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Effect of starch-lipids inclusion complex formation on functional properties of flour in tandoori roti

Narpinder Singh*, Kulwinder Kaur, Hardeep Singh, Harmeet Singh

Department of Food Science and Technology, Guru Nanak Dev University, Amritsar-143005, India

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Abstract

The effects of baking tandoori rotis, in the presence of different oils, on changes in functional properties of flour were studied. Both the levels and oil types showed significant effects on iodine spectra, water solubility, water absorption, viscosity and pasting properties of tandoori roti. Water solubility, water absorption, ratio of absorbance (630/520 nm) and viscosity decreased with the increase in levels of all the oil types. Among the different oils studied, hydrogenated oil showed the most pronounced effect on water solubility, water absorption, and absorbance ratio (630/520 nm) while the peanut oil showed the least effect. However, the reverse was true for peak viscosity, viscosity at 95°C, viscosity at 50° C and consistence coefficient. © 2000 Published by Elsevier Science Ltd. All rights reserved.

Keywords: Tandoori roti; Water solubility; Water absorption; Absorbance; Pasting properties

1. Introduction

Wheat is the staple food of North Indians; about 80% of the wheat in this region of India is consumed in the form of chapati, tandoori roti, paratha and puree. Chapati is usually baked on a plate heated by burning wood or charcoal or an electrical heating element or gas burner. The method of preparation for tandoori roti is similar to that of chapati. Flour is mixed with water and kneaded into a dough of the desirable consistency. The dough is mixed with shortening and salt, sheeted and baked in a tandoor. The tandoor is an oval in-ground oven, the walls of which are plastered with clay. It is heated by burning wood or natural gas. The sheeted dough is placed on a cloth pad and, with the help of a pad, is pasted to the heated walls of the tandoor. Depending upon the heat in the tandoor, the roti is baked for 60 to 90 s (Faridi, 1988). Hydrogenated, peanut, butter and coconut oil are used in the preparation of tandoori roti.

Addition of lipids has been reported to alter the physical and chemical properties of starchy foods (Singh, Cairns, Morris & Smith, 1998). The changes brought about by the oils in starchy foods have been attributed to the formation of complexes between amylose and oil (Fan, Singh & Pinthus, 1997). The formation of amylose-lipid complexes during frying and extrusion cooking in the presence of oils has already been reported (Fan et al.; Gomez, Lee, McDonough, Waniska & Rooney, 1992).

The present study was undertaken to see the effects of addition of different oil types on functional properties of starch in tandoori roti.

2. Materials and methods

2.1. Materials

Commercial flour milled from HD-2329 variety was supplied by Jawala Flour Mill (Amritsar). Butter oil, peanut oil, coconut oil, and hydrogenated oil were obtained from a local market. The free fatty acids of all oils were less than 0.5%.

2.2. Roti making

The effect of blending different oils in wheat flour on amylose-lipid complex formation and pasting properties

* Corresponding author. Tel.: +91-183-258802; fax: +91-183-258802.

E-mail address: fst@gndu.ernet.in (N. Singh).

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was studied. Flour (200 g) was mixed for 3 min with different oils (1.25, 2.5 3.75 and 5%) using adequate quantities of water to get a dough of moderately stiff consistency in a mixing bowl with a laboratory mixer (National Manufacturing Company, Lincoln, NE) The dough was divided into 80 g portions and rounded off by hand into a round ball. It was rolled into rotis of 10 cm diameter. The rotis were baked in a tandoor at 250°C for 60 s.

Tandoor was an oval in-ground oven, the walls of which were plastered with clay. It was heated by burning wood. The sheeted dough was placed on a cloth pad and with the help of the pad was pasted to the heated wall of the tandoor. Rotis, after baking were dried in a hot air cabinet drier at 40°C and ground to pass through 52 mesh sieve in a laboratory grinder. The ground tandoori roti samples were packed in polyethylene bags and kept in a refrigerator for further analysis.

2.3. Complexing index

Complexing Index (CI) was determined using the method of Gilbert and Spragg (1964) as described earlier by Guraya, Kadam and Champane (1997). This method involves the formation of a starch-iodine complex and measurement of starch which is not complexed with lipids. The absorbance is related to the portion of starch that is complexed to the iodine. The iodine solution used for analysis was prepared by dissolving 2 g of potassium iodide and 1.3 g of I_2 in 50 ml of distilled water and allowing it to dissolve overnight. Then the final volume was made to 100 ml using distilled water. A 5 g sample (triplicate) was mixed with 25 ml of distilled water in a test tube. The test tube was vortexed for 2 min and centrifuged for 15 min at 3000 rpm. The supernatant (500 μl) and distilled water (15 ml) were added to the iodine solution (2 ml). The tube was inverted several times and the absorbance was measured at 690 nm. CI was calculated from the equation:

$$CI(\%) = \frac{\text{(absorbance of control} \\ - \text{absorbance of sample)} \times 100}{\text{absorbance of control}}$$

2.4. Water solubility and absorption indices

For determination of water solubility (WSI) and water absorption (WAI) indices of tandoori roti, 2.5 g of ground sample was dispersed with 25 ml distilled water in a beaker. After stirring for 30 min the dispersions were transferred into centrifuge tubes and the beakers were rinsed with 10 ml of distilled water. The samples were centrifuged at 3000 rpm for 15 min. The supernatant was decanted and determined for solids contents and sediment was weighed. WSI and WAI were calculated using the following equation:

$$WAI = \frac{\text{weight of sediment}}{\text{weight of dry solids}}$$

$$WSI = \frac{\text{weight of dissolved solids in supernatant} \times 100}{\text{weight of sample}}$$

2.5. Iodine spectra

The method of Sowbhagya and Bhattacharya (1971) was used to determine the iodine spectra of tandoori roti starch. Starch samples were solubilized in 1 N KOH as recommended by Schoch (1964). The absorbance spectra of extract of starch–iodine complexes were measured using a UV-visible spectrophotometer (UV-1601, Shimadzu) from 400 to 700 nm and wavelengths of maximum absorbance (λ_{max}) values were determined. The ratios of absorbances at 630 and 520 nm for different samples were also determined.

2.6. Pasting properties

Pasting properties of ground roti samples were studied using a Brabender visco-amylograph equipped with 700 cm-g sensitive cartridge and cooling coil. A 50 g sample (14% moisture basis) was blended with 450 ml of distilled water to obtain a smooth dispersion. The dispersion was heated from 30 to 95°C (3°C/min) and held at 95°C for 15 min and then cooled to 50°C (3°C/min). The pastes were transferred in 250 ml beaker and brought to a temperature of 30°C in a TC-500 water bath (Brookfield Engineering Inc.) and measured for shear stress at different shear rates using a Brookfield viscometer (Model DV-II Brookfield Engineering Labs, Inc., Stoughton, MA). The measurements were taken 2 min after the spindle (No. 18) was immersed, so as to allow a thermal equilibrium and to eliminate the effect of immediate time dependency. The consistency coefficient (k) and flow behaviour indices (n) of samples were determined as described earlier for honey (Singh & Bath, 1997). Log–log plots of shear stress versus shear rate were drawn and k and n value of cooked samples pastes were calculated.

2.7. Statistical analysis

The data reported in Tables 1 and 2 are average of three replications which were subjected to one-way analysis of variance (ANOVA) using Minitab statistical software (Minitab Inc., USA).

3. Results and discussion

3.1. Complexing index

The complexing index progressively increased with the increase in levels of different oils. Hydrogenated oil showed the highest ability towards complex formation, followed by coconut, butter and peanut oil. For hydrogenated oil, the complexing index was 21, 23.6, 24.5 and 25.7% at 1.25, 2.5, 3.75 and 5% addition levels while the complexing index for peanut oil was 12.56. 15.35, 17.8 and 19.4% at corresponding oil levels (Table 1). The lower ability of peanut oil to form a complex may be attributed to the presence of higher amounts of polyunsaturated fatty acids. In our earlier study, we have reported that wheat germ oil, which contains 85% unsaturated fatty acids, is ineffective in the formation of a complex with amylose during extrusion cooking of starch (Singh & Smith, 1997). Fan et al. (1997) also observed amylose-lipid complex formation during frying of starch patties in canola oil. Schweizer, Reinmann, Solms and Eliasson (1986) reported that addition of linoleic acid and soya oil, in drum-dried wheat flour, resulted in a starch complex formation. Among coconut, butter and peanut oil, the coconut oil showed the highest ability to complex. These variations may be attributed to a variation in the composition of oils (Matz, 1976).

Table 1
Effect of oil levels on the complexing index (CI), water solubility (WSI) and water absorption (WAI) index in tandoori roti[a]

Levels	Characteristics	Peanut oil	Butter oil	Coconut oil	Hydrogenated oil
0	CI(%)	–	–	–	–
1.25	CI(%)	12.6d	16.5d	18.6d	21.0d
2.5	CI(%)	15.4c	17.9c	20.9c	23.6c
3.75	CI(%)	17.8b	19.9b	22.6ab	24.6b
5	CI(%)	19.4a	21.6a	23.2a	25.7a
0	WSI(%)	23.6a	23.6a	23.6a	23.6a
1.25	WSI(%)	22.9ab	20.6b	19.9b	16.2b
2.5	WSI(%)	20.3c	18.2c	16.6c	14.2c
3.75	WSI(%)	18.9d	16.8d	15.3d	12.3d
5	WSI(%)	15.3e	14.9e	12.9e	10.0e
0	WAI(%)	6.3a	6.3a	6.3a	6.3a
1.25	WAI(%)	5.33b	5.34b	5.30b	5.27b
2.5	WAI(%)	5.28b	5.30b	5.15b	5.10bc
3.75	WAI(%)	5.17bc	5.25b	5.08bc	4.86cd
5	WAI(%)	5.0c	5.22b	4.88c	4.65d

[a] Values with similar letters in a column for a particular parameter do not differ significantly ($P < 0.05$).

3.2. Water solubility and absorption indices

Water solubility indicates the level of degradation of starch during processing. The processing of starchy material results in changes in the molecular structure of starches, making them more water-soluble (Colonna, Tayeb & Mercier, 1989). Water absorption and solubility of tandoori roti progressively decreased with increase in the level of all the oil types; however, the decrease was more pronounced with the addition of hydrogenated oil (Table 1). The decrease in water solubility with addition of all oils was statistically significant and is consistent with the complexing index results. The oils causing maximum reduction in water solubility showed maximum complexing and vice versa. The changes brought about by different oils may be attributed to the differences in their composition. Badrie and Mellowes (1992) postulated that complex formation occurred on extrusion cooking of cassava flour with soybean oil, particularly from 5% addition of soybean oil, which resulted in decreased WSI of extrudates.

3.3. λ_{max}

The λ_{max} for amylopectin, branched or short chain fractions and for amylose, linear or long-branched chain fractions, has been reported to be 520 and 630 nm, respectively (Sokhey & Chinmaswamy, 1992). The λ_{max} for tandoori roti baked without addition of oils

Table 2
Effect of oil levels on λ_{max} and absorbance ratio (630/520 nm) of tandoori rot[a]

Levels	Characteristics	Peanut oil	Butter oil	Coconut oil	Hydrogenated oil
0	λ_{max} (nm)	593a	593a	593a	593a
1.25	λ_{max} (nm)	588b	588b	583b	580b
2.5	λ_{max} (nm)	586b,c	584c	582b,c	578b,c
3.75	λ_{max} (nm)	585.5c	583c	580c	573c
5	λ_{max} (nm)	582d	579d	573d	570d
0	Ratio (630/520 nm)	1.79a	1.79a	1.79a	1.79a
1.25	Ratio (630/520 nm)	1.74b	1.74b	1.00b	0.948b
2.5	Ratio (630/520 nm)	1.57c	1.63c	0.953c	0.918c
3.75	Ratio (630/520 nm)	1.44d	1.46d	0.936d	0.901d
5	Ratio (630/520 nm)	1.29e	1.38e	0.913e	0.893d

[a] Values with similar letters in a column for a particular parameter do not differ significantly ($P < 0.05$).

was observed to be 593 nm. The λ_{max} of tandoori roti decreased with the increase in the levels of all oils (Table 2). The statistical analysis revealed a significant effect of all oil levels on λ_{max}. A maximum decrease with hydrogenated oil and minimum with peanut oil was observed. The decrease in λ_{max} indicate a reduction in availability of amylose in aqueous solution to form an iodine amylose complex. The greater reductions in λ_{max} by hydogenated and coconut oil confirm their higher ability to form a complex with starch as compared to peanut and butter oil. Fan et al. (1997) observed λ_{max} for native starch at 602 nm, which decreased to 595 after the frying of corn starch patties in canola oil at 165°C for 5 min.

3.4. Absorbance

The change in ratio of absorbance of iodine polysaccharide complex at 630 and 520 nm has been reported to be an indication of a change in the composition of linear or branched fraction of starch molecules (Bhatanagar & Hanna, 1994; Sokhey & Chinmaswamy, 1992). The 630/520 nm ratio of tandoori roti decreased with the increase in levels of different oils. Statistical analysis showed a significant effect of all oils on absorbance ratio (630/520 nm) in tandoori roti. The hydrogenated oil caused a greater reduction in absorbance at 630/520 nm as compared with butter, coconut and peanut oil (Table 2). The decrease in ratio of absorbance (630/520 nm) in tandoori roti baked with the addition of oils may be attributed to the reduction in availability of amylose in aqueous solution to form the iodine-amylose complexes (Fan et al., 1997).

3.5. Pasting properties

Peak viscosity, viscosity at 95 and 50°C decreased with the increase in the level of all the oils. Among different oils studied, hydrogenated oil caused the greatest reduction in peak viscosity (Table 3). The viscosity at 50°C, for tandoori roti baked with the addition of hydrogenated oil at 1.25, 2.5, 3.75 and 5%, was 800, 780, 710 and 700 BU, respectively, and with peanut at corresponding addition levels was 800, 640, 605 and 580 BU. The reduction in viscosity by the oils depends upon their ability to form complexes with starch. Peanut oil had the lowest complex forming ability and hence caused greatest reduction in viscosity. A reduction in viscosity at 95 and 50°C with the addition of linoleic acid (1%) and soya oil (2%), measured using an amylograph in drum dried wheat flour has been observed earlier (Schweizer et al., 1986). Krog (1973) reported that amylose complexing agents increase pasting temperature and paste consistency and set back with wheat and corn starch.

3.6. Flow behaviour

The shear stress and shear-rate relationships for tandoori roti paste were linear with R^2 value in the range of 0.92–0.98. Tandoori rotis baked in the presence of different oils showed a decrease in consistency coefficient (k). The decrease was more pronounced with the addition of peanut oil. The k values for tandoori roti baked with the addition of 1.25, 2.5, 3.85 and 5%, peanut oil were 15.7, 13.2, 12.0 and 10.5 Pas^n, respectively (Table 4), while k values for tandoori roti at corresponding addition levels of hydrogenated oil were 19.9, 17.3, 16.5 and 15.5 Pas^n, respectively. The variation in decrease in k values caused by different oils may be attributed to the same factors as described above for the change in viscosities at 95 and 50°C, measured by the amylograph. The flow behaviour indices (n) of tandoori roti pastes were less than 1 which indicates its pseudoplastic behaviour. Tandoori roti pastes baked in the presence of different oils showed lower n values than those prepared without oils. The n values in all pastes were less than 0.35, indicating their strong pseudoplastic behaviour.

It could be concluded that the changes in functional properties of flour during baking tandoori roti depend upon levels and oil types used. Hydrogenated oil and coconut oil showed greater ability to form a complex

Table 3
Effect of oil levels on peak viscosity and viscosity of tandoori roti

Levels	Characteristics	Peanut oil	Butter oil	Coconut oil	Hydrogenated oil
0	Peak viscosity (BU)	380	380	380	380
1.25	Peak viscosity (BU)	265	270	310	325
2.5	Peak viscosity (BU)	245	265	305	330
3.75	Peak viscosity (BU)	240	260	300	300
5	Peak viscosity (BU)	220	250	300	290
0	Viscosity at 50°C (BU)	870	870	870	870
1.25	Viscosity at 50°C (BU)	800	645	800	800
2.5	Viscosity at 50°C (BU)	630	640	680	780
3.75	Viscosity at 50°C (BU)	580	600	660	710
5	Viscosity at 50°C (BU)	540	580	640	700

Table 4
Effect of oil levels on k and n of tandoori roti paste

Levels	Characteristics	Peanut oil	Butter oil	Coconut oil	Hydrogenated oil
0	k (Pas^n)	20.6	20.6	20.6	20.6
1.25	k (Pas^n)	15.7	16.1	19.9	20.0
2.5	k (Pas^n)	13.2	15.7	17.4	19.6
3.75	k (Pas^n)	12.2	13.7	16.0	16.6
5	k (Pas^n)	10.5	11.5	15.1	15.5
0	n	0.32	0.32	0.32	0.32
1.25	n	0.26	0.286	0.265	0.31
2.5	n	0.299	0.26	0.21	0.28
3.75	n	0.25	0.30	0.29	0.25
5	n	0.27	0.269	0.244	0.20
0	R^2	0.95	0.95	0.95	0.95
1.25	R^2	0.95	0.95	0.92	0.93
2.5	R^2	0.96	0.95	0.94	0.87
3.75	R^2	0.98	0.97	0.95	0.85
5	R^2	0.96	0.98	0.90	0.97

with starch than peanut and butter oil and hence caused greater changes in functional properties of tandoori roti.

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