HIGH MILK-PROTEIN BREAD

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SUMMARY

The protein content of bread was increased from 13.96 to 18.04% on a dry basis, or nearly 30%, by including 25 parts of nonfat dry milk per 100 of flour in the bread formula. The loaves had excellent flavor and good toasting quality; symmetry and crust color were substandard; crumb color, texture and grain, and cell structure good. The biological value of the protein was nearly doubled in comparison with the protein in bread containing only four parts nonfat dry milk per 100 of flour and, at the same time, the bread had good consumer acceptability in limited, preliminary trials.

The use of nonfat dry milk (NFDM) in bread has become an established practice in the United States. In 1957, the baking industry utilized 332.5 million pounds (6) at an estimated level of 3 to 4%, based on the flour used. This amount imparts obvious advantages in improved crust color, grain, texture, and toasting quality. Less readily observed advantages are improved dough uniformity, machinability, and water absorption and, finally, improved nutritive value of the bread is perhaps the most significant of all.

Despite these advantages, the per capita consumption of bread has decreased annually in recent years. This decrease can be attributed partly to current ideas of diet. It is, however, of considerable interest that Jack and Haynes (5), in a carefully controlled study, showed that young boys ate increasing amounts of bread containing increased amounts of NFDM. Levels of 6, 10, and 14% NFDM caused increased consumption of 4, 8, and 13%, respectively.

A detailed consideration of the nutritional advantages of supplementing wheat proteins which are deficient in L-lysine, with milk proteins that are rich in L-lysine, is not a simple matter. Bender (1) has recently given evidence that deficiencies of threonine and methionine exist in cereal proteins, so that L-lysine alone does not suffice for complete supplementation. The differences in amino acid requirements between experimental animals and man, and varying requirements of humans with age, sex, and physical activity, all make any exact interpretation of nutritional tests difficult. Nevertheless, the consensus of nutritionists, that milk furnishes an excellent supplementation for cereal proteins, is well-founded and supported by a large body of evidence.

The present investigation was undertaken to determine how high the level of NFDM could be raised in white bread formulas, and still produce satisfactory bread, without radically modifying production methods. Powers (7), in 1936, carried out a similar study and patented production methods based on mixing the dough two to five times as long as the optimum mixing time for bread dough without milk. The results of his study and those reported herein are, on the whole, in excellent agreement.

METHODS AND MATERIALS

The standard white bread formula and straight dough procedure currently in use in this laboratory for measuring the baking quality of NFDM were employed, with milk solids the only variable. The basic bread formula was:

Flour[1]	100 parts (12.0% protetein, 0.45% ash, and 14.0% moisture)
Sucrose	3 parts
NaCl	2 parts
Shortening	3 parts
Nonfat dry milk	0, 2, 6, 12, and 25 parts
Water	Variable to produce satisfactory dough consistency
Yeast food	0.25 parts
Compressed yeast	2 parts

Three loaves of approximately 1 lb. each were baked from each dough. To insure proper dough development, the ingredients were mixed in a Fleischmann vertical-type laboratory mixer until 1 min. after there was complete pick-up of the dough from the sides of the mixer. In this way, smooth-appearing doughs which were soft and pliable, although not sticky, were obtained. The doughs containing the highest level of NFDM were more plastic than usual, but could be handled and machined without difficulty. Fermentation was carried out at 82° F. and consisted of periods of 135, 40, and 20 min., with hand-working of the dough after the first and second periods. The last fermentation period was followed by machine-molding and a proofing period of 60 min. at 92° F. and 90% humidity. The bread was baked in a gas-fired, reel-type oven for 30 min. at 400° F., or for 40 min. at 350° F. Loaf volume was measured by seed displacement after 1 hr. of cooling at room temperature. All loaf volume measurements are the mean value of nine loaves baked from three doughs (three loaves each dough) on different days. The NFDM used in the baking was commercial grade and was purchased as having been manufactured by the superheated, spray-dried process. The undenatured whey protein nitrogen of this NFDM, as determined by the Harland and Ashworth (4) procedure, was 1.0 mg/g.

RESULTS AND DISCUSSION

Table 1 presents the pertinent data obtained, including variations in manufacturing procedure and the bread characteristics.

Loaf volume. All loaves containing NFDM were larger than the water bread loaves, those containing six parts NFDM/100 parts flour being the largest. Excluding the latter volume, the differences between loaf volumes of the other milk loaves were not significant. In baking the doughs containing 25 parts NFDM per hundred of flour, there was relatively little oven spring and the resulting bread was compact.

What the loaf volumes would have been, if the baking time and temperature had been the same for all loaves, is not known. In any event, the data indicate that good loaf volume can be obtained even at the highest level of nonfat dry milk in the bread formula.

[1] A mixture of equal parts of Northwestern and Southwestern bakers' grade patent flour was used.

TABLE 1
Characteristics of bread containing increasing levels of nonfat dry milk

NFDM	Loaf volume	Sym-metry	Crust color	Crumb color	Texture	Grain, cell struc-ture	Average mixing time	Dough quality	Baking temperature	Protein[a] (dry basis)
(parts/100 of flour)	*(ml.)*						*(min.)*		*(°F.) (min.)*	*(%)*
0	2,268	Fair	Pale	Fair	Good	Good	9.0	Good	400° — 30	13.96
2	2,342	Good	Fair	Good	Good	Good	10.5	Good	400° — 30	14.51
6	2,406	Good	Good	Good	Good	Good	14.0	Good	400° — 30	15.12
12	2,369	Good	Good	Fair	Fair	Poor	14.3	Good	350° — 40	16.47
25	2,303	Poor	Dark	Good	Good	Good	16.0	Plastic	350° — 40	18.04

[a] Calculated on the basis of $N \times 6.38$ for milk protein and $N \times 5.70$ for flour protein.

Symmetry. Only the loaves containing the highest level of NFDM were undesirable in this property, chiefly because of their tendency to have a ragged or sometimes a wild break. Probably this was due to the plastic character of the dough. In other experiments, these defects were lessened by increasing the water absorption of the dough or by the addition of small amounts of cysteine HCl or a monoglyceride.

Crust color. The crust color of the highest milk-protein breads (12 and 25 parts NFDM), according to standard scoring technique, was definitely dark red–brown, and must be classified as substandard. This was due to the high lactose and protein content, but the darker color might not be considered undesirable by many consumers. A pale crust-color was obtained with the water bread. It, too, was considered substandard.

Crumb color. As the NFDM level was increased there was a slight increase of creamy color in the crumb. At the highest level this did not appear excessive and should not be considered objectionable in a specialty bread.

Texture. In all cases, texture of crumb was considered good, except for the loaves containing 12 parts NFDM per hundred of flour. This particular level of NFDM invariably produced conditions resulting in coarse cell structure; there was a tendency for the dough to pull away from the sides of the baking pan, causing sunken sides to the baked loaf and undesirable cores at the sides immediately under the break.

To get the best results when bread containing high percentages of dry milk is made, it is generally necessary to increase the fermentation time, due to the increased buffering capacity resulting from the added milk solids. If this adjustment had been made, the bread containing 12 parts NFDM/100 of flour might have been better than reported (2).

Grain and cell structure. The loaves that contained 12 parts NFDM per hundred of flour always showed coarse cell structure with large round cells having thick cell walls. Those that contained the highest level of NFDM had a close grain. The cells were uniform and they had a thin wall structure.

Flavor and eating quality. As the nonfat milk solids level was increased, a distinct milk flavor became more pronounced and at the highest level was outstanding without being objectionable. This bread had a rather firm, but tender, texture and an excellent eating quality.

Mixing time. With increasing nonfat milk solids, the mixing time including proper dough development was extended, as might be expected. It was found that small additions of dough-softening agents would materially reduce the total mixing time. Cysteine HCl, 20 mg/900 g. flour solids, was effective in this respect without any harmful effects.

Dough quality. Nonfat milk solids, except for the highest level, improved handling quality of the doughs. At the highest level a certain plastic quality, which was not extreme, always developed. It caused no difficulty in loaf molding or other operations.

Baking time. To prevent excessive browning of the crust, and yet obtain thorough baking, the loaves that contained 12 and 25 parts of NFDM/100 of flour were baked at a 50° F. lower temperature for an additional 10 min. In a commercial operation some adjustments could be made because of the smaller loaves and excessive browning.

From the above, it is evident that the highest milk-protein bread compared favorably with other levels of NFDM bread when baked under the modified conditions. In some respects bread having a level of 25 parts of nonfat milk solids based on the flour would be considered a specialty bread, which might be expected to require wide variation from accepted bread-manufacturing procedure. However, our results were obtained following a production schedule with small variations, regardless of milk solids level.

Use of dry whole milk in high milk-protein bread. Since dry whole milk contains the fat component that is generally recognized as primarily responsible for improved flavor in milk products, it was desirable to determine if high milk-protein bread could be produced using dry whole milk. Satisfactory results were obtained with the formula, modified so that the dry whole milk was the only source of fat. The percentage of milk fat associated with the 25 parts nonfat milk solids level was approximately eight, based on flour weight. This is an extremely high level and its effect on the finished bread was distinct. The making characteristics of high milk-protein bread using dry whole milk were the same as those with NFDM; volume of the finished bread was about 5% lower than the control water bread, while a readily noticeable difference was an alteration in flavor and odor of the bread. At low levels of milk solids in the bread, it was difficult to distinguish the NFDM from the dry whole milk bread, but at the 25 parts level the difference was unquestionable. Direct comparison of slices of bread of each type permitted identification of the source of milk solids without error, while a comparison of flavor differences was less reliable. The use of dry whole milk in producing 25 parts nonfat milk solids bread also resulted in an improvement in crust color. The brown color of the bread was several shades lighter and the bread had a more uniform, toast-brown color. Increasing the level of fat to eight with shortening did not effect the same result, although the equivalent amount of butter oil added separately from the milk solids seemed equally effective. The explanation of this has not been determined.

Acceptance of high milk-protein bread. To test acceptance of high milk-protein bread on a limited scale, loaves of experimentally produced NFDM bread were supplied to laboratory personnel. The bread was sliced by machine and delivered in plastic bags for use in any manner in which bread was consumed in the home. It was supplied on four days, and voluntary comments were recorded on the day following delivery. From the seven to nine families to whom the bread was supplied, unanimously favorable opinions were returned with varying degrees of enthusiasm. Excellent flavor, good toasting properties, and firm chewing quality were the terms most frequently used in describing what the consumers liked in their sample loaves. Although it had been anticipated that there would be objections to the somewhat deeper creamy color of the crumb and to the heavy crust color, in no case were these qualities mentioned adversely. All of the personnel apparently recognized that the test bread was a specialty type, and no direct comparisons with standard commercial loaves were required or made. It was interesting to note that the number and size of crumb irregularities in the sliced bread apparently meant a great deal to these consumers. Such properties are predominantly controlled by the molding operation and can be corrected. Most of the test consumers were able to detect flavor differences when the bread contained dry whole milk, although exact differences were difficult to describe.

Nutritive value of high milk-protein bread. To obtain a comparison of the nutritive value of the protein in bread containing 25 parts NFDM/100 of flour, with the protein in bread containing four parts NFDM/100 of flour, the rat growth method was used (3). Standard techniques and procedures were followed in which equal amounts of nitrogen from the bread sources were fed at a level of 1.455% of the diet, for a period of 4 wk., and the nitrogen efficiency ratios were determined. With the nitrogen efficiency ratio of a casein standard at 100, the comparative value for the protein in the higher milk-protein bread reached 49; whereas, it was only 26 in the bread containing the lower amount of NFDM.[2] Thus, the nutritive quality of the protein contained in the highest milk-protein bread was almost twice that of the standard, or reference, white bread.

[2] The authors wish to express appreciation to Dr. Leo Friedman of the Nutrition Division of the U. S. Food and Drug Administration for conducting the nutritional studies connected with this investigation.

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