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REGULAR ARTICLE

KIT RELIABILITY FOR CONTROLLING THE QUALITY OF OILS IN FOOD FRYING

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ABSTRACT

In Benin, West Africa, frying is one of the major ways of cooking. However, the chemical composition of the oil used in the food frying process contains unsaturated fatty acids and other by-products that compromise the oil quality making it toxic and often carcinogenic. The aim of this study was to check the reliability of kits in controlling three frying yams oil quality. The food frying was performed using oil in a discontinuous heating period of 15 min followed by three hours of cooling period for two experimental days. The temperature, and the oil chemical samplings were assessed with the kit every thirty minutes. In addition, selected oil chemical characteristics were determined to quantitatively and qualitatively appreciate the chemical modifications during the fast food versus the rapid food processing methods. Our findings indicate that water and volatile chemical compounds vary significantly for the first day of analysis from 0.18% to 1.6% for groundnut oil; from 0.14% to 1.4% for palm oil and from 0.17% to 1.6% for cotton oils. We detected a decrease of iodine index to 25%; 35.31% and 27.78% for groundnut, palm and cotton oils respectively. However, the peroxide index increases to 55.33%; 61.90% and 57.78% for groundnut, palm and cotton oils respectively. The increases of acid and saponification indices were also observed. Under conjugated effect of water temperature contained in the yam and air contact, the chemical characteristics of oil vary with the frying time. Our results reveal concordance consistent data with both the rapid methods and laboratory data set analysis.

Keywords: Kits, frying oils, chemical characteristics, Benin

INTRODUCTION

Oils are used in different food processing including margarines, meat frying, dressing etc. **(Berger, 1986**). The food frying increases often the fatty matters consumption (**Gertz, 2000)**. Palm oil is one of the most worldwide oils used in industrial frying due to its good resistance to oxidation **(Berger, 2005),** with an estimated use of about 5 to 10 million tons per year.

Consumption of fries such as yams, fishes, potatoes, peanuts etc. takes an important place in Benin. Most people in Benin consumed these foods as snack or breakfast, while others take them during lunch. The vegetable oils such as groundnuts, palms and cotton oils are the most commonly used in the frying processes. Generally, the overused oils during repeated frying operations lead to obvious oil color modification. In addition, the oils undergo recurring heating/cooling cycles that enhance the generation of toxic by-products in the used oils over time. For economical purpose, new oil is generally added to the used one when the level of oil content is deemed too low for the frying process. These practices increase the potential of oil spoilage and ultimately lead to carcinogenicity **(Lamboni *et al.* 2000).**

Oxidation is a major cause of flavor deterioration of lipids, fatty acids, oils, and fat-containing foods. However, this oxidation can be significantly inhibited by antioxidants such as tocopherols. Research evidence demonstrated the inhibition effects of tocopherols on auto-oxidation of oils **(Frankel *et al.,* 1959a,b; Huang *et al.*, 1994, 1995, 1996; Jung and Min, 1990).** The auto-oxidation of oils is enhanced by a combination of factors including heating or frying oils and temperature **(Gottstein and Grosch 1990)**. Different chemical reactions during food frying include hydrolysis **(Chung *et al.*, 2004; Naz *et al.*, 2005)**, oxidation **(Min and Boff, 2003; Houhoula *et al.*, 2003)** polymerization and isomerisation **(Kim *et al.*, 1999; Dobarganes *et al.*, 2000; Tompkins and Perkins, 2000, Choe and Min, 2007)**. The toxic by-products of the food frying processes **(Guillemin, 1973)** are responsible various human related pathologies **(Bonne *et al.*, 1991)**.

The traditional methods for assessing oil quality and the degree of oil spoilage during food frying processes are not only difficult and expensive, but also inadequate to the optimum requirement for the field assays, because the oil samples cannot be preserved at appropriate temperature during field assays. Newly more recent colorimetric tests have been developed for rapid chemical properties of oil quality in food frying processes. These news alternative methods are more economic and easy to be implemented for field assays. In this paper, we compare and highlight the efficacy of the new calorimetric kit based methods to the the traditional methods in assessing the quality of oils used in food frying processes in Benin

MATERIAL AND METHODS

Preparation and Sampling

Three oils, traditional raw palm oil, unrefined groundnut oil and refined cotton oil labeled Vitalor®; have been investigated in this study. The samples were from oils that had been used for cooking process for two days in periodic heating intervals (15 min) followed by three hours cooling intervals. The remaining oils after frying yams were re-used for the next cooking operation according to the cooking practices of the people.

For the food frying cycle, the oil was heated to appropriate temperature and the sized yam pieces were introduced into the heated oil. The temperature of each cooking sample was measured with a calibrated thermometer from 0 to 400°C.

Oil samples (100g per oil) were collected throughout in 30 min intervals after introducing the yam pieces. A total of sixteen oil samples were collected for the forty eight (48) samples, which amount to 4.8Kg of oil being sampled for the experimental setup as detailed in table 1.

Table 1 Heating organization

Designation	Values
Experimentation Temperature °C	150±5
Time of each heating operation min	195
Number of heating operation/1440 min	1
Total Number of heating operation per oil	2
Heating time cumulated per oil min	390
Heating time cumulated for oils min	1173
Oil quantity used at the beginning ml	3000
Saucepan capacity ml	5000
Temperature increasing time min	Groundnuts oil: 15 Cotton oil : 15
Cooling time to 28°C in min	240
Sampling interval in min	30
Oil quantity sampled per unit g	100

Assessment of carbonyled components using Fritest

Fritest Kit controlling oil quality

In the First step, the end of the syringe termed «control solution» is introduced inside sampling flask tube. In Second step: Return together the flask and the syringe and fill up with control solution, pulling slowly the piston till the stumble. If there are air bubbles, repeat pumping operation. Replace the flask and the syringe in initial position. In the Third step: introduce the full syringe inside sampling tube and drain the content of one of the test tube Rinse the spoon, filling it and draining it twice with preferentially hot fat for examination. At the end, fill it again, keeping it horizontal, and let the oil dropped in excess. In the Fourth step: drain the whole contents of the spoon, using a pouring flask inside the test tube. In the Fifth step: Close the test tube with the cork inside the kit and shake it slowly In the Sixth step: after one minute, hold the test tube between the colors sealed plates and compare the color towards the bottom as close as possible.

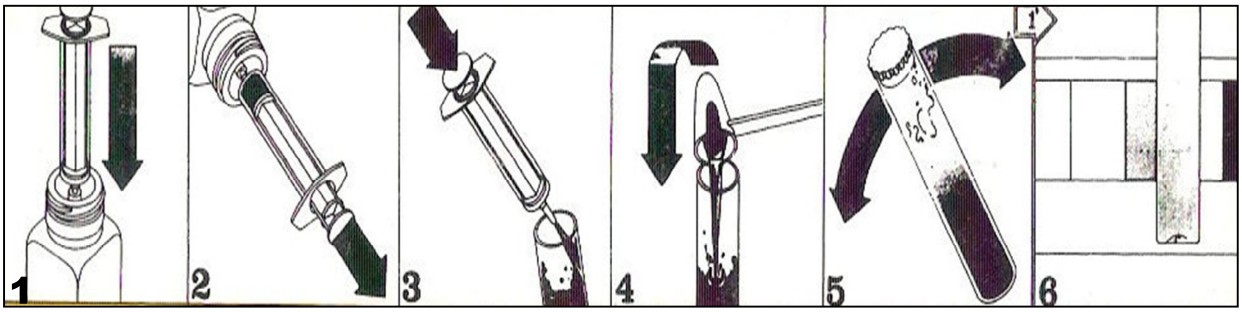

Figure 1 Step of Fritest utilization

Colors appreciation range

Color 1: the oil is perfect, Color 2: the oil is still good, Color 3: changing oil is recommended. The oil has reached the recommended limit for foodstuffs even though the taste was still perfect, Color 4: Stop. The oil is spoiled. After color appreciation, the operating oil solution should be discarded and the device rinsed with water.

RESULTS AND DISCUSSION

We focused our effort in assessing the reliability of kits used in controlling oil quality during food frying in BENIN. 48 oil samplings were used in rapid tests, which were then used in subsequent laboratory assessment of characteristics highlighted below.

Fritest Results

Fritest is a rapid, easy and economical test that precisely gives a detail status of color, odor and taste condition of the oil. It helps in knowing when the oils used in food frying are due for change. The results obtained are detailed in tables 2, 3 and 4 for the groundnut, palm and cotton oils respectively. The result analysis of the first day showed that the oils were good during the first 60 minutes of cooking as well as for the next sixty minutes. But from 150 minutes of cooking till the end of the frying operations, the oil was good for frying operations. The oil was therefore suggested to be changed for subsequent frying operations. The spoilage of the oil was confirmed by the high percentage of carbonyl components inside the heated oil. The results of the second day analysis suggested that the oil was spoiled.

Table 2 Groundnut oil (1st and 2nd day)

Day	Sampling interval	Temperature recorded °C	Digit recorded with the test
1st	New oil (beginning)	28	-
	Just before introducing pieces of yam into frying bath in min. after	150	1
	30	130	1
	60	140	1
	90	142	2
	120	138	2
	150	150	3
	180	145	3
2nd	Yesterday oil	28	-
	Just before introducing pieces of yam Into frying bath of yesterday in min. after	140	4
	30	121	4
	60	130	4
	90	140	4
	120	140	4
	150	142	4
	180	143	ND

This oil deterioration may be attributed to the effects of temperature and heat duration combined with prolonged effect of oxidations of fatty acids.

Table 3 Palm oil (1st and 2nd day)

Day	Sampling interval	Temperature recorded °C	Digit recorded with the test
1st	New oil (beginning)	28	-
	Just before introducing pieces of yam into frying bath in min.after	150	1
	30	135	1
	60	145	1
	90	130	2
	120	138	2
	150	147	2
	180	148	3
2nd	Yesterday oil	28	-
	Just before introducing pieces of yam Into frying bath of yesterday in min.after	140	4
	30	135	4

60	134	4
90	146	4
120	129	4
150	142	4
180	143	ND

Table 4 Cotton oil (1st and 2nd day)

Day	Sampling interval	Temperature recorded °C	Digit recorded with the test
1st	New oil (beginning)	28	-
	Just before introducing pieces of yam into frying bath in min.after	150	1
	30	138	1
	60	138	1
	90	146	2
	120	143	2
	150	137	3
	180	149	3
2nd	Yesterday oil	28	-
	Just before introducing pieces of yam Into frying bath of yesterday in min.after	140	4
	30	145	4
	60	142	4
	90	139	4
	120	133	4
	150	147	4
	180	149	ND

Evolution of water content and volatile matters

Water content and volatile matters during food frying varied significantly for the 1st day from 0.18% to 1.6% for groundnut oil, from 0.14% to 1.4% for palm oil and from 0.17% to 1.6% for cotton oil. For the second day the variation was from 0.8% to 1.8% for groundnut oil, 0.8% to 1.2% for palm oil and 1% to 1.4% for cotton oil (Table 5).

Water content and volatile matters amount variation is currently in relation with water content of the sliced yam pieces to be fried. The water content leads to the hydrolysis of triglycerids, which contribute to oil spoilage.

Table 5 Values of water and volatile matters contents (%: w/w)

Sampling interval	Oils					
	1st day			**2nd day**		
	Groundnut	**Palm**	**Cotton**	**Groundnut**	**Palm**	**Cotton**
At the beginning	0.18	0.14	0.17	0.8	0.8	1
Just before introducing cutted yam min. after	0.14	0.10	0.12	0.6	0.4	0.6
30	0.60	0.80	0.60	1.2	0.8	0.8
60	1.00	1.20	1.60	0.8	0.6	0.4
90	1.60	0.80	0.80	1.8	1.0	1.4
120	0.60	1.40	0.40	0.2	1.2	0.4
150	0.20	0.40	0.60	0.4	0.4	0.8
180	0.40	0.60	0.80	0.8	0.4	0.6

Evolution of saponification indices

As highlighted in Table 6, we observed an increase of saponification indices during the food frying process. The saponification indices increased from 35.71%; 26.45% and 16.05% for groundnuts palm and cotton oils during the first two hours of the frying process in the first day of the process. On the second day of the frying process, we observed a moderate evolution of this indices in the range of 6.48%; 5.32% and 7.38% increase for groundnuts, palm and cotton oil respectively.

Table 6 Saponification indices values (mg KOH /g of oil)

Sampling interval	**Oils**					
	1st day			**2nd day**		
	Groundnut	**Palm**	**Cotton**	**Groundnut**	**Palm**	**Cotton**
At the beginning	196.35	190.74	192.14	299.46	237.02	208.97
Just before introducing cutted yam min.after	210.37	196.35	174.74	260.86	239.82	213.18
30	224.40	207.57	199.15	265.07	244.03	218.79
60	238.42	215.98	206.16	266.47	245.43	221.59
90	252.45	224.40	210.37	262.28	242.63	215.59
120	266.47	237.02	222.99	270.68	243.63	217.38
150	259.46	241.23	213.18	273.48	248.24	230.19
180	258.06	235.62	207.57	276.29	249.64	224.4

Evolution of iodine indices

Time and temperature significantly influence the three iodine indices (Table 7). These indices indicate the state of insaturation of fatty acids in the fat. The iodine indices considerably decrease during frying processes. The first day of frying the indices decreases for about 25%, 35.31% and 27.78% for groundnuts, palm and cotton oils respectively. These results are in concordance with those obtained by **Soumanou (1986)**. In the second day of frying process, the decrease of iodine indices was more pronounced. The data recorded at the end of the food frying processes were respectively 34.89%; 70% and 39.44%. The decrease of the iodine indices might be due to a combination of hydrolysis reaction, oxidation and production of unsaturated fatty acids and formation of highly reactive by-products such as hydroperoxides, aldehydes, and ketones (**Combe, 1996**). According to **Frenot and Vierling (2001)**, these reactions lead to more complex reactions such as isomerisation, polymerization and cyclisation.

Table 7 Iodine indices values (g/100g of oil)

Sampling interval	Oils					
	1st day			2nd day		
	Groundnut	Palm	Cotton	Groundnut	Palm	Cotton
At the beginning	101.52	53.94	114.21	72.96	31.72	79.51
Just before introducing cutted yam min.after	98.34	52.34	111.03	71.38	25.38	74.27
30	95.17	47.58	107.86	69.79	22.20	72.29
60	92.01	46.02	104.69	68.20	19.03	69.96
90	88.83	42.82	101.52	66.62	15.86	63.07
120	82.48	39.65	95.17	63.45	12.69	57.16
150	79.31	36.48	88.83	57.10	11.10	52.67
180	76.14	34.89	82.48	47.58	09.51	48.15

Evolution of acid indices

As shown in Table 8, time, temperature and the way of frying process significant influence the quality of the oils during frying. We noticed and increase of acid indices to about 4.48, 10.09 and 0.72mg KOH/g of oil for groundnuts, palm and cotton oils respectively in the first day of frying process. These results are in agreement with those obtained by

Soumanou (1986). The increase of these indices was in correlation with the oil triglycerides breakdown by heat. This might explain the high percentage of free fatty acids observed in the oil sample during frying. This breakdown according to **Lamboni *et al.* (2000)** and **Ramel *et al.* (1995)** could stand for polar component formation, and could affect the nutritional value of the oils.

Table 8 Acid indices values (mg KOH/g oil)

Sampling interval	**Oils**					
	1st day			**2nd day**		
	Groundnut	**Palm**	**Cotton**	**Groundnut**	**Palm**	**Cotton**
At the beginning	2.24	6.73	0.12	5.38	11.22	0.78
Just before introducing cutted yam in min. after	2.52	7.01	0.22	5.61	12.34	0.99
30	2.8	7.29	0.28	6.17	13.46	1.06
60	3.36	7.85	0.34	7.85	14.02	1.12
90	3.92	8.41	0.39	8.97	1.42	1.30
120	4.01	8.97	0.5	9.81	15.70	1.40
150	4.2	9.53	0.62	10.10	16.26	1.68
180	4.48	10.09	0.72	10.65	16.55	1.90

Evolution of free acidity

The results in Table 9 showed that this fatty acid content increases in function of heating time. Thus for the first day, it increased by 55.33%, 33.26% and 83.78% respectively for groundnut oil, palm oil and cotton. It has changed less during the second day and reached respectively 49.52%, 52.34% and 58.33% for oil. This increasing in acidity results from the hydrolysis of triglycerides and accordingly shows that the preparation time and temperature affect very considerably the triglycerides and fatty acids. These results are in concordance with those of RAZALI et al (2002).

Table 9 Values of free acidity (%)

Sampling interval	Oils					
	1[st] day			2[nd] day		
	Groundnut	**Palm**	**Cotton**	**Groundnut**	**Palm**	**Cotton**
At the beginning	1,13	3,07	0,06	2,70	5,12	0,40
Just before introducing cutted yam in min. after	1,27	3,20	0,11	2 ,82	5,63	0,45
30	1,41	3,32	0,14	3,10	6,14	0,53
60	1,69	3,58	0,17	3,95	6,40	0,56
90	1,83	3,84	0,20	4,51	7,04	0,65
120	1,97	4,10	0,25	4,93	7,16	0,70
150	2,25	4,35	0,31	5 ,07	7,68	0,85
180	2,53	4,60	0,37	5,35	7,80	0,96

Evolution of the saponification indices

The results in table 10 show an increase in the saponification value relative to its observed value at the begining of the operation. It has increased respectively to the first day of 35.71%, 26.47% and 16.05% for groundnut oil, palm oil and cotton after 120 minutes before experiencing, and a slight decrease towards the end operations. On the second day there was a moderate evolution of this indices, respectively 6.48%, 5.32% and 7.38% for peanut oil palm and cotton.

Table 10 values of saponification indices (mg KOH / g of oil)

Sampling interval	Oils					
	1[st] day			2[nd] day		
	Groundnut	**Palm**	**Cotton**	**Groundnut**	**Palm**	**Cotton**
At the beginning	196,35	190,74	192,14	259,46	237,02	208,97
Just before introducing cutted yam in min. after	210,37	196,35	194,94	260,86	239,82	213,18
30	224,40	207,57	199,15	265,07	244,03	218,79
60	238,42	215,98	206,16	266,47	245,43	221,59
90	252,45	224,40	210,37	262,28	242,63	215,59
120	266,47	237,02	222,99	270,68	243,63	217,38
150	259,46	241,23	213,18	273,48	248,24	220,19
180	258,06	235,62	207,57	276,29	249,64	224,4

CONCLUSION

The physico-chemical analyses realized in the laboratory are in agreement with those recorded with Fritest. However, Kit method is a rapid and time efficient because the whole analysis can be accomplished in about 5 minutes contrarily to the conventional method.

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