OPTIMIZATION OF DEEP-FAT FRYING PROCESS FOR SWEETPOTATO CRISPS FROM DIFFERENT VARIETIES

By

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JUSTIFICATION

- Sweet potato crisps could be marketed as highly nutritious snack foods, particularly the orange-fleshed varieties
- Orange fleshed sweetpotato are relatively new to the consumers
- Differences in texture and chemical composition associated with varieties influences process conditions
- It is important to determine the optimum frying conditions required for the production of sweetpotato crisps with high nutritional quality and consumer acceptable sensory properties

MAIN OBJECTIVE

- To determine optimum deep fat frying conditions for sweetpotato crisps from different varieties

SPECIFIC OBJECTIVES

- To determine the effect of various combinations of oil temperature and frying time on selected quality (chemical and sensory) attributes of crisps from three varieties of sweetpotato roots
- To determine optimized frying conditions for each variety of sweetpotato crisps
- To determine the effect of two packaging materials on some chemical and microbial characteristics of optimized sweetpotato crisps stored under ambient temperature ($30\pm2^{0}C$)

MATERIALS

- Three varieties of sweetpotato roots (two orange-fleshed ,one yellow-fleshed)
- Refined deodorized vegetable oil

Experimental design

- study based on hypotheses that colour, moisture content, oil content, crispness and beta-carotene content of the product are functionally dependent on the temperature of the oil and the frying time

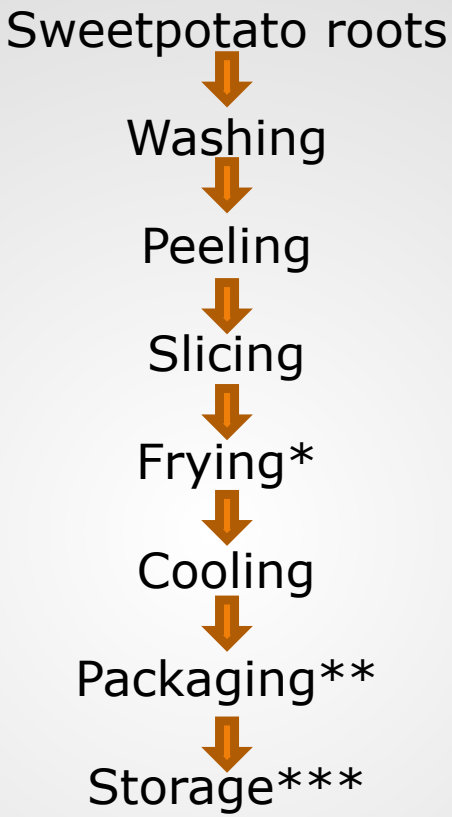
- range of oil temperature and frying time determined from literature review followed by trial experiments conducted in the laboratory

- Central composite rotational design with two factors was used, 13 runs and five center points were generated

TABLE 1: Experimental design showing coded and actual values of oil temperature and frying time used in the experiment

Trial	Variable codes		Actual values	
	X_1	X_2	Temperature (^{0}C)	time (min)
1	0	0.2	150	4.5
2	0	-2.5	150	2.38
3	0	0.2	150	4.5
4	2.5	0.2	164.14	4.5
5	2	-2	160	3
6	0	0.2	150	4.5
7	-2	-2	140	3
8	2	2	160	6
9	0	0.2	150	4.5
10	0	2.5	150	6.62
11	-2	2	140	6
12	0	0.2	150	4.5
13	-2.5	0.2	135.86	4.5

Preparation of sample



* - Temp/Time combination as generated by CCRD/ Bush glass fryer
** - Two packaging materials (High Density Polyethylene and Laminated Aluminium foil)
*** Room Temperature (30±2ºC)/ 6 weeks

Fig. 1. Flow chart for production of sweetpotato crisps (adapted from Fetuga *et al.,* 2013)

ANALYSIS OF SAMPLES

- Chemical and physical properties of sweetpotato crisps {Moisture content , Oil content (AOAC, 2005), Total carotenoids (Kimura et. al., 2004), Colour (L*a*b*) – Konica Minolta Chroma meter}

- Sensory properties (crispiness, orange, yellow and brown colours (Descriptive method/ Intensity scoring)

- Analysis on optimized samples
  - Chemical properties: (Protein content, Crude fibre, Ash content)
  - Sensory analysis (Ranganna, 1999)
    - Product test – Descriptive method/ 10cm line intensity scale /10 trained panelists
    - Consumer test – Acceptance method /9-point Hedonic scale / 50 untrained in-house panelists

STORAGE STUDIES

2 packaging materials (high density polyethylene and laminated aluminum foil)

The products stored at ambient temperature (30±2ºC) for 6 weeks

Storage Studies

- Microbial Analysis (FDA, 2013) (Total viable count, Total mould count, Salmonella count, Shigella count, Staphylococcus count)
- Chemical Analysis (Peroxide value, Free fatty acid, Saponification value, Total carotenoids, Carotenoid retention)

Statistical analysis

- Data generated for optimization was analyzed with Response surface methodology using Design Expert 6.0.8.
- The data generated from the analysis of the optimized products was analyzed with ANOVA using Statistical Analysis System
- Means were separated with Duncan Multiple Range Test (DMRT)
- Data was analyzed at $p<0.05$

RESULTS

Table 2: Effect of Oil temperature and frying time on chemical and colour properties of sweetpotato crisps on Mother's delight variety

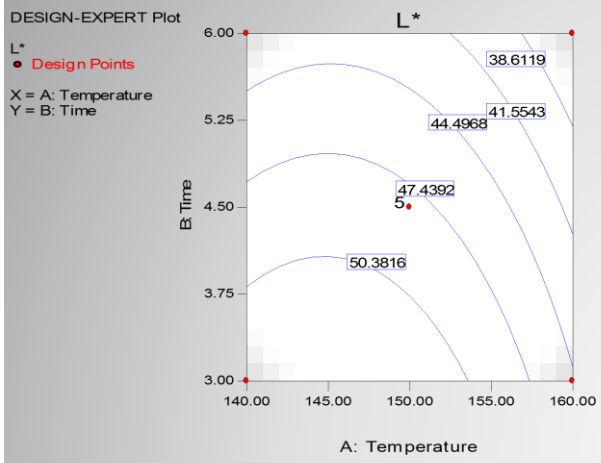
Trial	Temperature (^{0}C)	Time (min)	Moisture Content (%)	Oil Content (%)	Total Carotenoids (µg/100g)	L*	a*	b*
1	150.00	4.50	36.97	31.43	3793.72	2.07	46.58	21.74
2	150.00	2.38	47.80	29.72	4925.28	15.66	**56.22**	**26.78**
3	150.00	4.50	41.63	29.00	3758.36	2.25	46.82	22.45
4	164.14	4.50	22.81	31.73	1057.61	1.14	37.13	18.26
5	160.00	3.00	33.39	25.78	3677.98	5.11	42.91	17.69
6	150.00	4.50	43.25	31.67	3713.35	2.25	50.85	20.83
7	140.00	3.00	37.96	26.30	**5953.96**	18.81	49.45	21.06
8	160.00	6.00	18.61	30.56	4086.03	1.74	34.36	14.90
9	150.00	4.50	19.62	35.67	3761.58	2.27	49.29	23.01
10	150.00	6.62	30.36	35.72	2848.25	2.21	41.81	17.67
11	140.00	6.00	**16.79**	32.77	4795.52	5.25	39.86	13.60
12	150.00	4.50	36.90	**25.07**	3771.22	2.21	46.94	18.75
13	135.86	4.50	45.19	31.66	4124.74	5.96	49.33	22.31

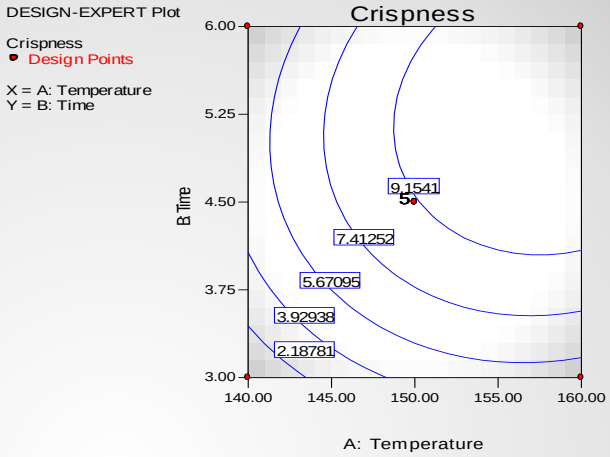
values are means of replicate determinations
L* - lightness a* - redness b* - yellowness

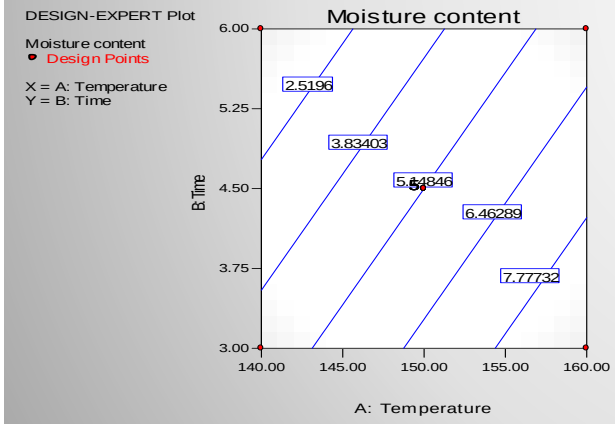
Table 3: Effect of Oil temperature and frying time on Sensory properties of sweetpotato crisps on Mother's delight variety

Trial	Temperature (^{0}C)	Time (min)	crispiness	Colour orange	Colour brown	Colour yellow
1	150.00	4.50	9.29	8.88	0.00	0.00
2	150.00	2.38	0.50	8.80	0.00	2.92
3	150.00	4.50	9.11	8.81	0.00	1.29
4	164.14	4.50	9.56	0.00	9.43	0.34
5	160.00	3.00	5.39	7.22	0.00	0.57
6	150.00	4.50	8.88	8.63	0.00	0.69
7	140.00	3.00	0.03	7.98	0.00	2.35
8	160.00	6.00	**9.33**	0.00	8.38	0.06
9	150.00	4.50	9.09	**8.92**	0.00	0.99
10	150.00	6.62	9.04	0.00	7.63	0.00
11	140.00	6.00	1.70	8.08	0.00	0.48
12	150.00	4.50	9.04	8.77	0.00	1.66
13	135.86	4.50	3.18	7.97	0.00	0.93

values are means of replicate determinations







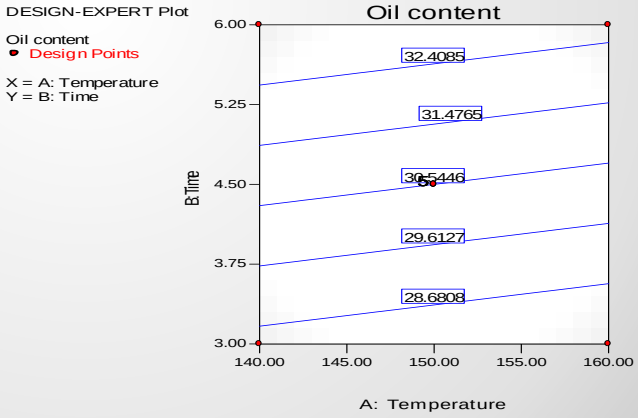


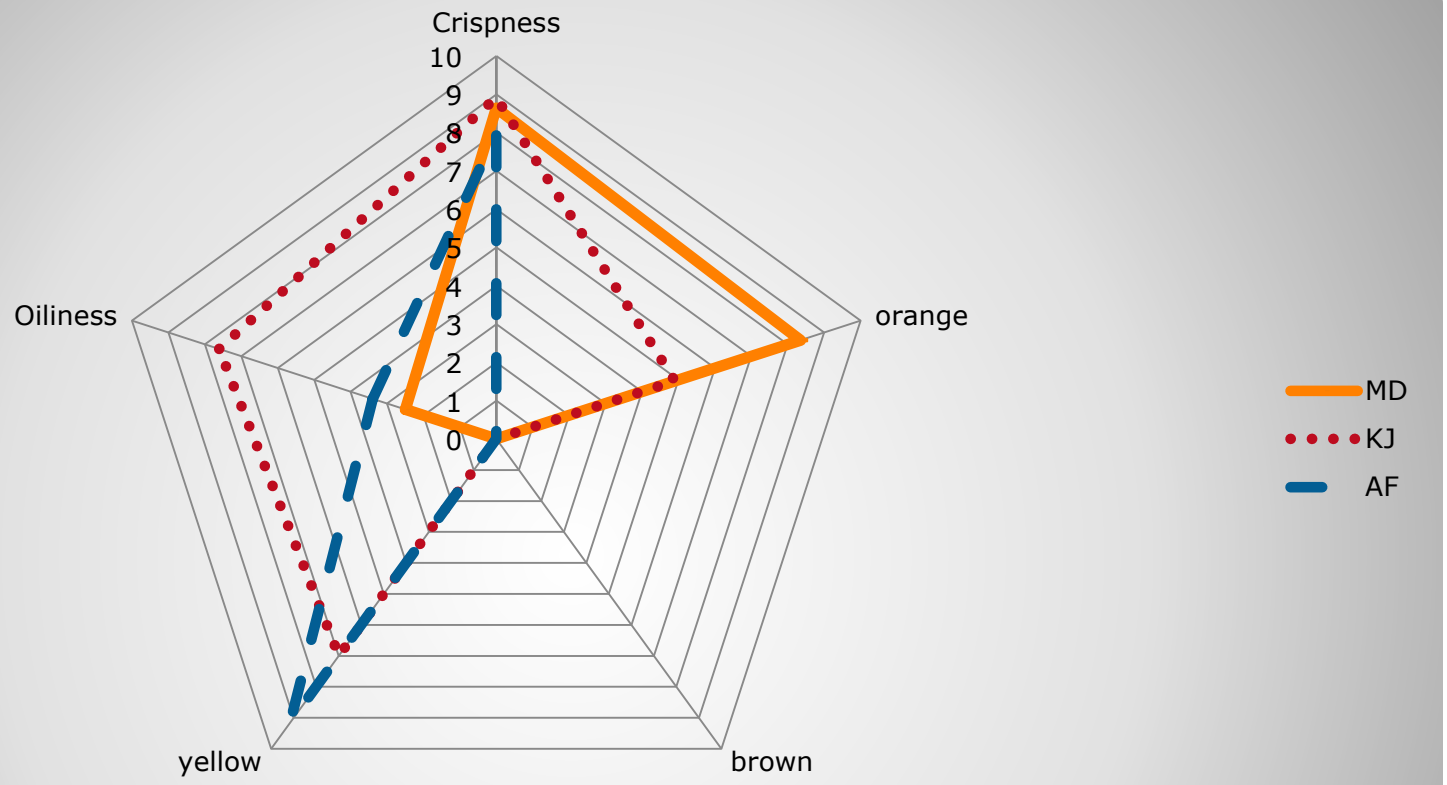
Figure 2: Contour plots showing the effect of temperature and time on L*, crispiness, moisture content and oil content of optimized sweetpotato crisps from Mother's delight variety

Table 4: Chemical and colour properties of optimized SP crisps from three varieties of SP roots

Variety	Temp (^{0}C)	Time (min)	†Moisture Content (%)	†Oil Content (%)	†Total Carotenoid (µg/100 g)	†L*	†a*	†b*	Crude protein (%)	Crude fibre (%)	Crude ash (%)
MD	**156.55**	**3.51**	5.15	28.70	3866.74	46.94	21.20	35.36	3.71	8.87	1.27
KJ	**140.00**	**6.00**	2.48	24.66	3530.52	45.34	3.99	29.10	5.77	9.14	1.01
AF	**150.68**	**6.00**	2.08	26.92	1934.04	46.28	3.26	23.34	3.40	6.63	1.65

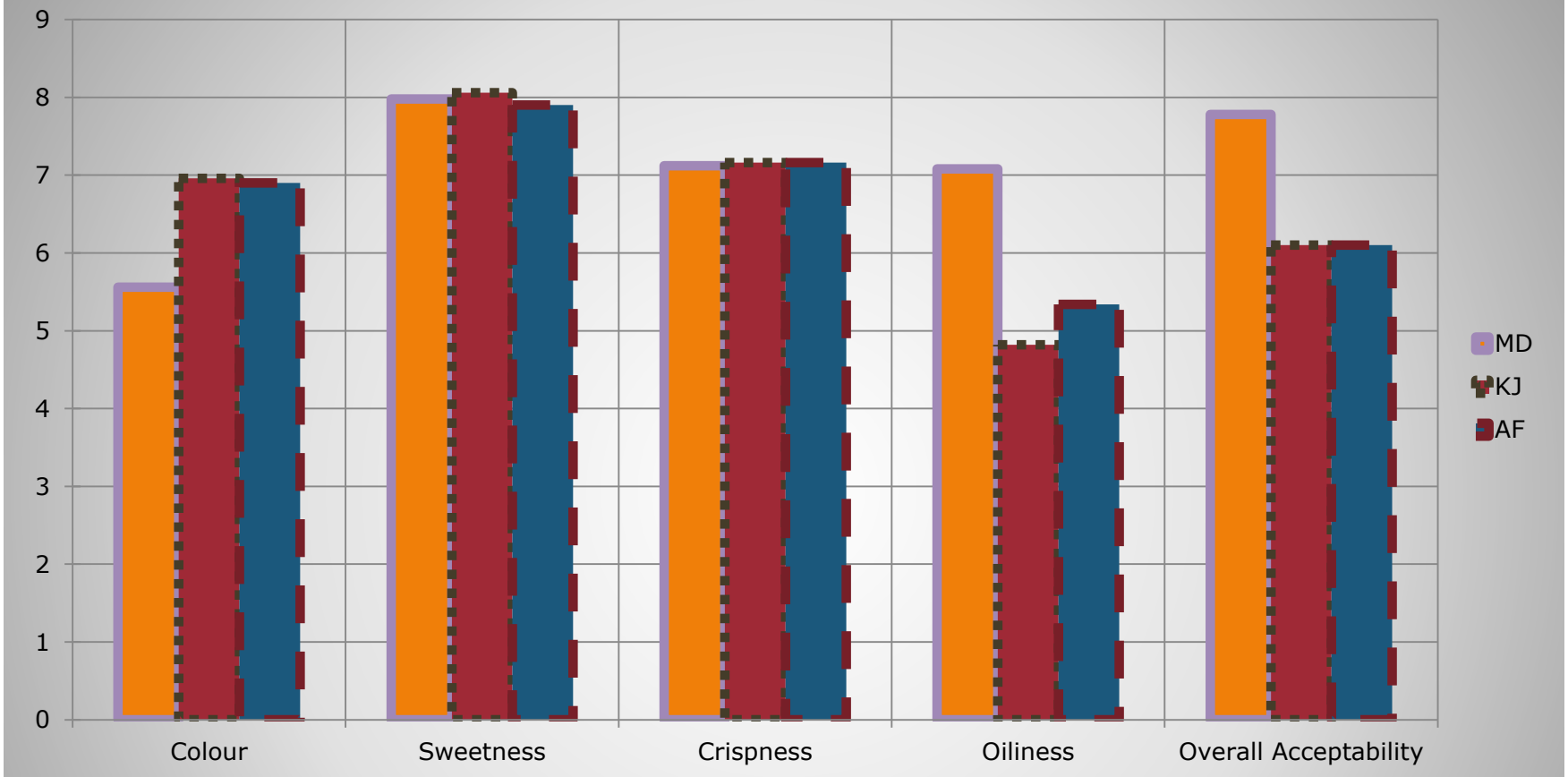
†values generated from software

MD – Mother's delight KJ – King J AF – Anoma Funfun
L* - lightness a* - redness b* - yellowness



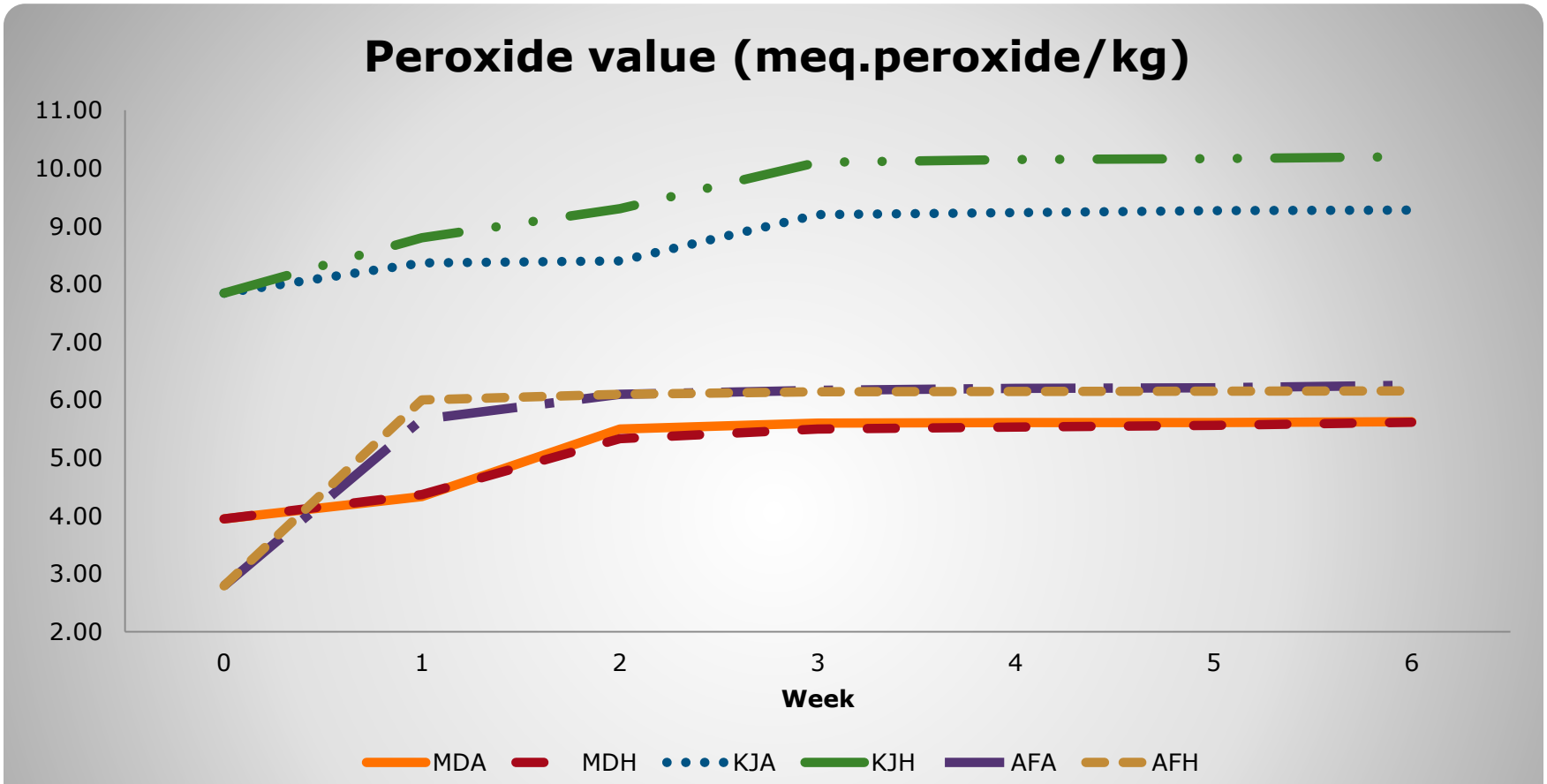
MD – Mother's delight (156.55^{0}C, 3.51 min)
KJ – King J (140^{0}C, 6 min)
AF –Anoma Funfun (150.68^{0}C, 6 min)

Figure 3: Spider chart for sensory attributes of optimized sweetpotato crisps from three varieties



MD – Mother's delight, UMU (156.55^{0}C, 3.51 min)
KJ – King J (140^{0}C, 6 min)
AF – Anoma Funfun (150.68^{0}C, 6 min)

Figure 4: Consumer sensory scores for optimized crisps from varieties of SP roots



MDA – Mother's Delight in Aluminium foil
MDH – Mother's Delight in HDPE
KJA – King J in Aluminium foil
KJH – King J in HDPE
AFA – Anoma Funfun in Aluminium foil
AFH – Anoma Funfun in HDPE

Figure 5: Peroxide Values of SP crisps as influenced by variety and storage period

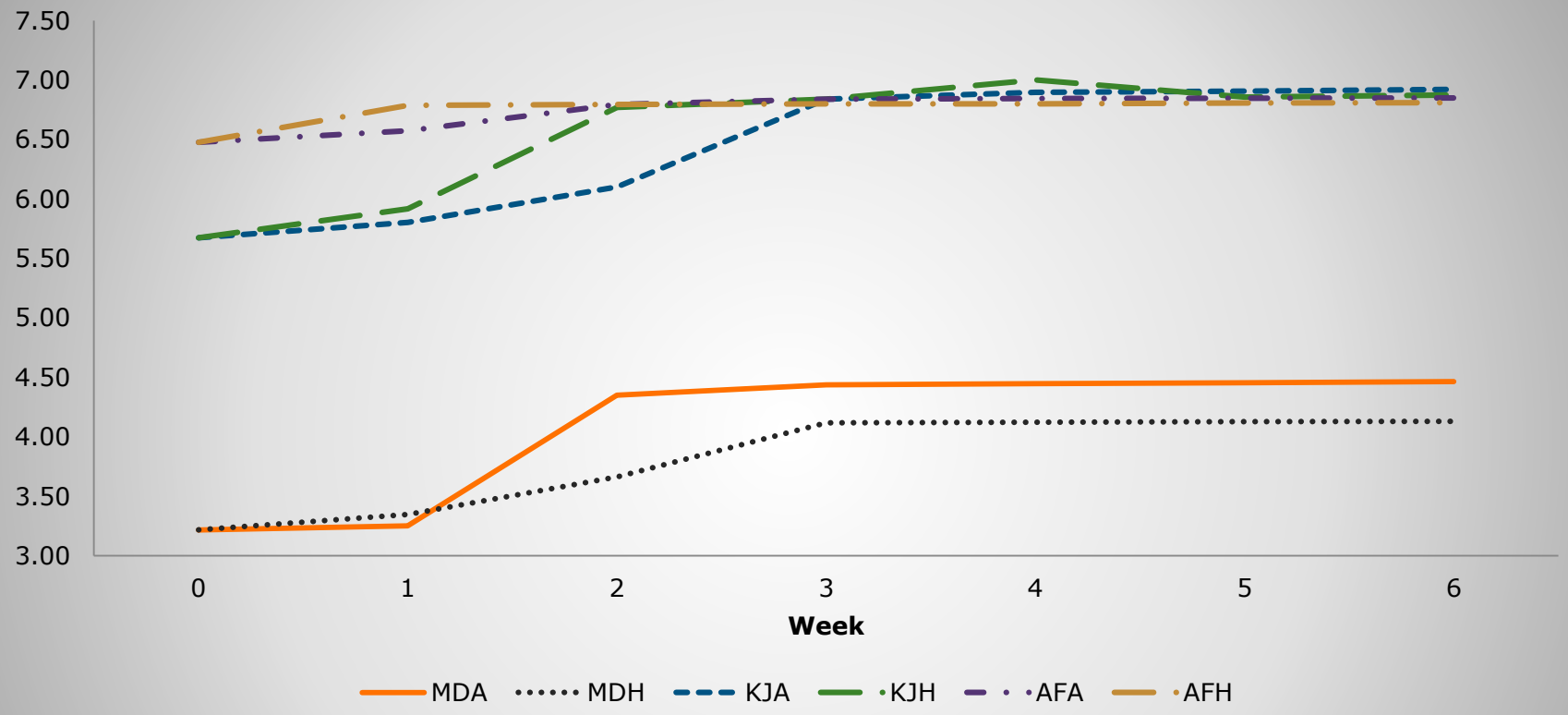


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Figure 6: Free Fatty Acid Values of SP crisps as influenced by variety and storage period

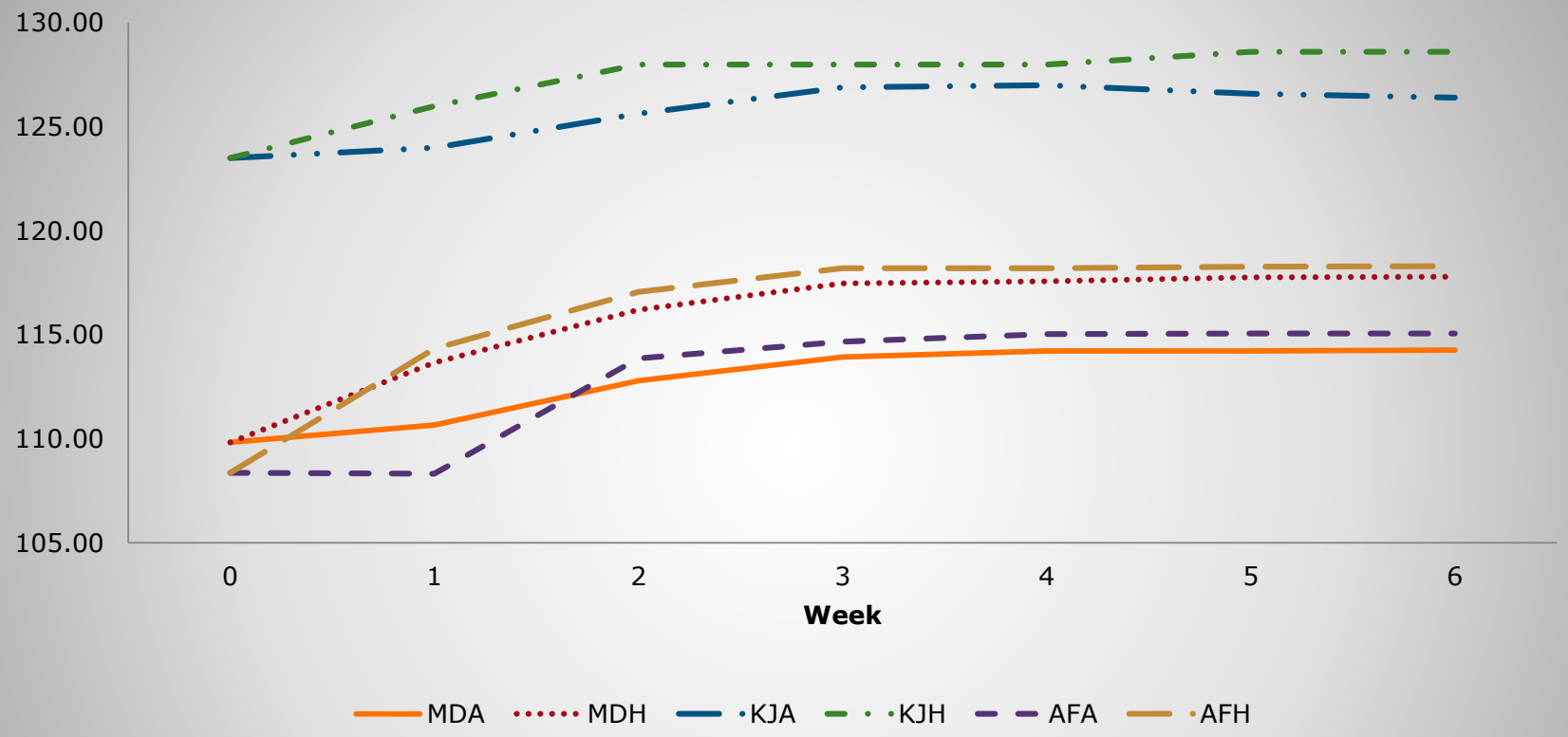

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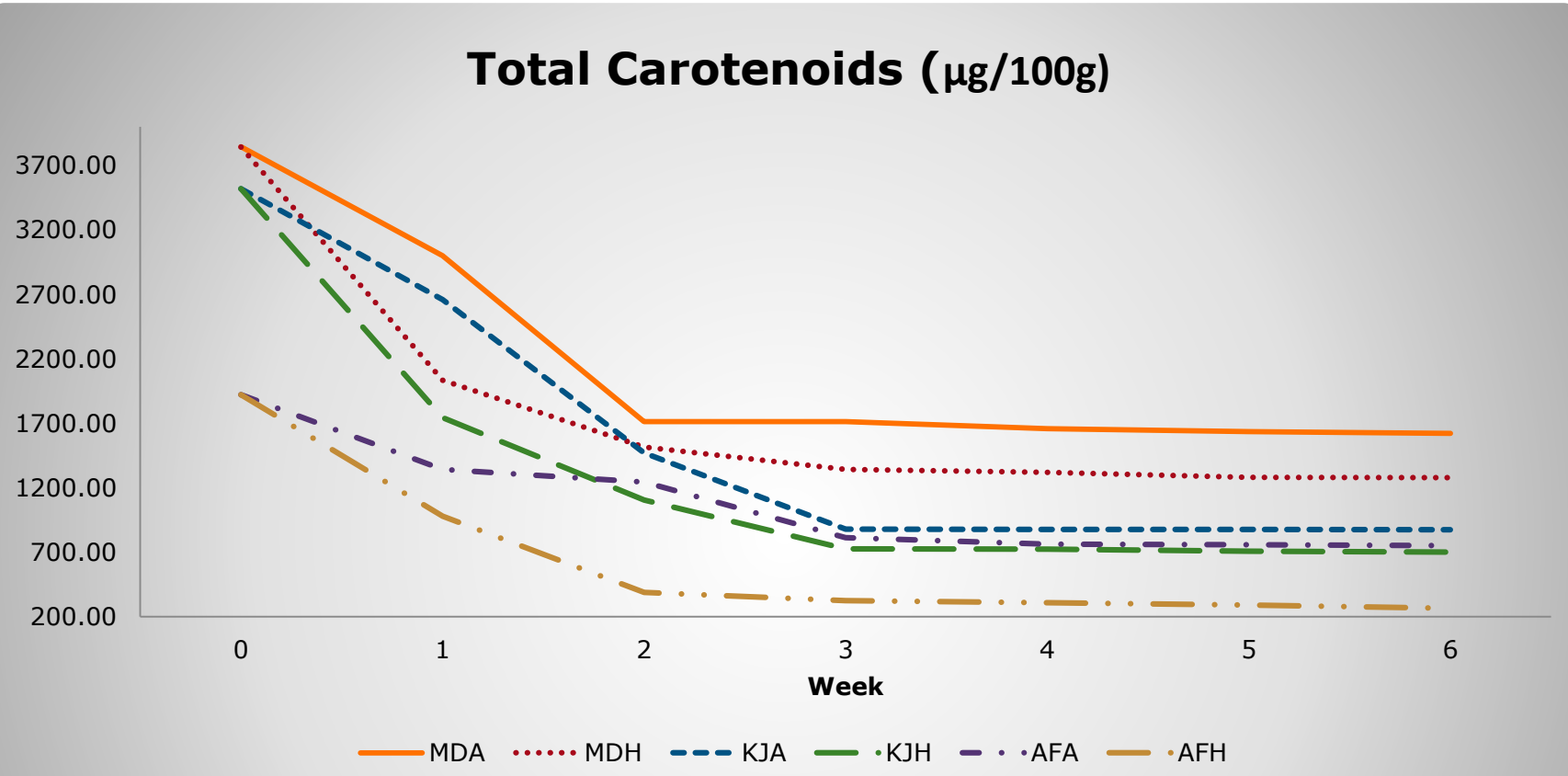
Figure 7: Saponification Values of SP crisps as influenced by variety and storage period



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MDH – Mother's Delight in HDPE
KJA – King J in Aluminium foil
KJH – King J in HDPE
AFA – Anoma Funfun in Aluminium foil
AFH – Anoma Funfun in HDPE

Figure 8: Total Carotenoid Values of SP crisps as influenced by variety and storage period

Table 5: Carotenoid Retention Values of SP crisps as influenced by variety and storage period

Sample/week	0	1	2	3	4	5	6
MDA	100.00[a]	78.07[c]	44.56 [ab]	44.54 [c]	43.15 [c]	42.52[e]	42.20 [e]
MDH	100.00 [a]	52.89 [a]	39.40 [ab]	34.94 [abc]	34.29 [bc]	33.29[d]	33.26 [d]
KJA	100.00 [a]	75.57 [c]	41.74 [a]	24.93 [ab]	24.91 [ab]	24.89 [c]	24.86 [c]
KJH	100.00 [a]	49.54 [a]	31.42 [a]	20.60 [a]	20.59 [a]	20.10 [b]	19.89 [b]
AFA	100.00 [a]	69.80[b]	64.71 [b]	42.31 [bc]	39.67 [c]	39.38 [e]	39.02 [e]
AFH	100.00 [a]	50.92 [a]	20.23 [a]	16.84 [a]	16.07 [a]	15.08 [a]	13.81 [a]

Values in any column, with the same letter are not significantly different ($P < 0.05$)
MDA – Mother's Delight in Aluminium foil
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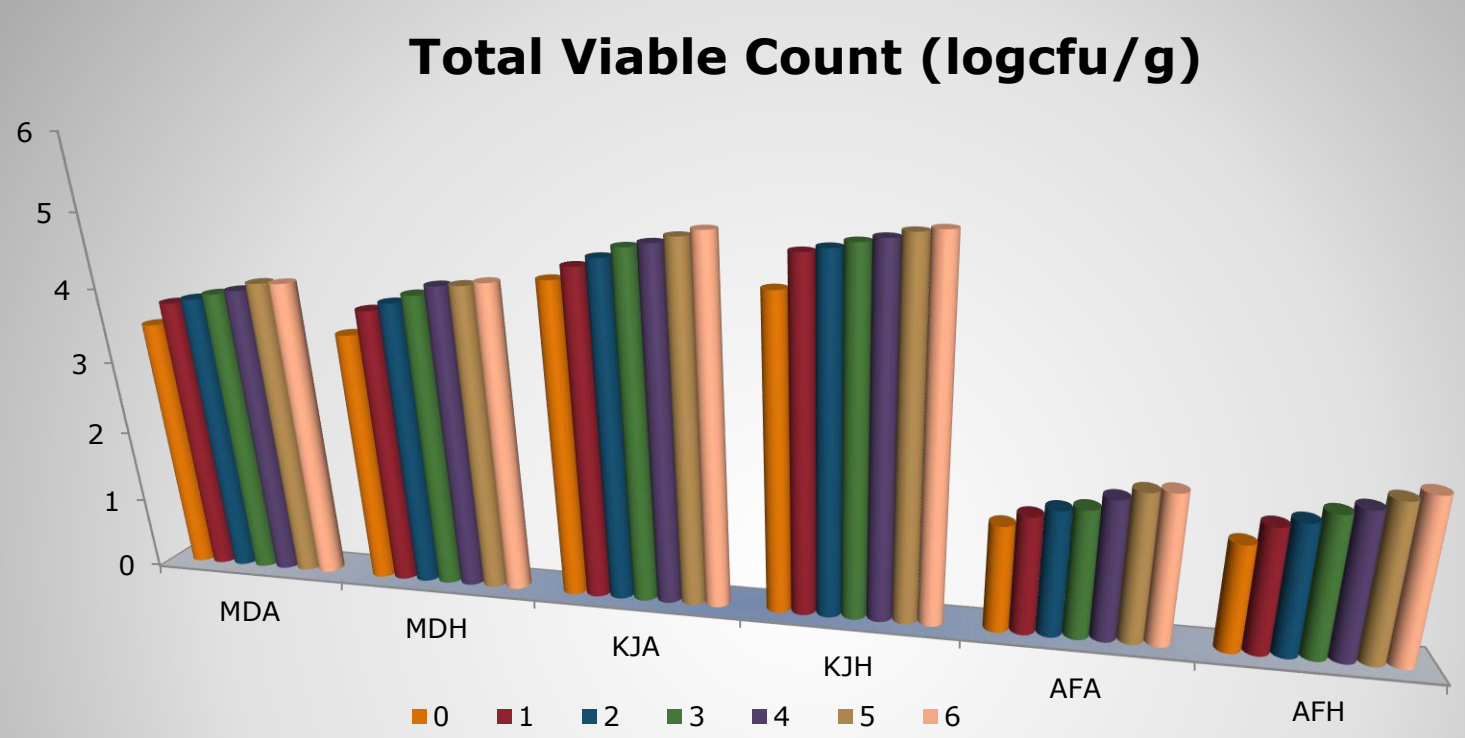

*Results of microbial counts are averages of triplicate values with standard error obtained from colony forming unit on agar plate and converted to the standard log cfu/ml values at appropriate dilution factors for each medium.

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Figure 9: Total Viable Count of SP crisps as influenced by variety and storage period

Conclusion

The optimum frying conditions and corresponding qualities for each variety are:

- Mother's delight, UMU SP03 (156.55^{0}C, 3.51 min) moisture content – 5.15%, oil content – 28.7%, total carotenoids – 3866.74 µg/100g, a* - 21.20, b* - 35..36, crude protein – 3.71%, crude fibre – 8.87%, crude ash – 1.27%, crispiness – 8.64, orange – 8.35, oiliness – 2.5
- King J, UMU SP01 (140^{0}C, 6 min) moisture content – 2.48%, oil content – 24.66%, total carotenoids – 3530.52 µg/100g, a* - 3.99, b* - 29.1, crude protein – 5.77%, crude fibre – 9.14%, crude ash – 1.01%, crispiness – 8.92, orange – 4.9, oiliness – 7.61
- 'Anoma Funfun', UMU SP02 (150.68^{0}C, 6 min) moisture content – 2.08%, oil content – 26.92%, total carotenoids – 1934.04 µg/100g, a* - 3.26, b* - 23..34, crude protein – 3.4%, crude fibre – 6.63%, crude ash – 1.65%, crispiness – 7.99, orange – 0, yellow – 9.15, oiliness – 3.39
- Aluminium foil showed a good barrier for oxidative and microbial rancidity and also better carotenoid retention ability

Recommendation

- The optimum frying conditions generated in this study should be validated in real time SME production of sweetpotato crisps from each variety

Selected references

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