

New Ingredient in Bakery, Technological and Nutritional Effects of Buttermilk

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Abstract—Buttermilk is a by-product obtained during butter preparation, has a nutritional composition similar to skimmed milk but with an increased proportion of phospholipids. Phospholipids was proved to have functional properties. Buttermilk is produced in large amounts due the preparation of butter and could be considered for use in various food product to obtained functional, sensorial and nutritional improved product. To increase the sustainability we used fresh, unprocessed buttermilk. The aim of this study was to investigate the effects of water replacement in bread formulation with fresh, unpasteurized buttermilk. Dough rheology was improved especially at 50% buttermilk addition and at higher levels did not put on advantage. Bread with added buttermilk showed small improvement of specific volume; denser crumb; pleasant smell and taste; yellowish crumb; darker crust colour. The nutritional value was improved, especially mineral and protein content and amino acid balance. White bread showed more significant improvement of nutritional value.

Keywords— *phospholipids, MFGM, functional, sustainable, fresh buttermilk*

I. INTRODUCTION

Buttermilk is a by-product obtained during butter preparation by churning sweet or fermented cream. Some confusions could occur between buttermilk obtained by churning of cream and buttermilk obtained from fermentation of cultured skim milk. This article refers to buttermilk obtained as a by-product in butter preparation. During churning the membrane of fat granule is broken and fat released. Most of water soluble components from cream remained in liquid phase after the butter granules are removed. The composition of buttermilk is very similar to skimmed milk [1] or whey in main components but casein protein are missing in whey [2] [3]. Buttermilk has superior functional properties due the complex lipids from the membrane of milk fat globules (MFGM). The lipids of this membrane are particularly rich in phospholipids [4]. The phospholipids present are phosphatidylcholine, phosphatidylethanolamine, sphingomyelin, phosphatidylserine and phosphatidylinositol. Phospholipids in whole milk represent 1.6 to 1% of total lipids while, in buttermilk, represent 10% of total lipids (2%) [4] or even 22% (of 0.6% lipids) [5]. Only skim milk shows higher percentage but because the fat content is very low also the quantity of phospholipids is smaller than in buttermilk. The phospholipids present in MFGM (milk fat globule membrane) were studied for their functional properties.

Some studies proved that MFGM was effective to reduce the blood pressure [6] [7]; to reduce the serum cholesterol; to inhibit activity of β -glucuronidase; to prevent the activation of carcinogenic precursor in colon and had antimicrobial antiviral activity too [5].

These nutritional and functional properties [8] [9] recommend the use of buttermilk in various food products. Buttermilk components have emulsifying properties and contribute to the flavor of products [3]. Buttermilk is used currently, mainly in dry form, as a cheaper solution to replace dry skimmed milk in different formulation, as ice-cream. Buttermilk is used traditionally to produce a special kind of butter in France after concentration by centrifugation. Also, the presence of casein allows the preparation of cheese. The properties of buttermilk depend with the method used for butter preparation. Sweet cream is preferred for butter preparation but in Romania cultured and fermented cream is used, the buttercream has a lower pH and a specific soured taste and smell. Functional properties of buttermilk are independent of pH but at low pH (lower than 5.0) the emulsifying properties and protein solubility are lower and viscosity is higher. When cream was processed at low temperature and pH the proportion of polar lipids increased [10]. Buttermilk is used also in bakeries in cake formulations [11] to replace dry milk and will improve rheology, texture and volume of products due the phospholipids present and theirs emulsifying properties [12]. The complex fats present in buttermilk could improve the bread properties (volume and freshness) in a similar manner as shortenings or surfactant [13]. The aim of this research was to study the effects of fresh buttermilk in bread formulations. The use of fresh buttermilk instead of dry one will increase the sustainability of bakery by reducing the production costs of new bakery products with improved nutritional properties and even with functional properties.

II. EXPERIMENTAL

First, in this experiment we replaced the water from bread recipe with fresh buttermilk or a mixture of butter with water in 1 to 1 ratio. Three types of flour were used: white flour (type 650), black flour (type 1350) and whole flour. The characteristics of flour are presented in Table I. Yeast used for experiment was fresh, commercial grade, from local market. Fresh buttermilk (0.3% fat, 1.9% protein and 6.4 dry mater content) was kindly provided by a local producer and kept at -20°C until was used. We determined the hydration capacity for every flour (55, 60 and 64% for flour type 650, 1350 and respectively whole flour). For baking test flour was mixed with water (control) and we replaced water with the

same amount of water-buttermilk mixture or buttermilk. 2.4% yeast and 1.8% salt were added to dough. Kneading dough was performed with a lab scale mixer 5 minute at low speed and 3 minute at high speed. After 15 min of resting the dough was scaled (570 g/piece) and round moulded, rested and oblong moulded. After proofing 45 min at 30 °C the dough was baked 22 min at 220 °C. The breads were analysed after 24h. The specific volume was analysed by rape seed displacement method, according to Romanian standard (SR 91:2007) crumb porosity was expressed in % as ratio between pore volume and total volume of crumb sample and crumb elasticity was expressed in % as the height recovery of a bread crumb after compressing at half of initial height for 1 min and free recovery for 1 min. Bread moisture was determined by drying for 45 min at 130 °C . Rheological tests of flour were performed with Alveograph Chopin (121 ICC Method). The nutritional values were estimated by calculation, using the bread recipe, bread moisture and USDA nutritional data for ingredients [14].

TABLE I. FLOURS CHARACTERISTICS

	Type 650	Type 1350	Whole flour
Moisture %	15.3	14.3	15.2
Acidity, ml NaOH 1N / 100g	2.2	2.9	3.5
Wet gluten, %	28.5	27.5	29.4
Ash, %	0.64	1.300	1.85
Falling Number, s	259	240	261

III. RESULTS AND DISCUSSION

The results of rheological tests are presented in Fig. 1. The replacement of water with buttermilk effects the rheological behaviour of dough in different manner, depending on the amount of replacement and type of flour. Black flour seems to be most affected by buttermilk addition. Tenacity of dough prepared from white flour decrease when half of water was replaced but in all other cases the dough's tenacity increased. Black flour proved to have the highest response, the dough tenacity increased with almost 50% at 50% water replacement and wit more the 110% at total replacement. Whole flour showed a small and constant increase of overpressure with water replacement. The dough extensibility (L) had a similar evolution for all flours investigated, at 50% water replacement the extensibility of dough increased while at 100% replacement the extensibility decreased at values below the control. The most responsive was white flour while whole flour was less responsive. The extensibility of dough from white flour increased with 22% at 50% water replacement while at full replacement decreased with 55% compared with control. The doughs seemed to become tougher and shorter, especially at full replacement of water.. The ratio between tenacity and extensibility (P/L) had similar behaviour as the tenacity. As a result of increasing tenacity and extensibility we observed that, in most of the cases, the dough's energy increased at 50% replacement of water with buttermilk while at 100% replacement the energy was a bit lower than control.

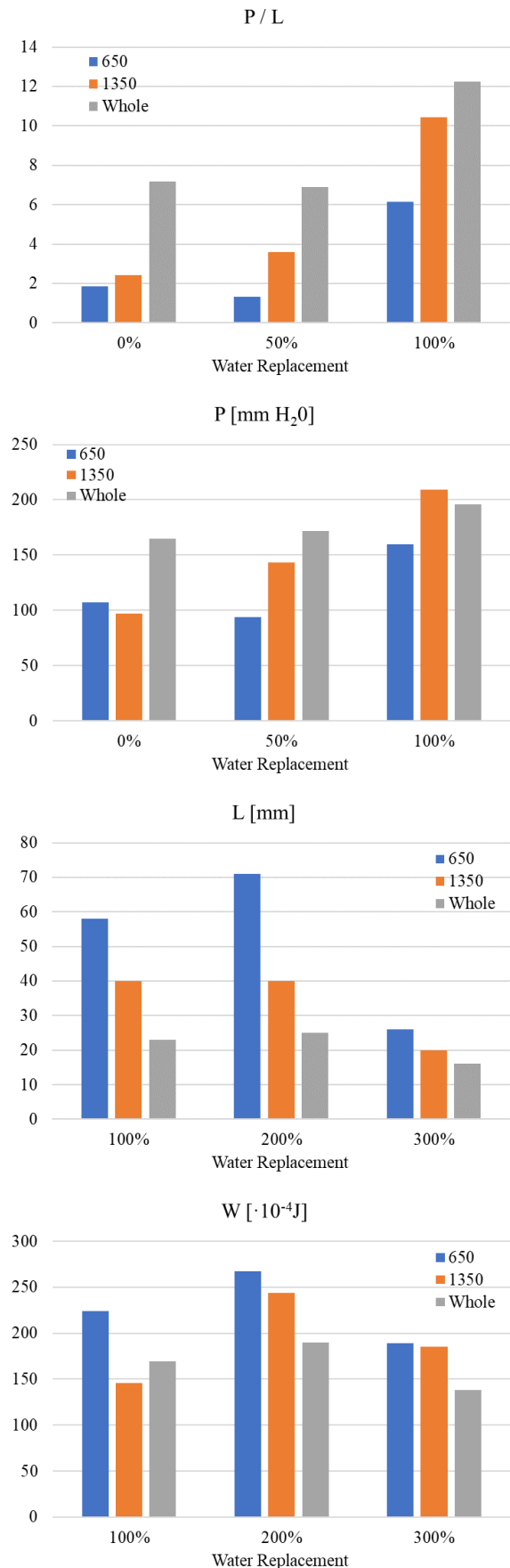


Fig. 1. The variation of W and P when buttermilk replaced water in dough prepared from white, black and whole flour.

As in the case of tenacity, whole flour showed a different response, the dough energy increased with 67% (for white and whole flour the energy increased with only 19 and respective 12%) at 50% replacement and at 100% replacement the energy decreased but remained with 26% higher than control. We expected that the phospholipids present in buttermilk to continuously improve the rheology of the dough due their surfactant properties but seemed that other buttermilk components (casein protein and acidity) had opposite effects.

The rheological effects of buttermilk addition were in correlation with the results of baking tests. The specific volume of samples is presented in Fig. 2. The replacement of water with buttermilk determined a small improvement of specific volume. A higher improvement was observed at 50% replacement. At 100% replacement of water the volume decreased but remained higher than control. The specific volume increased, for all types of flour, with 9 to 14% at 50% buttermilk addition and 5 to 7% for 100% buttermilk. Small improvement of volume could be due the emulsifying properties of phospholipids from buttermilk. The increasing acidity of bread samples (Fig. 2) could be the cause of low response to increasing amount of phospholipids present in buttermilk.

The sensorial properties of breads samples with added buttermilk changed too. The crumb color became yellowish and the crust colour become browner and darker. The lactose

and protein present in buttermilk contribute to the colour promoting formation of melanoidin in bread crust. The crumb structure of the samples with 50% buttermilk were more open but at 100% buttermilk the pores were smaller, and the crumb denser and wet. The smell and taste were slightly sweet-soured, pleasant, with notes of milk at 50% buttermilk while at 100% the taste and smell were more soured.

We calculated the nutritional value of white and whole bread, control and sample with 100% replacement of water. For a better understanding we calculated, based on control sample, the percentual variation observed for some nutrients. The results are presented in Table II.

Nutritional value of breads prepared with buttermilk were improved. We observed only small changes of energy delivered by samples and this could be the effect of water. We replaced the water with buttermilk in the same proportion, but the quantity of water delivered to the dough was smaller. The moisture of breads prepared with buttermilk were smaller than control, with 2 to 4%. The dry material present in buttermilk contributed too at caloric value. The protein content of breads increased with 9 to 10%. The proteins present in buttermilk have high nutritional values and ameliorate the quality of proteins from wheat. Concerning the human needs, the protein from wheat are deficiently in some essential amino acids: lysine, threonine and tryptophan [15]. The buttermilk addition increased the tryptophan content in white and whole bread with 12.4 and respective 10%. A higher impact was observed in the case of

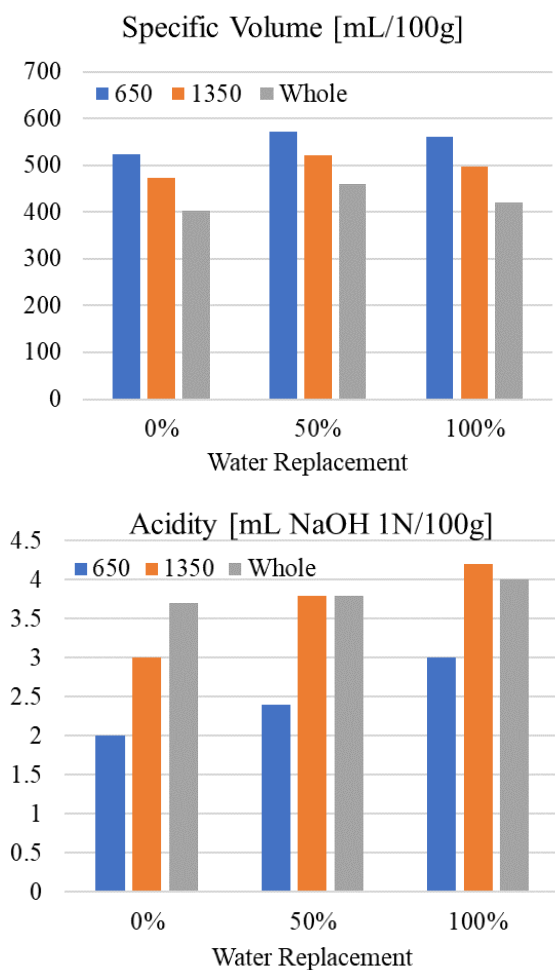


Fig. 2. Characteristics of bread samples prepared with buttermilk.

TABLE II. NUTRITIONAL VALUE OF BREAD PREPARED WITH AND WITHOUT BUTTERMILK FROM WHITE AND WHOLE FLOUR

	White Bread			Whole Bread		
	Control	100% Buttermilk	Variation [%]	Control	100% Buttermilk	Variation [%]
Energy, kcal	234	243	4	214	223	4
Protein, g	7.9	8.7	10.2	8.4	9.2	9.4
Total lipid (fat), g	1.1	1.2	12.3	1.6	1.7	8.4
Carbohydrate, by difference, g	46.9	48.1	2.5	45	46.4	2.6
Ash, g	1.3	1.5	14.3	2.0	2.1	9.4
Calcium (Ca), mg	10.2	37.8	267	22	48.7	123
Iron (Fe), mg	0.6	0.7	1.2	2.3	2.3	0.5
Magnesium (Mg), mg	16.8	19.4	15.3	86	88.9	3.1
Phosphorus (P), mg	68.8	90.6	31.7	229	251	9.4
Potassium (K), mg	75.9	113	49.0	238	274	15.4
Carotene beta, µg	0.64	0.85	32.7	3.1	3.33	6.72
Tryptophan, mg	91	103	12.4	111	122	10.1
Threonine, mg	214	250	16.9	237	273	15
Lysine, mg	162	225	39.3	237	299	26.2

threonine (16.9 and respective 15%). The highest improvement was observed in the case of lysine, for white and whole bread the content increased with 39 and respective 26.2%. The fat from buttermilk, despite their low level, increased the lipid content of bread with almost 10% and lactose from buttermilk increased the carbohydrate content with 2%. Buttermilk contribute significant at mineral content of bread, bread's ash content increased with almost 10%. The main minerals responsive for that improvement were calcium and magnesium while level of iron showed minor changes. From the data analysed we observed that nutritional value of white bread benefited the most from buttermilk use.

IV. CONCLUSION

This research proves that fresh buttermilk has the potential to be used in bread formulation to obtained new bread assortment with improved sensorial and nutritional characteristics and with functional properties. The dough rheology showed significant improvement at 50% replacement of water and at 100% we observed deterioration, comparative with control. Bread's specific volume was enhanced using buttermilk, the improvements were minor and visible especially at 50% water replacement. Best proportion for water replacement is 50%. More researches are needed to test the effects of buttermilk on a bigger number of flours and to understand how buttermilk components influence the baking process. Nutritional values of bred was improved by buttermilk addition, especially calcium, protein content and amino acid balance.

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