# Characteristics of Bread and Buns Made with Lard and Vegetable Oils of Different Iodine Values

**Basil S. Kamel***
Atkemix Inc., Brantford, Ontario, Canada N3T 5K9

**A good-quality white loaf of bread or rolls can be baked by substituting liquid vegetable oil (canola, soya and palm) for the standard shortening, *i.e.* lard, tallow or partially hydrogenated vegetable shortening. Canola oil and soya oil produced lower specific volumes of 5.56 and 5.55 $cm^3/g$ and higher softness indices when used with mono- and diglycerides only. Palm oil and lard produced specific volumes of 6.33 and 6.15 $cm^3/g$ and lower softness indices with mono- and diglycerides. When a blend of surfactants consisting of mono- and diglycerides and sodium stearyl lactylate (SSL) was used at 0.5% of flour weight, palm, canola, lard and soya gave comparable results in specific volume and compressibility. Rolls baked with the same fats and oils, and addition of ethoxylated stearic acid (MYRJ 45H) or a blend of MYRJ 45H and SSL, all gave good specific volumes ranging from 6.92 to 7.27 $cm^3/g$ and a softness index range of 0.71–0.86 and 0.68–0.86 after 48 and 96 h of storage. When a proper surfactant is used, good-quality bread and rolls can be baked with liquid vegetable oil. Furthermore, the usage level of liquid oil can be cut by approximately 30% in comparison to lard or shortening while still maintaining quality.**

KEY WORDS: Canola oil, compressibility, lard, palm oil, soya oil, specific volume, surfactant.

Recent trends in the baking industry have been to replace lard, tallow and hydrogenated shortening with liquid vegetable oils or a mixture of oils and surfactants (1-5). Many reasons are attributed to this continuing trend including health, nutritional considerations, availability, cost, bulk handling and storage, labelling, and reduced usage. Possible disadvantages of liquid oils in bread formulations include slow proof time, poor oven spring, open grain, dull crumb, weak side walls, and low loaf volume. These effects can be corrected by the addition of proper surfactants (2,4).

The importance of fats and oils as baking ingredients varies with the bakery product. The addition of fat is optional in certain bread types, such as Arabic pita bread, Chinese steam bread, chapatti, and flat Iranian bread. In other bread varieties, fat is added at levels ranging from 2% to 8%. Different fats and oils are added to baked goods to produce improved volume, soft texture, uniform cell structure, tenderizing effect upon the crumb and crust, improved shelf life, and to facilitate dough handling and processing. Fat and protein also act as emulsifiers for the gas bubbles. This will enhance dough shortening by the incorporation of air, and these attributes may be reinforced by added surfactant. Fats also increase the caloric value, enhance flavors of the products and stabilize cake batters.

This study was undertaken (i) to determine if fats and oils of varying iodine values have any effect on the characteristics of white loaf and rolls; (ii) to determine the type of surfactant or surfactant blend needed to improve the functionality of fats and oils; and (iii) to evaluate the effect of fats and oils on the shelf life of bread and rolls.

*Address correspondence at Atkemix Inc., P.O. Box 1085, Brantford, Ontario, Canada N3T 5K9.

## MATERIALS AND METHODS

*Bread baking.* A commercially milled bread wheat flour Harvest Queen (Ogilvie Mills, Montreal, Canada), with 13.7% protein, 12.1% moisture, and 63.3% Farinograph water absorption, was used in baking the loaves. All other ingredients were purchased locally. A standard dough formulation, shown in Table 1, was used. All ingredients were mixed in a Hobart mixer for 1 min at the low speed (setting 1), for 1 min at the medium speed (setting 2), and finally, for 8 min at the high speed (setting 3). After a 6-min rest, the dough was scaled to 519 g, rounded, and given another 9-min rest at room temperature. Rested dough was sheeted and molded on an ACME Rollsheeter (McLean and Son, Pico Rivera, CA). Molded pieces were placed in lightly greased bread pans (24 × 11.5 × 7 cm) and proofed at 34°C and 90% relative humidity for 65 min. This was the time required by the control (without any surfactant) to reach a height of 3 cm above the edge of the baking pan. The loaves were baked for 20 min at 215°C in a rotary-rack oven. Duplicates of each treatment were baked, each consisting of six loaves.

*Rolls baking.* The same flour used in bread was used in rolls baking. The formula used is shown in Table 1. All ingredients were mixed, at medium speed (setting 2) for 15 min in a Hobart mixer. The dough was proofed for 20 min, scaled to 80 g, hand-rounded, and given another 10-min rest at room temperature. Rested dough was sheeted and placed in greased rolls pans and proofed at 35°C and 90% relative humidity for 55 min. The rolls were baked for 15 min at 165°C in a rotary-rack oven: triplicate bakes for each treatment, each batch consisting of 12 rolls.

*Surfactants.* Four commercially available surfactants were used in the baking formula: ATMUL 500 (a mono- and diglyceride, 54% min alpha monoglyceride), ATMUL P-44 [a powder combination of mono- and diglyceride and sodium stearyl lactylate (SSL)], MYRJ 45H (a hydrate of polyoxyethylene 8 stearate) and ATLAS S-45 (a hydrate of polyoxyethylene 8 stearate and SSL) were all obtained from ICI-Canada, Toronto, Ontario, Canada. The approximate Hydrophilic-Lipophilic Balance (HLB) values of the above emulsifiers are approximately 3.5, 7.5, 11.1 and 11.5, respectively.

*Regulation.* Mono- and diglycerides are G.R.A.S. (Generally Recognized As Safe) materials and used extensively in bakery products. SSL is allowed in Canada at 0.375% and up to 0.5% of flour weight in the United States. MYRJ 45 is not allowed in bakery products in the United States but is allowed in Canada in unstandardized bakery products at 0.4%. The maximum allowed level of ATMUL P-44 in Canada is 0.55% of flour weight.

*Physical properties.* The breads and rolls were allowed to cool for 1 h, weighed and tested for volume by rapeseed displacement. The specific volumes were then calculated. Moisture was determined on a composite sample from one loaf per treatment by the oven drying method at 105°C

TABLE 1

**White Loaf and Roll Formulations**

| | Baker % | |
|---|---|---|
| Ingredient | Rolls | Bread |
| Flour | 100 | 100 |
| Water | 62.0 | 66.0 |
| Compressed yeast | 3.0 | 2.0 |
| Yeast food | 0.5 | 0.5 |
| Sucrose | 5.0 | 4.0 |
| Nonfat dry milk solids | — | 4.0 |
| Salt | 1.5 | 2.0 |
| Fat/oil | 4.0 | 3.0 |
| Calcium propionate | 0.2 | 0.2 |
| Surfactant | 0.8 | 0.5 |
| Fresh eggs | 4.2 | — |

TABLE 2

**Composition of the Fats and Oils Used in Baking Formulation**

| | | Fatty acid | | | | |
|---|---|---|---|---|---|---|
| Fats and oils | I.V.[a] | C16:0 | C18:0 | C18:1 | C18:2 | C18:3 |
| Lard | 64.4 | 24 | 16 | 47 | 9 | 0.3 |
| Palm oil | 51.4 | 46 | 5 | 39 | 9 | 0.5 |
| Soya oil | 135.5 | 11 | 4 | 23 | 54 | 8 |
| Canola oil (rapeseed) | 118.1 | 4 | 3 | 63 | 20 | 8 |

[a]I.V. = iodine value.

overnight. The remaining loaves and rolls were double-wrapped in polyethylene bags and stored at 23 ± 1°C until used. The loaves and rolls were sliced into 12-mm thick slices. The end slices in the loaves were discarded. The compression measurements on two loaves and 12 rolls per treatment were obtained with the baker compressimeter (F. Watkins Corp., Caldwell, NJ). A plunger diameter of 36 mm was used according to the procedure of AACC method 74-10 (6). The force was recorded at 3.0 mm compression (25% deformation). One measurement per slice was obtained from the center of the slice.

The retarding effect of the surfactants on the firming rate of the tested breads and rolls was expressed in terms of a softness index, which was calculated as a ratio between the compression force recorded for the emulsifier-treated bread and the control at the same period of storage.

## RESULTS AND DISCUSSION

The iodine value and typical fatty acid composition of the lard and oils used in bread and rolls baking is shown in Table 2. Lard contains high C18:1 and C16:0 and has the highest level of C18:0. Canola oil is dominated by C18:1 and C18:2. Soya oil has the most C18:2 while palm oil is dominated by C16:0 and C18:0. Soya and canola both contain 8% of C18:3. These differences in fatty acid composition affect the liquid-to-solid fat ratio of the individual fat and oil. This ratio is approximately 70:30 for lard. Positive relationship between solid fat index and baking performance was reported by Pomeranz *et al.* (7). They also reported that better dough strengthening is obtained when fats and oils with a higher melting point are used. The addition of nonpolar lipids damages the bread quality of defatted flour while the addition of polar lipids increases loaf volume and improves texture (7–9).

The utilization of various fats and oils and oil/surfactant blends, and their mechanism in baked goods were reported by other workers (2,4,5,10,11). These authors concluded that surfactants are effective additives in overcoming the negative effects of vegetable oils in yeast-raised baked goods.

White bread was baked with lard and different vegetable oils, with two types of surfactants, and compared to a lard-based control containing no surfactant. The data showed that differences occur. Canola oil and soya oil, with addition of mono- and diglyceride, produced lower specific volumes of 5.56 and 5.55 $cm^3/g$ in comparison to the lard control with no surfactant, which produced a specific volume of 5.99 $cm^3/g$. Palm and lard, with the mono- and diglyceride, gave 6.33 and 6.15 $cm^3/g$. Softness index after 24, 96 and 168 h of storage showed that canola and soya gave the highest values, while palm and lard produced softer bread. When a combination of surfactants consisting of monoglycerides and SSL was used, canola and soya gave better specific volumes than palm and lard. Softness indices were similar but generally softer than the sets of bread made with the same oil but with the mono- and diglyceride as emulsifier (Table 3).

The rolls baked with the same fats and oils performed differently from the bread. Different sets of surfactants were used and consisted of ethoxylated stearic acid (MYRJ 45) and a combination of MYRJ 45 and SSL. The vegetable oils and lard with both surfactants gave similar specific volumes in the range of 6.92–7.27 $cm^3/g$, which was higher than the control. Compressibility and softness indices, after 48 and 96 h of storage, were generally the same (Table 4).

Hartnett and Thalheimer (2) reported that bread baked with soya oil produced lower specific volume than bread made with equivalent levels of lard. The final bread quality was also poor when lard, soya oil and cottonseed oil were used at 2–3% of flour. With a surfactant consisting of mono- and diglyceride and polysorbate 60, superior results were achieved.

Bruinsma and Finney (4) screened eleven different vegetable oils and three oil/surfactant blends in bread baking at 2% oil level. The bread volume for all oils remained low, but improved when the level was increased to 6%. The oil/surfactant blend, at the 2% level, performed better. All eleven oils, with the physical addition of 0.2–0.3% SSL and diactyl tartaric acid ester of mono- and diglyceride (DATEM) to the dough, improved results and satisfactory volumes were obtained.

Pomeranz *et al.* (12) showed that glycolipids are more beneficial than phospholipids, shortening, fat or a combination of vegetable oil and emulsifier, and are essential ingredients in breadmaking. They also concluded that corn oil or soybean oil at 2% can replace shortening in steam bread with comparable results. Addition of 0.1–0.2% surfactant improved softness and was superior to shortening alone.

The antifirming characteristics of surfactants were attributed to their ability to form soluble helical complexes with amylose, and to its limited interaction with amylopec-

**TABLE 3**

**Characteristics of White Loaf Made with Different Fats and Oils**[a]

| Surfactant | Type of fat | Specific volume ($cm^3/g$) | Storage time (h) 24 | 96 | 168 | 96 | 168 |
|---|---|---|---|---|---|---|---|
| | | | Compressibility (g force) | | | Softness index | |
| ATMUL 500 | Palm | 6.33 | 80 | 134 | 207 | 0.83 | 0.78 |
| ATMUL 500 | Canola | 5.56 | 106 | 155 | 237 | 0.97 | 0.90 |
| ATMUL 500 | Lard | 6.15 | 74 | 117 | 184 | 0.73 | 0.70 |
| ATMUL 500 | Soya | 5.55 | 104 | 160 | 230 | 0.99 | 0.87 |
| ATMUL P44 | Palm | 6.31 | 72 | 116 | 177 | 0.72 | 0.67 |
| ATMUL P44 | Canola | 6.57 | 68 | 105 | 167 | 0.65 | 0.63 |
| ATMUL P44 | Lard | 6.24 | 72 | 108 | 157 | 0.67 | 0.59 |
| ATMUL P44 | Soya | 6.46 | 70 | 105 | 154 | 0.66 | 0.58 |
| Control[b] | Lard | 5.99 | 93 | 160 | 264 | 1.0 | 1.0 |

[a]The moisture content of the loaves ranged between 37.5–38.5%.

[b]The control contains no emulsifier.

**TABLE 4**

**Characteristics of Rolls Made with Different Fats and Oils**

| Surfactant | Type of fat | Moisture (%) | Specific volume ($cm^3/g$) | Storage time (h) 24 | 48 | 96 | 48 | 96 |
|---|---|---|---|---|---|---|---|---|
| | | | | Compressibility (g force) | | | Softness index | |
| MYRJ 45H | Palm | 32.1 | 7.03 | 79 | 116 | 199 | 0.71 | 0.72 |
| MYRJ 45H | Canola | 31.7 | 6.95 | 83 | 124 | 186 | 0.76 | 0.68 |
| MYRJ 45H | Lard | 31.3 | 6.92 | 89 | 137 | 207 | 0.84 | 0.75 |
| MYRJ 45H | Soya | 32.5 | 7.06 | 74 | 125 | 171 | 0.76 | 0.62 |
| ATLAS S45 | Palm | 33.1 | 6.93 | 85 | 141 | 236 | 0.86 | 0.86 |
| ATLAS S45 | Canola | 32.1 | 6.97 | 85 | 119 | 197 | 0.72 | 0.72 |
| ATLAS S45 | Lard | 32.7 | 7.18 | 83 | 124 | 208 | 0.76 | 0.76 |
| ATLAS S45 | Soya | 31.5 | 7.27 | 80 | 119 | 189 | 0.72 | 0.69 |
| Control[a] | Lard | 32.4 | 6.63 | 108 | 164 | 275 | 1.0 | 1.0 |

[a]The control contains no emulsifier.

tin. Dough strengthening is also produced by complexation with proteins (13). The different types of surfactants vary in these interactions. Junge *et al.* (11) found that surfactants that improve grain did not significantly alter dough densities, but surfactants that improve grain allowed more and smaller cells to form during the mixing stage than did nonimproving surfactants. Mixtures of surfactants improved both volume and grain.

The trend of replacing plastic fats (lard, tallow, hydrogenated vegetable shortening) in baked goods with liquid vegetable oil will continue in the future, due to the increase in automated operations, which require bulk handling of ingredients to maintain production speed and reduce cost. A one-third reduction in total fat can also be attained by switching from plastic shortening to liquid oil. This is due to the fact that lard is comprised of 30% solid fraction. If a substitution was made with vegetable oil only, the liquid fraction of the fat should be replaced, which represents 70%. The selection of the proper surfactant or surfactant blend, and its usage level, will also play a significant and important roll in obtaining good-quality bread.

## ACKNOWLEDGMENT

The author appreciates the endless effort of Miss Kelly Fitzpatrick for typing and correcting this manuscript.

## REFERENCES

1. MacDonald, I.A., and G.P., Lensack, *Cereal Science Today 12*:1 (1967).
2. Hartnett, D.I., and W.G. Thalheimer, *J. Am. Chem. Soc. 56*:944 (1979).
3. Osnabrugge, W.V., *Cereal Food World 33*:564 (1988).
4. Bruinsma, B.L., and K.F. Finney, *Cereal Chem. 61*:279 (1984).
5. Knightly, W.H., *Ibid. 59*:171 (1981).
6. AACC Approved Method (74-10), American Association of Cereal Chemists, St. Paul, MN, 1980.
7. Pomeranz, Y., G.L. Rubenthaler and K.E. Finney, *Food Technol. 20*:105 (1966).
8. MacRitchie, F., and P.W. Gras, *Cereal Chem. 50*:292 (1973).
9. Pomeranz, Y., G.L. Rubenthaler and K.F. Finney, *Food Technol. 19*:120 (1965).
10. Smith, W.M., *Bakers Dig. 53*:8 (1979).
11. Junge, R.C., R.C. Hoseney and E. Marston Varriano, *Cereal Chem. 58*:338 (1981).
12. Pomeranz, Y., M. Huang and G.L. Rubenthaler, *Ibid. 68*:353 (1991).
13. Lorenz, K., W.J. Dilsaver and K. Kulp, *J. Am. Oil Chem. Soc. 59*:484 (1982).

[Received November 24, 1991; accepted March 19, 1992]