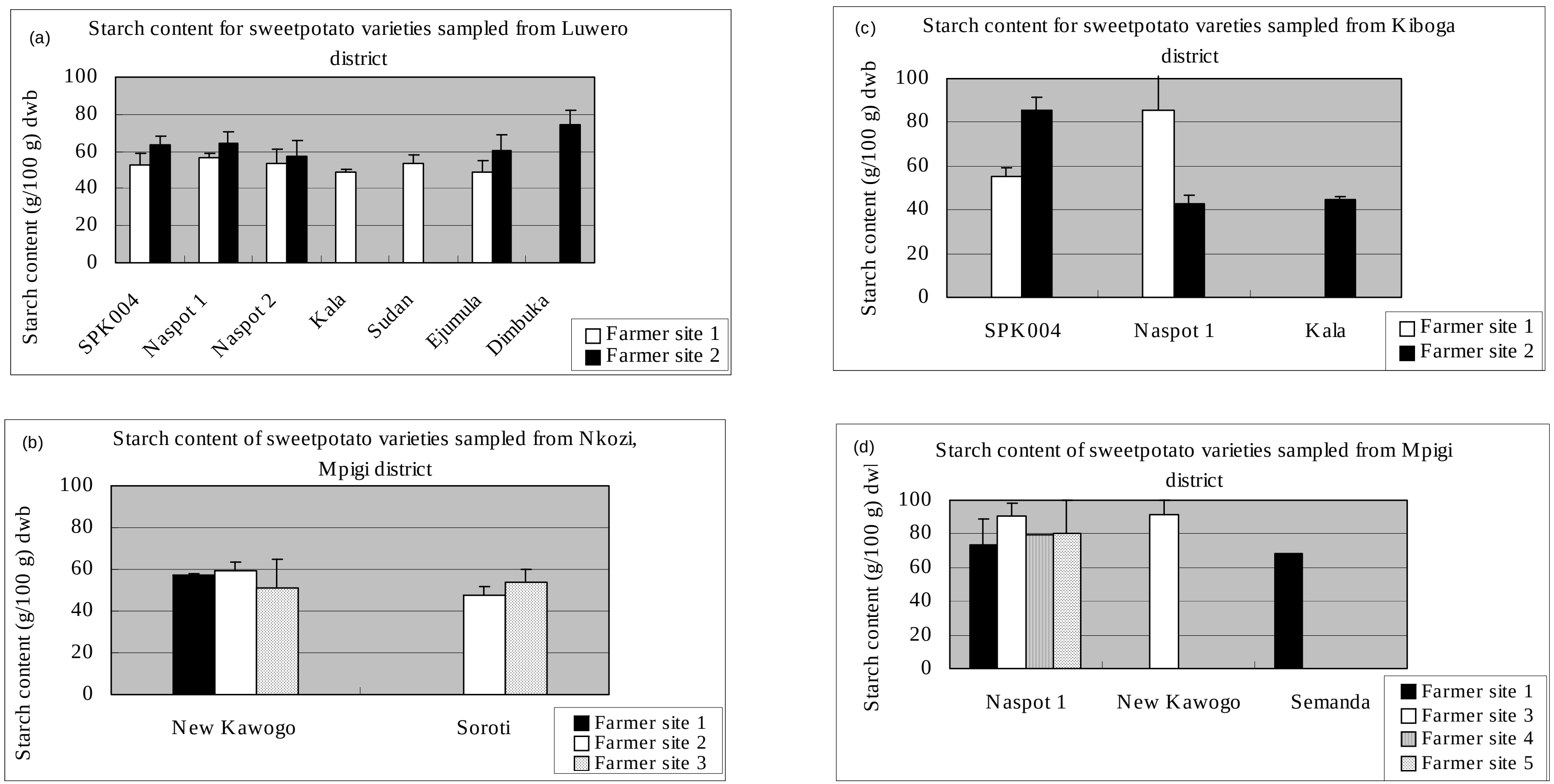


Figure 2 Starch content of sweetpotato varieties sampled from three districts of Central Uganda

The starch content of SP varieties likewise depended on maturity, SP variety, farmer site location and district. This was expected due to soil compositions and the climatical regimes. The starch content of most varieties ranged between 40 to 60 % (Figure 2), except for those varieties procured from Kituntu and Nkozi sub counties (Mpigi), which contained high starch contents more than 60% (Figure 2 d). .

3.1.4 Sugar content

It is known that SP contains high levels of sugars, which have a significant effect on the processing qualities and also impart a desirable taste to SP. Generally SP roots contain sucrose, fructose and glucose (Takahata et al., 1995;Picha, 1986). Maltose is only present in specific SP root varieties (Van Den et al., 1986).

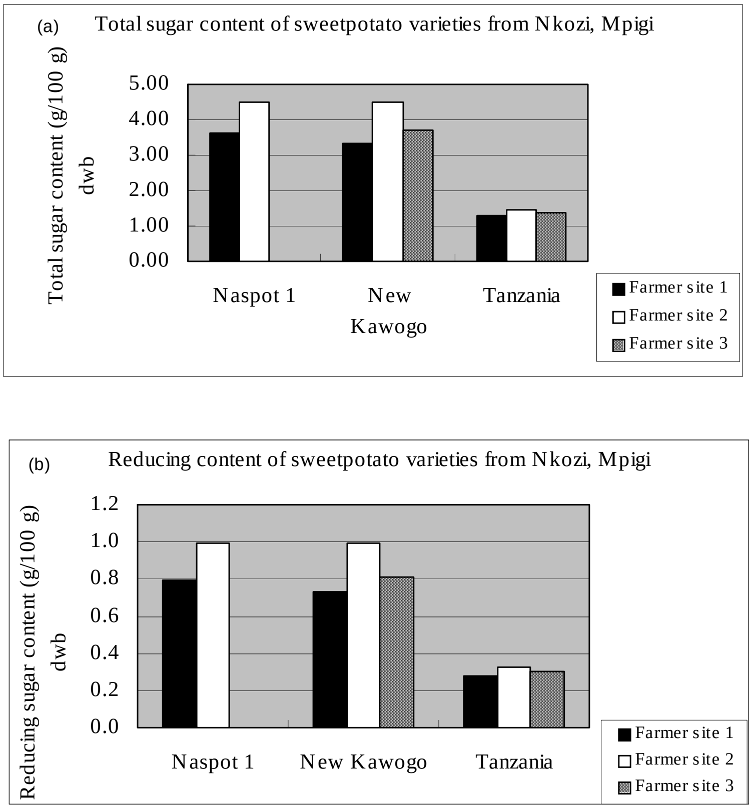


Figure 3 Sugar content of sweetpotato varieties sampled from three districts of Central Uganda

Figure 3 shows the sugar levels of SP varieties from Nkozi, Mpigi district. Sugar content in SP is dependent on various factors such as maturity age, SP variety and geographical location, which was eveident for the varieties from Nkozi, Mpigi (Figure 3). Total and reducing sugar levels for these varieties were however, lower than sugar levels reported for other SP varieties investigated by Collado et al.(1997), and Wanjekeche and Keya (1995). Tanzania had much lower sugar levels (total and reducing) than Napsot1 and New Kawogo, which had comparable amounts (Figure 3). This indicated that both Naspot 1 and New Kawogo maybe susceptible to high levels of browning, attributed to mallard reactions, compared to Tanzania variety, when heat processed. Therefore, Tanzania may require different processing conditions from Naspot 1 and New Kawogo.

3.2 Output 2 - Activity milestone 2.1.17 (Quality parameters, laboratory, of stored samples and chips to determine acceptability by farmers compiled by end of June

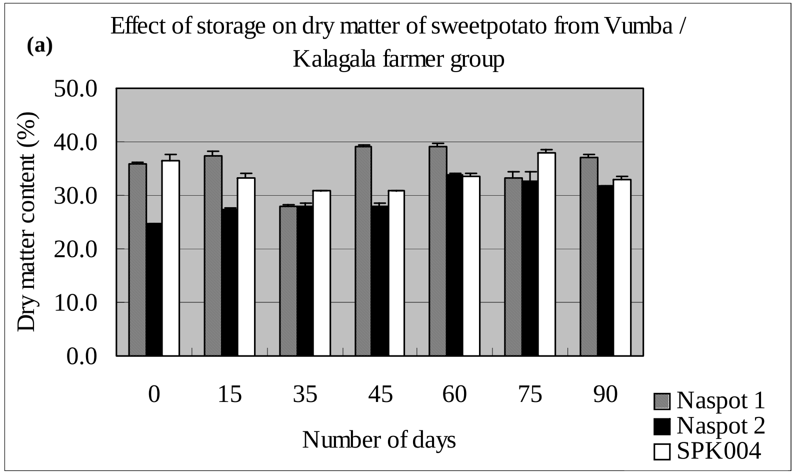
3.2.1 Effect of on-farm fresh storage structures and conditions on chemical composition of sweetpotato roots

This has been an on-going activity from quarter 2 into quarter 4 that involved FOSRI introducing storage structural technologies to farmers, and evaluating the storage performance of fresh SP in these storage structures. The storage structures introduced to the farmers were the pit and clamp storage structures (see FOSRI report). Three farmer groups have been involved in the storage experiment (Table 2). The following discussion is however, based on the Kiboga and Luweero farmer groups, where the clamp and pit storage structures were constructed, respectively Acceptability tests on these varieties have been reported by FOSRI coalition partner.

The storage conditions were maintained at the prevailing farmer field ambient conditions for farmers so that they were able to evaluate the feasibility and viability of these storage structures. The following is a discussion of the effect of storage structures on the selected chemical components of SP.

3.2.1.1 *Effect of storage on dry matter content of sweetpotato roots*

Figure 5 shows the dry matter content of SP stored for 90 days. The clamp storage structure involved wrapping SP with several layers of dry clean grass, while the pit structure involved covering SP with large amounts of soil (see FOSRI report). For both the clamp and pit storage structures no clear trend in changes in dry matter content was observed for all SP varieties under study (Figure 4). It is possible that both storage structures maintained the relative humidity and temperature to prevent desiccation of the roots over the 90-day period.



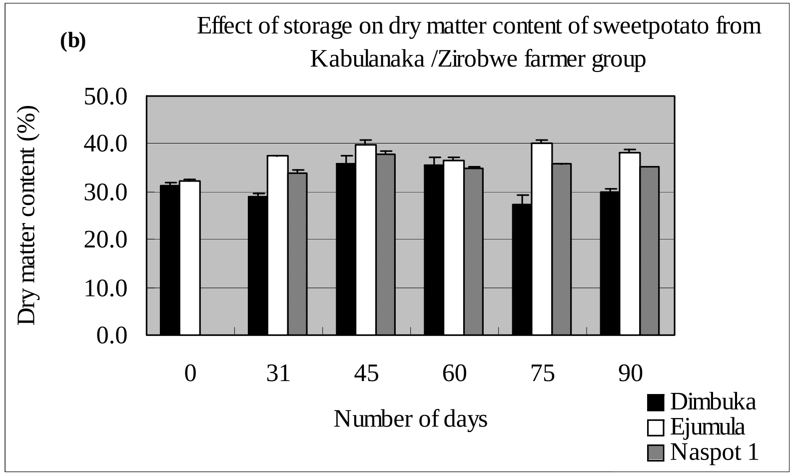


Figure 4 Change in dry matter content of Sweet potato varieties stored for 90 days in adopted storage technologies (pit and clump storage structures)

3.2.1.2 *Changes in beta-carotene content of sweetpotato*

Figure 6 shows the change in beta carotene content of sweetpotatoes in storage structures that were constructed by farmers in Kiboga and Luweero districts. The beta carotene content of SP varieties was highest for *Ejumula* (12.54), followed *SPK004* (6.7), *Dimbuka* (0.28), *Naspot* 1 (0.24) and *Naspot* 2 (0.24). Generally, a gradual decrease in beta-carotene content was recorded for SP samples under storage experiments for both Kiboga farmer group (up to 45 days) and Luweero farmer group (up to 60 days). Sharp decreases in beta-carotene content were recorded for Naspot 1 for both farmer groups and Naspot 2 for Luweero farmer group.

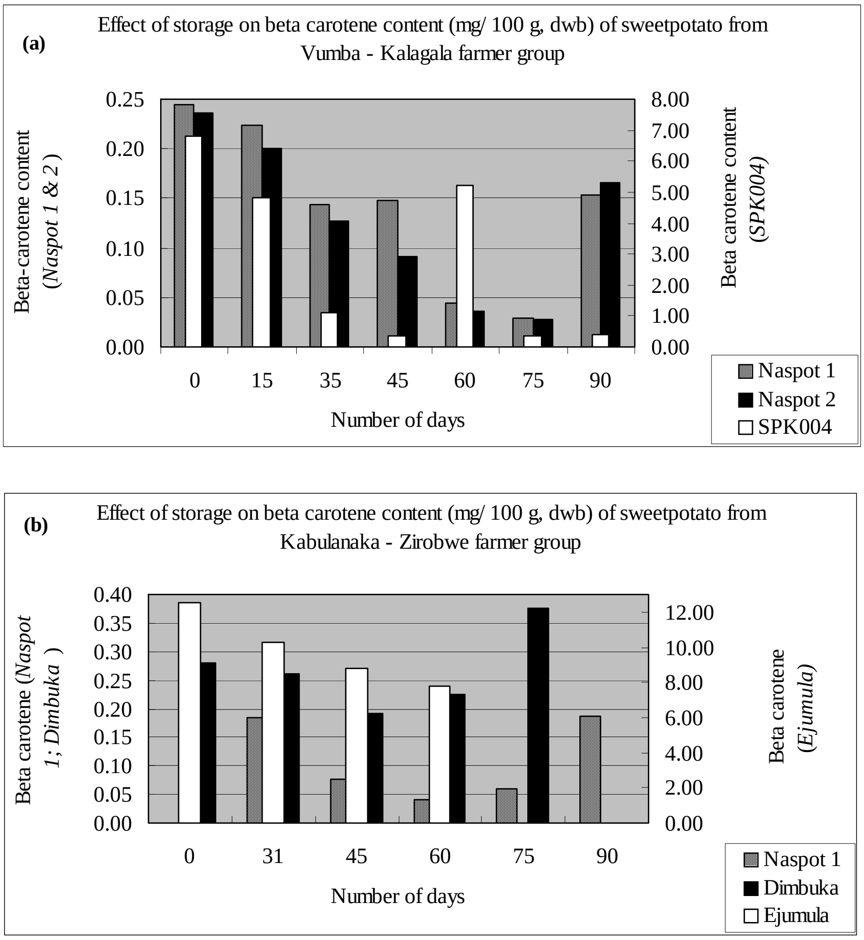
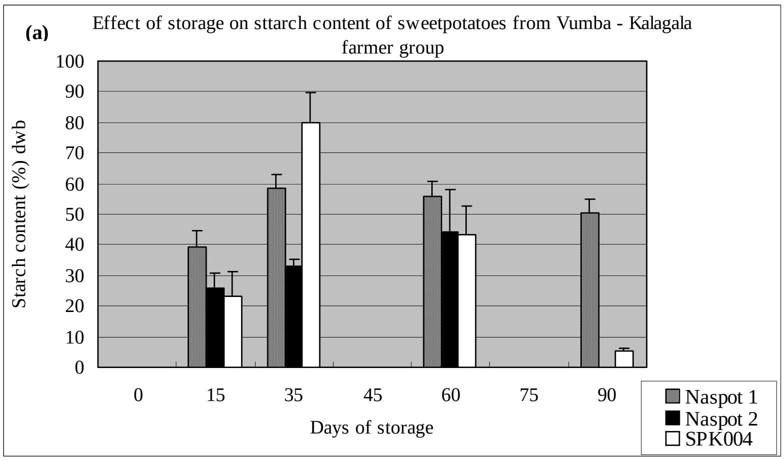


Figure 5 Change in beta-carotene content of Sweet potato varieties stored for 90 days in adopted storage technologies (pit and clump storage structures)

All SP showed drastic decreases in beta carotene content after 45 to 60 days (Figure 5). It is possible that SP stored beyond 60 days will have beta carotene content that will not provide sufficient (the recommended daily allowance) vitamin A content, particularly for the vulnerable groups.

3.2.1.3 *Changes in starch content of sweetpotato*

Figure 6 shows the changes in starch content of SP in storage structures that were constructed by farmers in Kiboga and Luweero districts. Typically SP contains no clear trend was observed in the changes of starch.



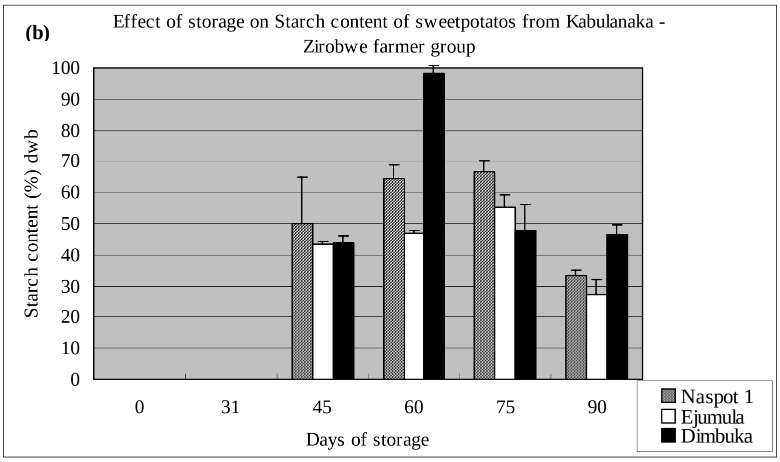


Figure 6 Change in starch content of Sweet potato varieties stored for 90 days in adopted storage technologies (pit and clump storage structures)

3.2.1.4 *Changes in sugar content of sweetpotato*

Increases in sugar contents were noted for Ejumula and SPK004 varieties arising from the increased reducing contents (Figures c and d). The high reducing sugar contents for these varieties would have an effect on the processing quality and shelf life of processed products. This increase could be attributed to the hydrolysis of the starches due to the native amylases found in SP for these particular varieties. However, no clear trend in changes of starch were noted.

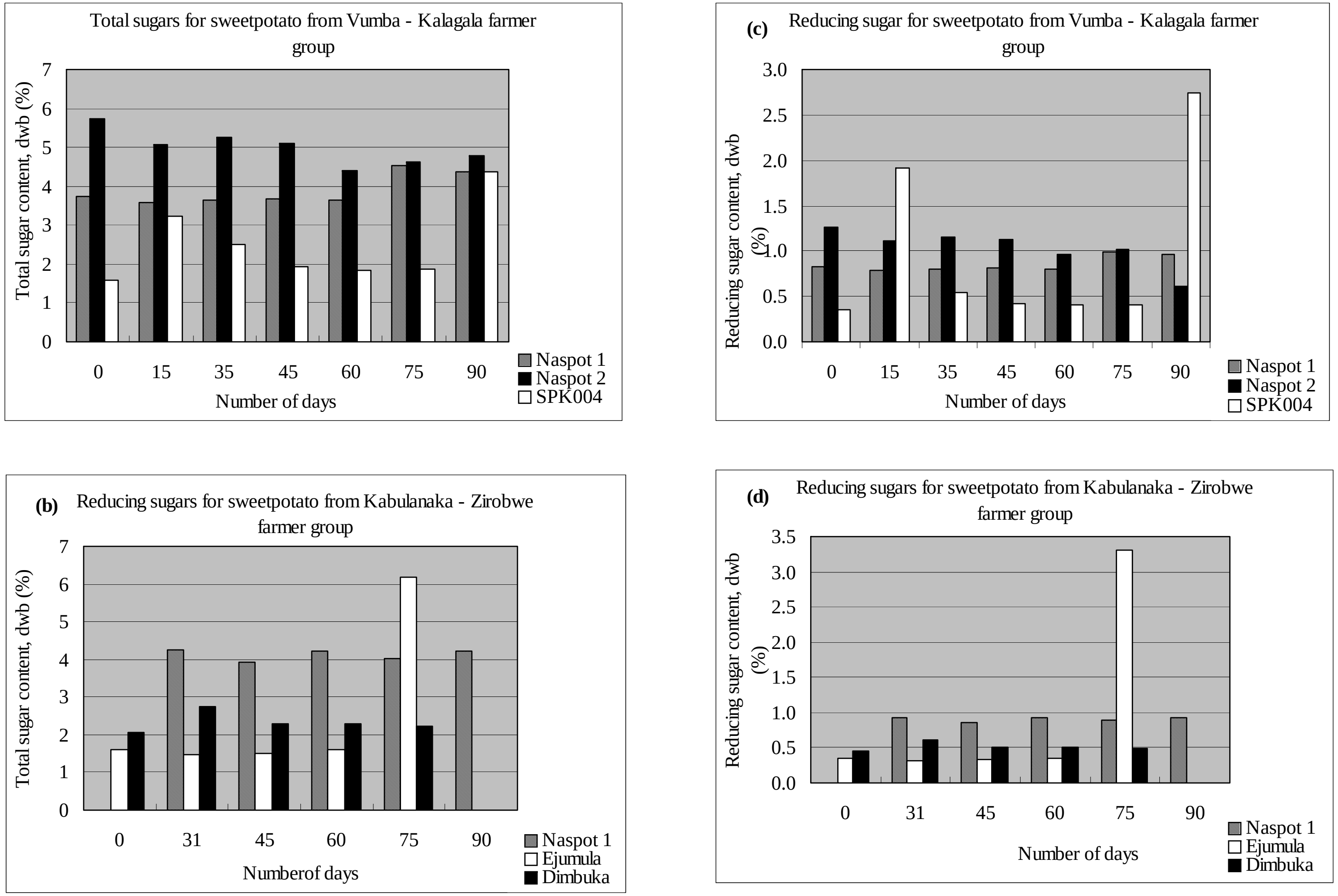


Figure 7 Effect of storage on total sugar content (a-b), and reducing content (c-d) of sweetpotato

3.2.2 Nutritional composition of sweetpotato composite flours

KARI developed composite sweetpotato flours from Naspot 1 variety combined with millet, maize, ground nuts and soya bean. The nutritional value for these flours was measured and are shown in tables 4 and 5.

Table 4 Beta carotene content of sweetpotato (*Naspot 1 variety*) composite flours developed by KARI

Sweet potato composite flour	**Beta carotene (μg / 100 g) dwb**	**Vitamin A content (RE / 100 g)**	**Vitamin A (I.U / 100 g)**
1	4,914.5 ± 1881.0	819.16	16,366.78
2	1,657.2 ± 21.0	276.20	5,518.48
3	1,690.1 ± 0.2	281.69	5,628.08
4	1,492.7 ± 0.0	248.79	4,970.74
5	418.7 ± 2.8	69.79	1,394.34
6	512.3 ± 0.2	85.37	1,705.78

Table 5 Nutritional value of sweet potato (*Naspot 1* variety) composite flours

Sweet potato composite flour	**Moisture (%)**	**Dietary fibre (%)**	**Energy (K cal/g)**	**Zinc (mg/g)**	**Crude protein (%)**	**Crude fat (%)**	**Total sugars (%)**	**Total Plate Count (x 10^6) cfu/g**	**Yeast & Mold (x 10^3) cfu/g**
1	6.79±0.27	6.35±0.54	4.49±0.03	2.64±0.59	19.50±1.71	7.83±0.92	18.69±0.82	3.00	0.86
2	10.33±0.19	4.77±0.38	4.01±0.08	3.34±1.24	***18.55 10.31***	5.09±0.59	24.16±0.69	3.30	3.50
3	8.48±0.18	7.67±0.30	4.56±0.00	1.57±0.14	22.06±0.62	8.37±0.95	21.27±0.36	5.50	1.50
4	10.33±0.19	4.59±0.91	3.73±0.03	3.08±0.37	9.74±0.31	3.05±0.08	21.94±2.21	2.70	4.10
5	12.85±0.47	0.90±0.16	4.42±0.03	2.36±0.02	8.66±0.07	1.28±0.23	10.67±2.87	0.80	0.10
6	12.10±0.30	5.03±0.15	3.77±0.05	4.32±0.42	6.86±0.27	1.95±0.21	7.63±2.38	2.20	3.60

4 Way forward

Analysis of most of the new varieties has been accomplished and will be incorporated into the SP coalition data base. Dissemination of nutritional value for these varieties to the farmer groups in a simplified lay-mans format will be done. Sweetpotato varieties Sowola, *93/29 and 329* varieties, with a promising export potential, were not characterized, and therefore will be analyzed in the future.

5 References

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