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Studies of a 2:1 sodium carbonate:sodium bicarbonate mixture as papadkhar substitute for papads

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Abstract

The *papad khar* is an essential and vital ingredient in papad making, and contributes to organoleptic quality in terms of crispness and expansion of fried papads. However, the quality of *papad khar* varies from one geographical region to another, causing widespread problems in standardization. This work aims at developing a 2:1 combination of sodium carbonate:sodium bicarbonate as a *papad khar* substitute for papads in terms of fried papad quality, and the post-frying quality of the oil. Results indicate the substitute to be effective at 1%. However, analysis of the fried oil quality indicates that it is effective for up to two frying cycles.

Keywords: *Papad khar*; 2:1 Mixture of sodium carbonate:sodium bicarbonate; Papad

1. Introduction

Papad is a popular food item, prepared from cereals, legumes and combinations thereof in India, which is consumed after roasting or frying. Increased mass production of the papad for domestic consumption and export has necessitated standardization and quality evaluation of the finished product. Among the legumes, black gram is the most common raw material for papad making.

The effect of papad on the frying oil is of particular importance to the consumer, since oil is an expensive ingredient. One of the vital ingredients, incorporated in papad dough is, '*papad khar*' or '*Saji khar*'. Chemical analysis of different samples of *papad khar* have shown that it is a mixture containing 1.6–58.3% carbonates, 0–18.9% bicarbonates, 1.2–72.0% chlorides and 0–2.6% sulphates (Venkatesh, Shurpalekar, Prabhakar, & Amla, 1970). In the absence of *papad khar*, dough offers resistance to rolling, while the use of excessive amounts of *papad khar* causes darkening of the frying medium and an increase in its viscosity, resulting in soapy papads which are bitter in taste and also absorb large quantities of oil (Chaudhary, Rajgopal, Roy, & Mudambi, 1985). It is therefore necessary to determine the optimum level of *papad khar* giving the desired product. The quality and composition of the *papad khar* varies according to its place or origin. This causes problems in standardizing papad formulations. A 2:1 mixture of sodium carbonate:sodium bicarbonate (SC:SBC) has been reported to be a suitable substitute for *papad khar* (Shurpalekar, Prabhakar, Venkatesh, Vibhakar, & Amla, 1972).

The present work was undertaken with the objective of comparing the optimized levels of commercially available *papad khar* and SC:SBC for pre- and post-frying quality of papads and their effects on frying oil characteristics after multiple frying cycles.

2. Materials and methods

2.1. Materials

Black gram (*Vigna Mungo* L.) was purchased from a local market of Mumbai city, cleaned free of stones and

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straws and ground to pass through a 60 mesh sieve. *papad khar* was purchased from a local market of Mumbai city. Common salt, asafoetida, and refined groundnut oil, as frying oils, were used in the study. Sodium carbonate and sodium bicarbonate were of food grade and procured from S. D. Fine-Chem. Ltd., Mumbai.

2.2. Methods

2.2.1. Preparation of papad

The papads were prepared from soft dough obtained by mixing 5 g salt, *papad khar* (0.5–3.0%) and 1 g asafoetida, and then adding 40 ml water to 100 g black gram flour. The dough was kneaded until soft with the help of 2 ml oil and then divided into small balls of 5–6 g each, which were rolled on circular plates with smooth surfaces, with a wooden pin, into discs of about 0.3–0.5 mm thickness and 15 cm diameter. The papads were dried in a tray drier at 50 °C to a moisture level of about 14% and packed in polyethylene bags. The papads were fried for total periods of 15–20 s. using groundnut oil at 170–180 °C. The product was pale yellow to light brown in colour with a distinct fried aroma. The samples were packed in polyethylene bags and stored in air-tight containers until further analysis.

Papads were also prepared with 2:1 SC: SBC mixture at 0.5–2.0%. A control blank sample of papad was also prepared without *papad khar* or SC:SBC mixture.

2.2.2. Analysis of papads before frying

The papads were analyzed for moisture content by drying in a hot air oven at 105 °C to constant weight (AOAC, 1975). The pH values of water extracts of papad of the papad samples were determined by soaking in distilled water for 1 h, and then measuring the pH of the uniform aqueous suspension (IS, 2639, 1972).

2.2.3. Analysis of papads after frying

Moisture content was done for all samples by drying in a hot air oven at 105 °C to constant weight (AOAC, 1975). The texture was measured in a Steven's LFRA texturometer, using a TA-18,1/2'' ball probe having normal mode, up to 8 at 2 mm/s. The texture was quantified as the total load (g) required to rupture the sample. Based on the subjective judgement, the texture was classified as brittle for a load of <350 g, crisp for a load of 350–450 g, and hard for a load of >450 g. The percentage expansion was calculated by using the formula (Annapure, Michael, Singhal, & Kulkarni, 1997).

$$\%\ \text{expansion} = \frac{\text{Diameter of papad after frying} - \text{Diameter of papad before frying}}{\text{Diameter of papad before frying}} \times 100$$

Oil content of the fried papad was done in triplicate, using Soxhlet extraction for 16 h with petroleum ether (60–80 °C fraction) as the solvent (AOAC, 1975). The (U_R) was calculated from the moisture content of papad before and after frying and the oil content of the papad using the formula given by (Pinthus, Weinberg, & Saguy, 1993).

$$\text{Uptake ratio}(U_R) = \frac{\text{Oilcontent}(\%)}{[M_\text{b} - M_\text{a}](\%)},$$

where M_b = moisture content of papad before frying and M_a = moisture content of papad after frying

The colour of the fried papad was measured for all samples using a Hunter Lab. Colorimeter where '*L*' measures lightness, the chromaticity dimensions '*a*' and '*b*' indicate 'redness when positive, gray when zero and greenness when negative' and 'yellowness when positive, gray when zero, blueness when negative', respectively. Sensory evaluation was done by a six-member panel, using a scoring a method in the range 1–10, where 1–2 is Very Poor, 3–4 is Poor, 5–6 is Medium, 7–8 is Good, 9–10 is Very Good (Jakobsen, 1949).

2.2.4. Analysis of frying oils

Batches of 50 g of papad, from each lot, were fried in 300 g of refined groundnut oil at 170–180 °C for 2–2 1/2 min. Frying from each lot was done for three cycles using the same oil. Frying fat was filtered through a muslin cloth and stored in amber-coloured bottles at ambient temperature. Fried papads were packed in polyethylene bags and stored in air-tight containers until further analysis. The oil, after each frying cycle, was analyzed for refractive Index by Abbe refractometer, iodine value, acid value and peroxide value as reported by Pearson (1971).

3. Results and discussion

3.1. Effect of the level of papad khar on the papad quality

Table 1 shows the effect of the *papad khar* level on the pre- and post-frying quality of black gram papads. In the absence of *papad khar*, the dough offered resistance to rolling and hence the papad remained thick. Papads were poor in diametrical expansion on frying. As the percentage of *papad khar* increased, the dough became easier to roll (Chaudhary et al., 1985). The pH of water-soluble extracts of papads without any *papad khar* (blank) was 5.62 and increased steadily to 7.58 at 3.0% *papad khar*. This is obviously due to the alkaline nature of the *papad khar*. Texture of the fried papad, in terms of crispness, also increased steadily from 225.0 to 362.50 g as *papad khar* increased from 0% to 3%. Ab-

Table 1
Effects of papad khar content on quality of black gram based papad[a]

Papad khar (%)	0	0.5	1.0	1.5	2.0	2.5	3.0
Before frying							
Moisture (%)	12.61 ± 0.02	12.05 ± 0.02	11.24 ± 0.04	12.59 ± 0.04	11.84 ± 0.02	13.04 ± 0.03	13.34 ± 0.02
pH of water extract	5.62 ± 0.01	6.00 ± 0.02	6.23 ± 0.02	6.70 ± 0.01	7.07 ± 0.01	7.26 ± 0.01	7.58 ± 0.02
After frying							
Moisture (%)	4.28 ± 0.01	5.31 ± 0.01	4.43 ± 0.02	4.73 ± 0.01	5.32 ± 0.02	5.28 ± 0.01	5.55 ± 0.01
Texture, load (g)	225.0 ± 6.25	262.5 ± 12.5	275.0 ± 6.25	279.0 ± 6.25	287.0 ± 15.59	321.87 ± 18.7	362.50 ± 15.5
Expansion	4.29 ± 0.37	4.93 ± 0.26	5.58 ± 0.46	6.89 ± 0.28	7.78 ± 0.45	8.27 ± 0.10	8.73 ± 0.13
Oil content (%)	10.25 ± 0.24	10.97 ± 0.09	12.78 ± 0.34	15.54 ± 0.16	20.75 ± 0.27	22.08 ± 0.1	23.11 ± 0.13
Uptake ratio, U_R	1.23	1.63	1.88	1.98	3.18	2.84	2.97
Colour							
L	49.25 ± 0.36	50.97 ± 0.01	51.64 ± 0.31	53.02 ± 0.47	55.71 ± 0.71	56.39 ± 0.16	55.46 ± 0.24
a	8.27 ± 1.06	6.31 ± 0.07	8.07 ± 0.97	4.91 ± 0.06	2.46 ± 0.85	2.33 ± 0.38	2.28 ± 0.15
b	22.03 ± 0.36	21.25 ± 0.02	21.72 ± 0.07	21.83 ± 0.27	20.32 ± 0.33	21.67 ± 0.42	20.28 ± 0.05
a/*b*	0.37 ± 0.05	0.30 ± 0.02	0.37 ± 0.04	0.23 ± 0.03	0.12 ± 0.04	0.11 ± 0.02	0.11 ± 0.01
Sensory analysis[b]							
Colour	6 ± 2	7 ± 1	7 ± 2	7 ± 1	7 ± 1	7 ± 1	7 ± 1
Flavour	5 ± 2	6 ± 1	6 ± 1	6 ± 1	7 ± 1	8 ± 1	8 ± 1
Texture	5 ± 2	5 ± 3	5 ± 2	6 ± 2	7 ± 1	8 ± 1	8 ± 1
Taste	5 ± 3	5 ± 2	5 ± 2	6 ± 2	7 ± 1	8 ± 1	7 ± 1
Overall acceptability	5 ± 2	5 ± 2	5 ± 2	6 ± 2	7 ± 1	8 ± 1	7 ± 1

[a] Results are means ±SD of three determinations.
[b] Based on scoring method of 1–10 by a six-member panel as follows: 1–2 is Very Poor, 3–4 is Poor, 5–6 is Medium, 7–8 is Good, 9–10 is Very Good. Regression equation correlating oil content (X) and U_R (Y) was: $Y = 0.1325\ X + 0.0578$ ($r^2 = 0.92$).

sence of *papad khar* gave very poor expansion (4.29%). As the level of *papad khar* increased from 0% to 3%, expansion of papad also increased from 4.29% to 8.73% and oil absorption correspondingly increased from 10.25% to 23.11%. This could be due to the increased surface area provided by CO_2 liberated from the sodium carbonate of *papad khar* during frying (Chaudhary et al., 1985). Papads with 2.5% and 3% levels were easiest to roll, had maximum expansion and maximum crispness on frying. Higher levels neither improved the rolling property of the dough nor the frying qualities of the papad. Such papads developed brown patches, and had a foamy oil deposit on the surface on frying. A good correlation (0.92) was observed between oil content and uptake ratio. This is in tune with earlier reports on potato chips. The term, uptake ratio, U_R, was developed to consider the moisture lost on frying and oil content of the fried product in a single terminology (Pinthus et al., 1993). Generally, this value is almost unity for potato chips, and the water lost during frying is assumed to be replaced by oil. In papads, the U_R was found to be as high as 2.90. This indicates that the oil pick-up may be related to the chemical composition and geometry of the product.

The colour of the fried papad, in terms of lightness, is indicated by '*L*' value and redness in terms of '*a*' value. It can be seen that increase in *papad khar* level gave lighter products, which were also lower in red intensity. This is probably due to increased expansion and is evident from the following regression equations obtained between the expansion (X) and '*L*' value and '*a*' value (Y).

$$Y = 1.53X + 43.043 (R^2 = 0.94)$$
$$(X = \text{Expansion}; Y = \text{'}L\text{', value}),$$

$$Y = 1.45X + 14.609 (R^2 = 0.88)$$
$$(X = \text{Expansion}; Y = \text{'}a\text{' value}).$$

Regression analyses of *papad khar* content (X) with the oil content, expansion and texture were as follows:

$$Y = 4.912X + 9.129 (R^2 = 0.95)$$
$$(X = \textit{papadkhar}\ \text{content}; Y = \text{Oilcontent})$$

$$Y = 1.586X + 4.26 (R^2 = 0.98)$$
$$(X = \textit{papadkhar}\ \text{content}; Y = \%\text{Expansion})$$

$$Y = 38.80X + 229.35 (R^2 = 0.91)$$
$$(X = \textit{papadkhar}\ \text{content}; Y = \text{Texture value as load 'g'})$$

A correlation coefficient greater than 0.9 in all cases indicates a direct effect of *papad khar* levels on fried papad quality. Sensory analyses showed best scores at 2.5% *papad khar*, indicating it to be optimum. This level gave good colour, flavour, texture, taste, expansion and oil content, comparable to the commercial sample. Levels greater than 2.5% caused a soapy and oily taste and had a disagreeable mouth feel. This was not desirable, and has also been reported earlier (Chaudhary et al., 1985).

3.2. Effects of the level of 2:1 SC: SBC on the papad quality

Table 2 shows the effect of incorporation of a mixture 2:1 of sodium carbonate:sodium bicarbonate (SC:SBC) on the pre- and post-fried black gram papad characteristics. The pH (of water solubles) was 5.62 in the absence of SC:SBC and increased steadily to 8.79 at 2% SC:SBC. Texture of papads, in terms of crispness, also increased from 225.0 g in absence of SC:SBC to 437.5 at 2% SC:SBC. Similar trends were also observed for the oil absorption and % expansion. Here also, a good correlation of 0.97 was obtained between uptake ratio, U_R and the oil content. Besides increasing the brightness and uniformity of the colour, carbonates also mellow the undesirable pulsy flavour and impart crispness to the fried papad. The desirable level of carbonates was found to be 1% as it gave good colour, flavour, texture and taste. Higher levels of carbonates, in addition to imparting an unacceptable alkaline taste, also resulted in a foamy oil deposit on the surface of papads on frying. This has also been previously reported (Shurpalekar et al., 1972).

Regression analyses of SC:SBC (X) and fried papad quality in terms of oil content, expansion and texture (Y) were as follows:

$$Y = 7.87X + 11.734\ (R^2 = 0.95)$$
$$(X = \mathrm{SC:SBC};\ Y = \text{Oil content}),$$

$$Y = 3.60X + 4.982\ (R^2 = 0.95)$$
$$(X = \mathrm{SC:SBC};\ Y = \%\text{Expansion}),$$

$$Y = 120X + 202.5\ (R^2 = 0.94)$$
$$(X = \mathrm{SC:SBC};\ Y = \text{Texture value as load `g'}),$$

A correlation coefficient greater than 0.9 in all cases indicated a of direct effect of SC:SBC levels on fried papad quality.

The fact that 1% SC:SBC is ideal for commercial *papad khar* can be seen from Tables 1 and 2, when the results of papad quality prepared with the optimized 2.5% *papad khar* and 1% SC:SBC are comparable. It can be seen that the papads have nearly the same pH values of water-soluble extract, which are 7.26 and 7.30, respectively, and the textures of the fried papads, in terms of crispness, are 321.87 and 325 g, respectively. Papads prepared with 1% SC:SBC have a greater expansion of 8.60% and lower oil content of 19.28% than those prepared with 2.5% *papad khar* which had an expansion

Table 2
Effects of 2:1 (SC:SBC) content on pre- and post-frying quality of black gram-based papad[a]

2:1 (SC:SBC) %	0	0.5	1.0	1.5	2.0
Before frying					
Moisture (%)	12.61 ± 0.02	13.45 ± 0.02	13.34 ± 0.04	14.18 ± 0.02	14.09 ± 0.02
pH of water extract	5.62 ± 0.01	6.47 ± 0.02	7.30 ± 0.05	7.81 ± 0.03	8.79 ± 0.05
After frying					
Moisture (%)	4.28 ± 0.01	4.21 ± 0.01	4.85 ± 0.04	4.37 ± 0.01	4.67 ± 0.02
Texture, load (g)	225.0 ± 6.25	225 ± 6.25	325 ± 25	400 ± 12.5	437.5 ± 15.50
Expansion	4.29 ± 0.37	7.79 ± 0.05	8.60 ± 0.07	10.10 ± 0.37	12.14 ± 0.48
Oil content (%)	10.25 ± 0.24	18.00 ± 0.17	19.28 ± 0.04	23.15 ± 0.15	27.36 ± 0.29
Uptake ratio, U_R	1.23	1.95	2.27	2.36	2.90
Colour					
L	49.25 ± 0.36	65.34 ± 0.19	64.66 ± 0.42	64.60 ± 0.31	63.77 ± 0.25
a	8.27 ± 1.06	-0.52 ± 1.16	0.23 ± 0.17	-0.51 ± 0.20	-0.89 ± 0.17
b	22.03 ± 0.36	22.37 ± 0.34	21.74 ± 0.30	20.61 ± 0.17	20.24 ± 0.09
a/b	0.37 ± 0.05	-0.02 ± 0.05	0.01 ± 0.01	-0.02 ± 0.01	-0.04 ± 0.01
Sensory analysis[b]					
Colour	6 ± 2	7 ± 2	7 ± 1	7 ± 1	7 ± 1
Flavour	5 ± 2	8 ± 2	8 ± 1	8 ± 1	7 ± 1
Texture	5 ± 2	8 ± 2	9 ± 1	9 ± 1	8 ± 2
Taste	5 ± 3	8 ± 2	9 ± 1	9 ± 1	8 ± 2
Overall acceptability	5 ± 2	8 ± 2	9 ± 1	8 ± 1	7 ± 1

[a] Results are means ±SD of three determinations.

[b] Based on scoring method of 1–10 by a six-member panel as follows: 1–2 is Very Poor, 3–4 is Poor, 5–6 is Medium, 7–8 is Good, 9–10 is Very Good. Regression equation correlating oil content (X) and U_R (Y) was: $Y = 0.095\,X + 0.279$ ($r^2 = 0.97$).

Table 3
Effects of multiple frying cycles on iodine value of the fried oil[a]

Papad khar (%)	Iodine value after each frying cycle			SC:SBC (%)	Iodine value after each frying cycle		
	1	2	3		1	2	3
0	71.3 ± 0.05	70.2 ± 0.07	68.7 ± 0.04	0	71.3 ± 0.05	70.2 ± 0.07	68.7 ± 0.04
0.5	72.0 ± 0.09	71.1 ± 0.05	69.1 ± 0.04	0.5	75.9 ± 0.04	72.1 ± 0.05	70.5 ± 0.05
1.0	73.1 ± 0.07	71.9 ± 0.08	70.0 ± 0.03	1.0	77.1 ± 0.03	75.3 ± 0.05	72.4 ± 0.03
1.5	74.7 ± 0.03	72.8 ± 0.03	70.4 ± 0.04	1.5	78.6 ± 0.03	76.7 ± 0.04	72.6 ± 0.04
2.0	76.1 ± 0.10	73.4 ± 0.10	71.2 ± 0.03	2.0	80.2 ± 0.04	78.4 ± 0.04	74.9 ± 0.03
2.5	77.5 ± 0.08	74.6 ± 0.09	72.5 ± 0.04				
3.0	78.4 ± 0.04	75.6 ± 0.04	73.1 ± 0.03				

[a] Results are means ±SD of three determinations. Iodine value of fresh oil is 87.3.

Table 4
Effects of multiple frying cycles on acid value of the fried oil[a]

Papad khar (%)	Acid value after each frying cycle			SC:SBC (%)	Acid value after each frying cycle		
	1	2	3		1	2	3
0	0.142 ± 0.001	0.210 ± 0.001	0.279 ± 0.001	0	0.142 ± 0.001	0.210 ± 0.001	0.279 ± 0.001
0.5	0.142 ± 0.001	0.211 ± 0.001	0.280 ± 0.001	0.5	0.142 ± 0.001	0.153 ± 0.001	0.168 ± 0.003
1.0	0.142 ± 0.001	0.211 ± 0.001	0.281 ± 0.001	1.0	0.142 ± 0.001	0.154 ± 0.001	0.168 ± 0.002
1.5	0.143 ± 0.001	0.211 ± 0.001	0.281 ± 0.001	1.5	0.143 ± 0.001	0.154 ± 0.001	0.168 ± 0.003
2.0	0.143 ± 0.001	0.211 ± 0.001	0.281 ± 0.001	2.0	0.143 ± 0.001	0.154 ± 0.001	0.168 ± 0.003
2.5	0.144 ± 0.001	0.211 ± 0.001	0.281 ± 0.001				
3.0	0.144 ± 0.001	0.211 ± 0.001	0.282 ± 0.001				

[a] Results are means ±SD of three determinations. Acid value of fresh oil is 0.14.

Table 5
Effects of multiple frying cycles on peroxide value of the fried oil[a]

Papad khar (%)	Peroxide value after each frying cycle			SC:SBC (%)	Peroxide value after each frying cycle		
	1	2	3		1	2	3
0	6.30 ± 0.01	7.42 ± 0.01	10.2 ± 0.01	0	5.20 ± 0.01	8.39 ± 0.01	10.2 ± 0.01
0.5	7.35 ± 0.01	8.84 ± 0.02	11.1 ± 0.02	0.5	5.69 ± 0.01	8.72 ± 0.01	10.9 ± 0.01
1.0	8.20 ± 0.01	9.39 ± 0.02	11.6 ± 0.01	1.0	6.85 ± 0.01	9.05 ± 0.01	12.2 ± 0.02
1.5	9.14 ± 0.01	11.0 ± 0.01	12.8 ± 0.02	1.5	7.14 ± 0.01	9.53 ± 0.01	12.3 ± 0.02
2.0	10.5 ± 0.02	11.7 ± 0.01	13.5 ± 0.02	2.0	7.93 ± 0.01	10.4 ± 0.01	12.7 ± 0.02
2.5	11.3 ± 0.02	12.2 ± 0.02	14.3 ± 0.02				
3.0	12.3 ± 0.01	13.1 ± 0.02	14.5 ± 0.02				

[a] Results are mean ±SD of three determinations. Peroxide value of fresh oil is 4.78.

of 8.27% and an oil content of 22.08%. Papads containing 1% SC:SBC had better colour, flavour, texture, taste and overall acceptability than papads prepared with 2.5% *papad khar*.

3.3. Analysis of the residual oil after frying

The analytical characteristics of residual oil after three cycles of frying of papads containing *papad khar* and SC:SBC at different levels are given in Tables 3–5.

Comparative effects of *papad khar* and SC:SBC on refractive index (RI) of oil during three frying cycles showed it to be the same, at 1.466–1.470. This could be due to the oil being held at high temperature only for a very brief period. This was also reported earlier (Kotwal, Vali, & Shastri, 1993; Sulthana & Sen, 1979).

Comparative effects of *papad khar* and SC:SBC on iodine value (IV) of oil during three frying cycles are given in Table 3. The iodine value normally gives an indication of the degree of unsaturation in a fat. The change in iodine value is attributed to formation of polymers (Melnick, 1957a, 1957b). However, the actual iodine value may be much smaller than the theoretical value, if the unsaturated linkage is found in abnormal places in the fatty acids or if they are in a conjugated a system (Chaudhary et al., 1985).

After each cycle of frying, a decrease in iodine value was observed. But, as the level of *papad khar* and SC:SBC increased, increase in the iodine value was observed. After three cycles of frying, the iodine value of control sample without *papad khar* or SC:SBC decreased to 68.66. With the incorporation of *papad khar*, the value increased to 73, up to 3.0% *papad khar*, and 74.93, up to 2.0% of SC:SBC. Heat and interaction of food with *papad khar* or SC:SBC seem to be responsible for (i) change in unsaturation (ii) position of double bonds and (iii) extent of conjugated systems (Chaudhary et al., 1985).

Comparative effects of *papad khar* and SC:SBC on acid value of oil during three frying cycles are shown in Table 4. An increase in acidity has also been attributed to the repeated use of oil for frying (Garrido, Sanchez, Arroyo, & Cuesta, 1994) and intermittent heating and cooling of oil (Okiy & Oke, 1981). The acid value increases due to hydrolysis of glycerides by *papad khar* and SC:SBC (Chaudhary et al., 1985). The change in the acid value after the first cycle of frying was marginal and not significant in either case, since the oil was held at high temperature for a very brief period. But, after the second frying, cycle increase in acid value was observed in both cases. After three cycles of frying, the acid value of control sample without *papad khar* or SC:SBC was 0.279. For all levels of *papad khar* and SC:SBC, it was almost constant, ranging from 0.280 for 0.5% to 0.282 for 3.0% *papad khar* and 0.168 for 0.5 to 2.0% level of SC:SBC.

Comparative effects of *papad khar* and SC:SBC on peroxide value (PV) of oil during three frying cycles are shown in Table 5. Increase in level of peroxide value in fried oils over unheated oil was due to breakdown and decomposition of the fatty acids to hydroperoxides (Narasimhamurthy & Raina, 1998). After each cycle of frying, and also as the level of *papad khar* and SC:SBC increased, increase in the peroxide value was observed. After three cycles of frying, the peroxide value of the control sample without *papad khar* or SC:SBC was 10.2 but it increased progressively to 14.5 for 3.0% *papad khar* and to 12.7 for 2% SC:SBC. A peroxide value greater than 10 indicates that the oil is rancid and unsuitable for frying (Pearson, 1971). The results obtained in this study suggest that frying oil for papads should not be used for more than two frying cycles. Beyond two frying cycles, peroxide value increases to greater than 10. However, the oil may be regenerated for further frying cycles. This regeneration could be brought about by filtration, adsorption, and steam deodorization (Hamada & Oohira, 1982; Koval, Moiseeva, & Zaiko, 1984; McNeill, Kakuda, & Kamel, 1986; Yates & Caldwell, 1993)

Thus, the present results clearly indicate that controlled frying does not adversely affect the physicochemical characteristics oil.

4. Conclusion

A 2:1 combination of sodium carbonate:sodium bicarbonate appears to a useful substitute for *papad khar*, judged from the quality of fried papad and oil quality after frying. This would aid in standardization of papad formulations by overcoming the variations encountered due to the differences in the quality of *papad khar* obtained from different geographical locations.

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