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Comparative assessment of chemical, functional, and pasting properties of flours produced from Zambian cassava varieties using Oven-, Sun-, and Freeze-drying methods

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Abstract

Cassava is generally a low nutrient food crop, particularly the roots, the primary crop consumed in the tropics. Because of the high post-harvest physiological deterioration (PPD), the evaluation of processing procedures geared towards extending the product's shelf-life cannot be overemphasized. To this end, cassava roots are usually dehydrated to reduce the water content using various dewatering and drying procedures. Therefore, it is imperative to determine which of the probable methods is most suitable to preserve the essential qualities of the cassava, hence this research. Seven clones of cassava roots were dried using three methods (sun drying, oven drying and freeze-drying). The effects of drying methods on nutritional, functional and pasting properties were investigated using standard methods. Generally, the highest % sugar contents were recorded for the freeze-dried samples. Similarly, the % starch was higher in the sun-dried samples of six out of the seven samples when compared to the oven-dried samples. Results recorded for the functional properties ranged from 31.29-61.04 %, 2.31-5.41 %, 119.68-206.78 % and 54.00-70.00 for solubility, swelling power, water absorption capacity and dispersibility, respectively. The variety of the cassava and drying methods significantly affected the color, chemical, functional, and pasting properties of the different cassava flours.

Introduction

Cassava (*Manihot Esculanta*) is one of the most important crop commodities globally, owing to its versatility in utilization. Cassava roots deteriorate rather quickly after harvest. Thus, to extend the shelf life, they are sundried or oven-dried in many cases to prevent the physiological deterioration of cassava that usually develops a few days after harvest. This deterioration usually leads to the production of flour or chips of sub-optimal quality. The roots are usually cut into smaller pieces to speed up the drying rate [1], and the size reduction of cassava roots leads to a shorter drying time as the surface area increases [2]. Sun-drying is the most prevalent drying method because it is the most straightforward and affordable drying method among smallholder farmers. However, it is imperative to note that Sun-drying is relatively slow compared to other drying techniques [3, 2]. Studies to improve the efficiency of sun-drying cassava roots have been reported [4, 2, 3]. However, the stability of the chemical, functional and pasting properties of cassava roots when different drying methods are employed has not been adequately investigated, especially on cassava varieties from Zambia. Hence the need to investigate whether there is a significant quality difference between sun-dried, oven-dried, and freeze-dried cassava flour. The information from this study will be helpful for breeders to guide breeding programs, food scientists to guide the utilization of cassava and processors to know the appropriate drying techniques that will give quality cassava flours.

Materials and Methods

Cassava genotypes were harvested from a Uniform Yield Trial at IITA's Kabangwe farm in Lusaka, Zambia, in December 2018. Samples were prepared and dried according to the process flow indicated in figure 1 which is based on the prescribed protocol [5]. Chemical analysis, functional and pasting properties determination was done following standard procedures for food quality analysis.

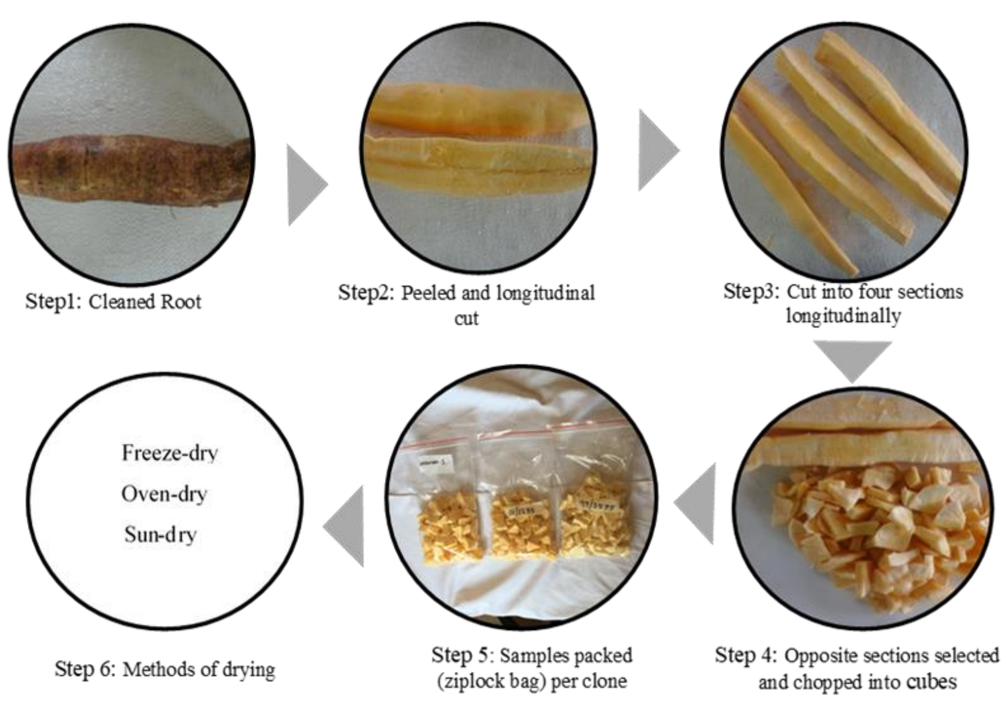

Fig1. Sample preparation process up to drying methods stage

Results analysis and presentation

The *proximate properties* of seven cassava genotypes flours that were oven-dried, sun-dried and freeze-dried are presented in table 1, 2 and 3 respectively. The moisture content was higher in the sun-dried method, with a mean of 9.08 % and the least was detected in the oven-dried samples at a mean of 7.44 %. Variety 99/3575 had the highest and lowest moisture content, when sun- dried (9.77 %) and oven-dried (6.22 %) respectively. The ash content was higher in the freeze-dried method, with a mean of 2.59 % and the least was detected in the sun-dried samples at a mean of 1.88 %. Variety 01/1235 had the highest ash content, when freeze-dried (3.47 %) and variety 01/1551 had the lowest when sun-dried (1.63 %). The fat content of the cassava flour was highest in the oven-dried method at 1.58 % and the least was observed in the freeze-dried sampled (1.20 %). The variety with the highest fat content was 01/1235 when oven-dried (2.13 %) and the lowest was noted in variety 99/0395 when freeze-dried (0.93 %). The amount of protein ranged from the mean of 1.98 % (freeze-dried) to 2.25 % (oven-dried). The highest and lowest protein content were observed in variety 01/1551 when oven-dried (3.02 %) and freeze-dried (1.40 %) respectively. The sugar content varied from the mean of 5.14 % to 9.36 %, from oven-dried and freeze-dried samples, respectively. The starch content had the mean range of 75.06 % (oven-dried) to 81.60 % (freeze-dried). The variety 01/1551 had the highest starch content, when freeze-dried (82.88 %) and variety MM96/1757 had the lowest starch content when oven-dried (71.48 %).

The *functional properties* of seven cassava genotypes flours that were oven-dried, sun-dried and freeze-dried are summarized in figure 2. The swelling power varied from a mean of 3.35 to 4.27 g/g, with freeze-dried having the lowest and sun-dried being the highest method, respectively. Solubility ranged from a mean of 46.72 % to 54.56 %; from sun-dried and oven-dried methods, respectively. The variety with the highest solubility capacity was MM96/1757 at 61.04 % and the least was observed in variety 99/3575 at 31.29 %. The water absorption capacity (WAC) ranged from a mean of 143.04 % to 183.71 % from sun-dried and freeze-dried samples, respectively. The variety 99/0395 had the lowest value (119.68 %) when the samples were freeze-dried, while 01/1235 had the highest value (206.76 %) when the samples were sun-dried.

Table 1: Proximate properties of 7 Oven-dried Cassava flours

	% MC	% Ash	% Fat	% Protein	% Amylose	%Sugar	%Starch
01/1235	8.95 ± 0.02^{e}	2.17 ± 0.05^{d}	2.13 ± 0.01^{d}	2.07 ± 0.00^{b}	36.46 ± 0.08^{e}	6.79 ± 0.02^{c}	76.81 ± 0.10^{d}
99/3575	6.22 ± 0.02^{a}	2.09 ± 0.02^{d}	2.04 ± 0.00^{d}	2.33 ± 0.08^{c}	39.29 ± 0.08^{f}	6.20 ± 0.05^{b}	77.09 ± 0.31^{de}
01/1551	7.26 ± 0.12^{c}	1.76 ± 0.01^{a}	1.46 ± 0.01^{c}	3.02 ± 0.09^{e}	35.98 ± 0.00^{c}	5.87 ± 0.07^{b}	77.92 ± 0.28^{e}
99/0395	7.08 ± 0.14^{ab}	1.84 ± 0.00^{ab}	1.56 ± 0.04^{c}	2.67 ± 0.09^{d}	32.28 ± 0.08^{a}	6.93 ± 0.02^{c}	74.57 ± 0.18^{c}
Unnknown-1(PHN 2K18)	8.44 ± 0.00^{d}	1.93 ± 0.01^{bc}	1.26 ± 0.04^{b}	1.64 ± 0.09^{a}	35.91 ± 0.08^{c}	11.72 ± 0.18^{d}	74.08 ± 0.20^{bc}
MM96/1757	6.78 ± 0.11^{b}	2.79 ± 0.02^{e}	1.59 ± 0.07^{c}	1.99 ± 0.08^{b}	33.31 ± 0.00^{b}	12.37 ± 0.20^{e}	71.48 ± 0.24^{a}
00/0093	7.33 ± 0.13^{c}	1.98 ± 0.05^{c}	1.03 ± 0.05^{a}	2.07 ± 0.00^{b}	36.22 ± 0.08^{d}	5.39 ± 0.00^{a}	73.47 ± 0.50^{b}
Mean	7.44	2.08	1.58	2.25	35.64	7.90	75.06
SD	0.88	0.32	0.37	0.43	2.11	2.67	2.15
CV(%)	11.85	15.27	23.29	19.19	5.93	33.87	2.87
p -value	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Means with different superscript letters along the same column are significantly different at $p< 0.05$

Table 2: Proximate properties of 7 Sun-dried Cassava flours

	% MC	% Ash	% Fat	% Protein	% Amylose	%Sugar	%Starch
01/1235	8.14 ± 0.10^{a}	2.29 ± 0.01^{d}	0.93 ± 0.01^{a}	1.74 ± 0.00^{a}	35.91 ± 0.08^{e}	10.60 ± 0.02^{e}	82.68 ± 0.10^{cd}
99/3575	9.77 ± 0.01^{c}	1.67 ± 0.04^{a}	1.10 ± 0.03^{b}	1.91 ± 0.00^{b}	33.03 ± 0.04^{b}	8.64 ± 0.00^{d}	80.14 ± 0.21^{a}
01/1551	9.61 ± 0.07^{c}	1.63 ± 0.09^{a}	1.11 ± 0.00^{b}	2.23 ± 0.00^{d}	40.79 ± 0.08^{f}	7.75 ± 0.00^{b}	82.88 ± 0.10^{d}
99/0395	9.24 ± 0.02^{b}	1.68 ± 0.01^{a}	1.62 ± 0.01^{e}	2.67 ± 0.09^{e}	33.94 ± 0.00^{d}	8.09 ± 0.00^{c}	81.56 ± 0.21^{bc}
Unnknown-1(PHN 2K18)	8.07 ± 0.05^{a}	2.00 ± 0.02^{b}	1.56 ± 0.04^{e}	1.90 ± 0.00^{b}	32.52 ± 0.08^{a}	12.23 ± 0.00^{g}	80.00 ± 0.73^{a}
MM96/1757	9.09 ± 0.01^{b}	2.14 ± 0.03^{c}	1.37 ± 0.00^{d}	1.72 ± 0.00^{a}	33.86 ± 0.08^{d}	10.60 ± 0.00^{e}	82.57 ± 0.42^{bcd}
00/0093	9.67 ± 0.01^{c}	1.75 ± 0.02^{a}	1.22 ± 0.03^{c}	2.09 ± 0.00^{c}	33.31 ± 0.08^{c}	6.27 ± 0.00^{a}	81.43 ± 0.10^{b}
Mean	9.08	1.88	1.27	2.04	34.76	9.36	81.60
SD	0.66	0.25	0.24	0.31	2.65	2.09	1.15
CV(%)	7.26	13.16	18.57	15.13	7.63	22.35	1.41
p -value	0.000	0.000	0.000	0.000	0.000	0.000	0.002

Means with different superscript letters along the same column are significantly different at $p< 0.05$

Table 3: Proximate properties of 7 Freeze-dried Cassava flours

	% MC	% Ash	% Fat	% Protein	% Amylose	%Sugar	%Starch
01/1235	6.55 ± 0.07^{a}	3.47 ± 0.02^{e}	1.32 ± 0.10^{b}	2.27 ± 0.00^{f}	39.45 ± 0.08^{f}	4.54 ± 0.18^{c}	76.44 ± 0.21^{a}
99/3575	7.66 ± 0.05^{b}	2.46 ± 0.02^{c}	1.27 ± 0.03^{b}	1.91 ± 0.00^{d}	39.61 ± 0.08^{f}	4.03 ± 0.00^{b}	78.44 ± 0.21^{b}
01/1551	9.45 ± 0.13^{d}	2.50 ± 0.02^{c}	0.99 ± 0.00^{a}	1.40 ± 0.00^{a}	37.48 ± 0.08^{e}	3.66 ± 0.05^{a}	80.56 ± 0.00^{c}
99/0395	7.47 ± 0.22^{b}	2.09 ± 0.01^{a}	0.93 ± 0.00^{a}	1.57 ± 0.00^{b}	34.25 ± 0.08^{b}	4.69 ± 0.03^{c}	78.66 ± 0.11^{b}
Unnknown-1(PHN 2K18)	7.82 ± 0.03^{bc}	2.30 ± 0.08^{b}	1.32 ± 0.05^{b}	2.25 ± 0.00^{e}	33.70 ± 0.08^{a}	6.66 ± 0.04^{e}	81.08 ± 0.71^{c}
MM96/1757	8.05 ± 0.04^{c}	2.81 ± 0.02^{d}	1.65 ± 0.05^{c}	1.89 ± 0.00^{c}	35.91 ± 0.08^{d}	6.27 ± 0.00^{d}	82.70 ± 0.10^{d}
00/0093	7.67 ± 0.05^{b}	2.51 ± 0.01^{c}	0.95 ± 0.05^{a}	2.58 ± 0.00^{g}	35.04 ± 0.08^{c}	6.14 ± 0.02^{d}	81.52 ± 0.84^{c}
Mean	7.81	2.59	1.20	1.98	36.49	5.14	79.91
SD	0.81	0.41	0.25	0.38	2.23	1.11	2.04
CV(%)	10.38	15.95	20.80	19.42	6.10	21.58	2.56
p -value	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Means with different superscript letters along the same column are significantly different at $p< 0.05$

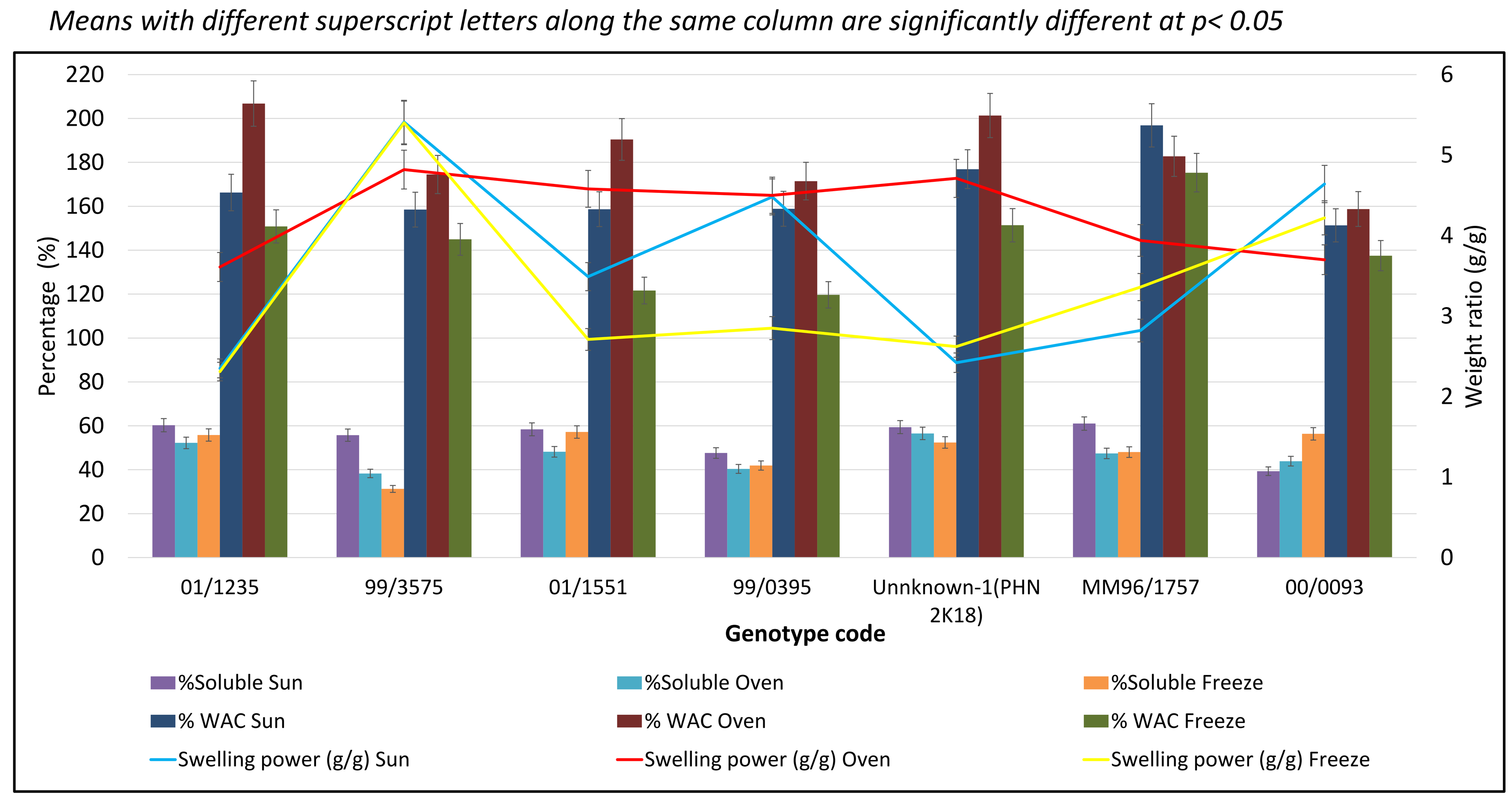

Fig2. Functional Properties

Discussion

The analysis of variance (ANOVA) revealed that variations among the samples were highly significant ($p<0.001$) based on the drying method, interaction of variety and drying method and variety (except for the fat content, which was not significantly different). The freeze-dried sample from 01/1552 was the best because of the high starch and low ash contents. It was observed that drying methods, variety and the interaction of the drying method and variety influenced the proximate composition of the cassava flours. The higher swelling power and solubility for sun-dried and oven-dried samples could be due to the micellar network's strength within the starch granules being a significant factor contributing to the swelling behaviour of starch [6].

Conclusion

Considering that starch is the most significant chemical property for cassava, the freeze-drying method could be considered the best for drying cassava for optimum starch retention. Thus, the freeze-dried sample from 01/1551 was the best because of the high starch and low ash contents. However, freeze-dried samples had the lowest swelling power, solubility, and water absorption capacity.

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