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Cake Flour Chlorination and Alternative Treatments (Review)

HANEE M. AL-DMOOR and JAFAR M. EL-QUDAH

Al-Balqa Applied University, Faculty of Technological Agriculture, Department of Nutrition and Food Processing, Al-Salt, Jordan.

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ABSTRACT

In order to produce satisfactory cake, ingredients must be balanced accurately. Flour acts as building structure that contributes in the crumb properties. Chlorine treatment of soft wheat flour has been widely used since the 1920s. The functional effect of chlorination is partially de-polymerizing and oxidizing of flour starch. Oxidized starch granules are able to swell more rapidly after the starch reaches the gelatinization temperature and the resulting batter system will be adequately viscous to support the cake's structure without collapsing. Batter expansion is superior for treated flours, even at the lowest chlorination rate, than for untreated flour. Alternatives to chlorine treatment need to be developed because of the potential carcinogenic effect of chlorination. Egg albumin contributes strength to cake crumb and improves cake volume. Acceptable cake volume can be achieved by heating but the dryer, stiffer crumb that springs back upon compression is not produced by heated flours. Xanthan gum L-cysteine, and hydrogen peroxide plus peroxidase to heat-treated flour and obtained volumes equivalent to cakes produced using chlorine-treated flour. Ozone treatments also are applied in cake flour with some benefits instead of chlorination.

Keywords: Cake, Flour, Chlorination, Alternative, Treatment, Ingredients.

INTRODUCTION

Cake quality is governed by three major factors: the suitability of the individual ingredients for the specific type of cake being made, a properly balanced formula, and the optimum mixing and baking procedures[2]. Cake flour was well-defined, low ash and low protein content produced for best cake bake performance by milling of soft wheat grains that highly refined flour which is extracted from the centre of the kernel of wheat[13]. Soft wheat flours are usually low water absorption which doesn't need severe mixing batter for resulting products possess qualities such as tenderness, softness, crispness and good texture[13]. It is well-known the general specifications for typical for cake flour include; moisture at 13.50±0.5%, protein at 8.00±0.5%, ash content of 0.35±0.05%. The best cakes are produced from low protein flour (7-9%), clean which is close as possible to being pure endosperm, with small particle size and little starch damage, which will blend easily to give a smooth cake batter and tender cakes[5,13]. Hard wheat flour has strong and higher protein content, generally used in the making of yeast leavened bakery products such as bread, while the soft flour has weak protein which is found suitable for the making of cookies, cakes, biscuits and crackers. Weak flour don't form steady gluten network when flour is mixed with water due to slighter amount and basic quality characteristics of gluten proteins in weak flour[2]. The important conditions of soft wheat dough products include low levels of water and add larger amounts of sugar and fat in low-power mode inputs to support the preparation of the dough is crumbly and extended, but be deficient in the strength and elasticity[35].

Gluten gives the structure in baked products, higher quantity of gluten proteins is inappropriate for cake production because large quantity of gluten proteins put off spread of dough and when handling of dough to specific size and shape of such product[2]. The larger quantity of gluten proteins formulate the dough physically powerful and more elastic that contracts or shrinks back after leaf formation. The glutenin proteins are held responsible for the strength and elastic nature of dough. Gluten network and interactions support gas retention and improve the dimensions of bakery products. Gliadin is globular protein in nature and recognized with less surface areas for interaction with other flour components which is an explanation the more extensible construct of the dough proteins[34,35]. The quality cakes also have been affected via starch properties in flour. Starch gelatinization function during baking considers an important factor for producing interior texture and the crust color formation of cakes. Increasing of the amount of starch wheat flour develops the demotions and spread ability of cake products. This outcome may be due to the dilution effects of gluten by expanding the amount of starch in the dough. More dilutions of gluten results better the extensibility and spread ability of dough during handing and baking[27]. Starch granules have been physically broken throughout the milling. The percentage of damaged is different between flours which milled from hard, soft and durum wheat varieties. For example milling of a hard wheat need more energy and thus harshness of breaking up results in higher percentage of damaged starch in hard wheat flours while lesser energy is needed to break soft wheat grains for preferred particle size flour and hence the soft wheat flour normally has slighter percentage of damaged starch. Consequently, the proportion of damaged starch in flour is an importance factor in some of rheological and final quality of baking products[34,27]. A high quality cake is supposed to have high volume with a fine homogeneous moist crumb and texture. Starch gelatinization, protein denatutration simultaneously with carbon dioxide formation gives cake it's porous, uniformity fine and soft structure. The degree of spreading out is dependent on the viscosity of the cake batter. If the cake batter is viscose, it would be not easy for the air bubbles to run off, which would produce a high volume cake[25].

Chlorine treatment of soft wheat flour has been commonly used since the 1920s. The flour bleached with chlorine at a pH level of 4.4 - 4.8. Chlorination of flour improved crumb color and lowers the gelatinization temperature of the starch within the flour[24]. Chlorination used to set cake faster and therefore reduces the loss of leavening during baking. Bleaching treatments also give the flour the ability to clasp more sugar and shortening lipids as well as water that influence in properties of the end products[23]. For this reason flour bleaching treatments used in high ratio cakes. Chlorine treatment of cake flour is functionally advantageous to the making of high-ratio (more sugar than flour, weight basis) cakes. The production of baked products using untreated wheat flour assumes increased importance as the cereals manufacturing becomes more universally as well as the safety awareness of chemically treated foodstuffs are subjected to increase in the controlling and inspection[4].

Chlorine treatment functions

The mechanism of Chlorination enhancements and the effects of chlorine on flour components have been discussed and studied of many investigations. Fractionation and reconstitution studies recommend that the starch fraction is mainly in charge for the valuable effect of flour chlorination. Chlorination is usually used on those soft wheat flours that are proposed for cake making in order to produce better cakes which affect all flour constituents, including starch, proteins, lipids and pentosans. Chlorination is enhancing starch pasting, increasing hydrophobicity of starch granule surface protein, decreasing gluten protein strength, and increasing water-holding capacity[24].

Chlorine treatments of flour intensify the increase the amount of sugar and liquid levels to make the so-called high-ratio cake. The significance advantage or profit of the high-ratio cake recipe is that product moisture levels can be increased without adversely impact in the mould-free during the shelf-life of the product. The higher moisture level enhances a more soft or fine texture and tender and mouth feeling eating quality to the final products[24].

Actions of Chlorine on Starch

Around 25% of chlorine reacts with the starch granules and this is the main developing effect

of the cake quality. It concludes that the chlorine reacts with the proteins interacted with the starch granules and give them more hydrophobic functions. There is also a confirmation that chlorination enhances the run-off of amylose from within the starch granules but that there is no change in the gelatinization degree of the starch.

The functional effect of chlorination is oxidizing and partially de-polymerizing of the flour starch. Oxidized starch granules are able to swell water more hurriedly after the starch reaches the gelatinization temperature. Also the resulting batter system will be satisfactorily viscous to stabilize the structure of cake without any of breaking-down. Batter expansion of chlorine treated flours is greater, even at the lowest chlorination rate, than for non chlorinated flour.

In addition chlorination modify flour starch through accelerates the thickening of the viscosity of the batter which tolerates the setting of the batter during baking time of cake[15]. It was found chlorination alters the gelatinization performance of the starch granules but does not change their gelatinization temperature degree, although is there an evidence of chemical interactions between the starch molecules. Therefore, it is recommended that chlorine effects the significant changes in starch performance by interactions and reacting with the other non carbohydrate compound which are attracted on surface on the starch granules.

Action of Chlorine on Protein

Treated flour with chlorine showed quantifiable alterations in the amino acids of the gluten. I was noted around 20% of the amide groups were hydrolyzed, and some disulfide and peptide bond cleavage taken place which considers an evidence of chlorine reactions with tyrosine and sulfhydryl groups[17,15,16 and 28].

Action of Chlorine on lipids

Treatment of flour with 2000 ppm of chlorine resulted in a decreasing of the unsaturated fatty acids in the flour to 40% of levels in non chlorinated flour. Around 50% of the chlorine level used is absorbed by the flour lipids (typically around 2% of the flour mass) but emerges to act no significant part in the improving action. Oleic acid was almost certainly transformed into dichlorostearic acid while a range of chlorinated compounds was produced from linoleic and linolenic acids. Treatment of flour with up to 120 ppm of chlorine did not significantly change the major fatty acids[17, 15 and 16].

Flour lipids can take part in two kinds of reactions with chlorine: oxidation and chlorine addition. Oxidation will disorder the fatty acid sat double bonds to form fragments containing carbonyl groups. Chlorine cross linked with unsaturated fatty acids at the double bond. Both reactions will minimize the level of unsaturated fatty acids. The action of chlorine is bleaching the flour color pigments so that a white flour and brighter product crumb color result in the final products. When soft-wheat flours were treated with chlorine, the chlorine pleased of the lipids was significantly increased, that of water-soluble components to a less significant levels, and of the gluten only slightly. It was noted water-soluble components include only 5% of the flour, but contained more than 90% of the added chlorine[7, 8].

Action of Chlorine on cake texture

Chlorine-treated flour produces cake crumb with a waterless, less sticky mouth feel that combines and packed together less in the mouth, producing a lighter, waterless and looser consciousness in the mouth than cakes produced with no chlorinated flour, which are often referred to as sticky [(26)]. That phenomenon is noticeable by compressing cubed of the crumb. Within 5–10 sec, cubes of cakes produced with chlorine-treated flour rapidly return or expand to the almost all of their original height after moderate compression, contrasting case in the cakes produced with no chlorine-treated flour, which after moderate compression unhurriedly expand to only about 50 % of their original height. White layer cakes baked with no chlorinated flour are unacceptable in volume, shape, crumb grain, and texture. Thus, various systems have been devised to produce cakes with distinctiveness that is similar to those produced using chlorine-treated flour. It was found chlorination alters the hexane-extractable flour lipids to increase batter expansion during baking of cake[7, 8].

In Farinograph and alveograph tests dough showed first strengthening of dough with treatment chlorine of flour, followed by subsequent declining

of dough[28]. The stronger setting retains the larger volume of the cake created by the chlorine treated flour lipids. The objective measurement of properties like the stickiness of cake crumb has been linked with the amount of chlorine gas used to achieve the desired lower pH value[17, 15, and 16]. If the not chlorinated flour has used in the production of high-ratio recipe, the cake structure will fall down, with defeat of crumb structure, the formation of opaque, dark colored stripes and the product eating quality becomes pasty as in the figure below.

Action of Chlorine on pH

It was pointed chlorine treatments of flour cause a pH reduction to the level of chlorine applied. Cake producers use pH as a specification or condition for the purchase of chlorinated flours. Unbleached flour has a pH range of 5.8 to 6.1 while optimum specification for bleached flour has a pH range of 4.6 to 5.1[24].

Chlorination levels and Safety

Flour chlorine treatment was used for enhance the cake production properties of flours for many years in the UK, the USA, Australia, New Zealand, South Africa and many other countries. The use of chlorination for cake flour treatment was withdrawn from the UK in 2000. It remains permitted in many other countries. Chlorine treatment of flour is made by mixing and blending the gas through the flour. Common levels of treatment lie between 1200 and 2500 ppm chlorine based on flour weight. The higher levels are usually used to treat flour intended for the produce of fruited cakes. The gaseous treatment has a number of effects on flour quality but only a diminutive proportion of the gas used actually confers the beneficial effects to the flour.

Soft wheat flours proposed for use in cake and cookie production are frequently chlorinated to improve baking performance by humanizing the functional properties of flour components. In the chlorination process, the flour is treated with chlorine gas. The chlorine content of untreated flour was recorded to be 430-540 mg chlorine/kg flour and of bleached flour 1310-1890 mg chlorine/ kg flour. Approximately all of the additional chlorine was in water-soluble and gluten (including lipid), and treatment did not significantly increase the chlorine in the starch. According to the codex standard for food additives the acceptable or satisfactory level of chlorine is 2.5 mg/kg flour and 30 mg/kg flour for Chlorine Dioxide.

The finding that chlorine treatment of flour enhanced cake quality applied to the development of recipes with high levels of sugar and liquid. These recipes, known as “high ratio”, became the customary in many countries such as Australia, America, Canada and Japan as well as the UK and USA. But the concern about the safety of chlorinated flour has direct many producers to consider for alternatives. The UK and Eire are alone in Europe permit chlorination and trials to estimate its safety have been carried out. However due to a disinclination of the manufacturing to fund further work, the chlorination of cake flour has not been satisfactory in the EU since November 2000.

Daniels[11] observed no unpleasant reaction when rats were fed cake prepared with Chlorine-treated flour at ingestion levels equal to the consumption of cake in the human diet. However, at higher ingestion levels, they founded effects on lactation in female rats and on the coat texture in

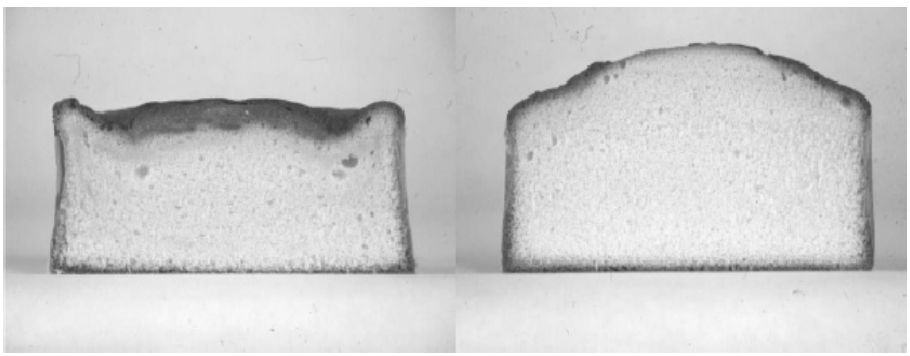

Fig.1: Effect of chlorination on cake quality

male rats. Cunningham [10] recorded reduced growth rate and augmented liver weight when they fed rats chlorine treated flour as a highly concentrated constituent of their diet. Ginocchio[20] showed the dose-related enhanced in heart and kidney weights and reduction in ovary weight among female mice fed high levels of chlorine-treated flour. In long-term and reproduction investigations in which rats and mice were fed diets containing 75-79% dried cakes prepared from flour chlorinated at levels up to 2500 ppm, no carcinogenic, or other toxic effects attributable to chlorination were experiential. The glomerulonephrosis and renal calcification seen in the long-term investigations in rats were considered to be due to nutritional imbalance and did not signify as toxic response to the chlorinated cake flour. The acceptable level of chlorine treatment of flours for cake production doesn't exceed more than 2500 ppm of Chlorine.

Chlorine treatment alternative methods

Alternatives to chlorine treatment need to be developed because of the potential carcinogenic effect of chlorination. Developing a useful alternative would start with a study of the mechanism of flour chlorination. Many of treatments and Additives are applied by the millers of cake flour producers or during cake making to get better rheological properties cake flour which is produced from hard wheat.

Egg and soya

Geera[19] studied the addition of dried egg albumen concentration plus, soya lecithin and xanthan gum in the formulation containing starch without the addition of chlorine and they evaluated its influence on geometry and crumb texture of the cake, by using the other ingredients which grant similar or better cake quality properties than cakes produced using chlorinated flours.

Ozonation

Ozone is able to be applied as an alternative to chlorine with many of the benefits of treatment. The optimum of the ozonation time was found from 8 to the 11 minutes with ranging temperature from 36 to 46 ^{o}C degrees. The oxidizing level of ozone is greater to chlorine treatment plus that the by-products of ozone treatment are less harmful compared to chlorine. It was found the ozonation treatment of cake flour cause decreased the pH of cake flour and increased the whitening of it. Many references on production of cake using a high-ratio white layer cake formulation showed that the volume of cakes significantly improved ($p < 0.05$) as ozonation time increased and the cakes texture were softer than those produced with chlorinated flours[14, 6].

Many studies on cake formulation using a high-ratio white layer point up that the cakes texture were softer , cell brightness , number of cells and the volume of cakes significantly improved as ozonation time increased compared with cakes that made with chlorinated flours. Also it was found an increase in Mixograph peak time, peak viscosity, and water retention capacity was practically developed as ozonation time increased[14, 6].

Xanthan gum

Thomasson[36] studied xanthan gum L-cysteine, and hydrogen peroxide plus peroxidase to heat-treated flour and achieved volumes equivalent to cakes prepared using chlorine-treated flour. Addition of 0.12% xanthan gum to the unchlorinated soft wheat flour (7% moisture) for 30 mints at 125 ^{o}C, produced cakes with volumes were bigger than those of cakes made with the chlorinated flour.

L-cysteine

Study for adding an L-cysteine at level 200 or 300 ppm during making of cake batter which prepared via unchlorinated produced cakes with volumes and crumb grain scores equivalent to cakes that prepared with the chlorinated flour[36].

Hydrogen peroxide

Addition of hydrogen peroxide and peroxidase enzyme to the cake batter containing heat-treated flour also improved the cake volume and color. Nevertheless, the volume of bread was slighter amount than that of the cakes produced with the chlorinated flour[18].

Ascorbic acid

Ascorbic acid is one of the most well-known ingredients used in dough improvers. During kneading of dough Ascorbic acid lead to a decline in the low molecular thiols glutathione and enhance in cysteine concentration[37].

Heat treatments

The flour heat treatment process has been experienced over many years by the major milling companies and commercial flours[31, 30]. Hanamoto and Bean [(22)] developed the cake baking production of no chlorinated cake flours and isolated starch by applying the controlled heat treatments instead of chlorination. Moreover flour baking performance was improved by minimizing the moisture level of the flour below 7% during heat treatment. In addition to the flour's cake baking quality was improved compared to that of the untreated control. Storage of the flour at room temperature for 60 days causes a development in volume and grain of cakes[33]. Other study shown that heat treatment of unaged flours enhanced the crumb and crust formation and properties during baking time[29].

Enzymes

The use of enzymes on behalf of chemical oxidants is a very motivating option to improve performance of cake batter, since they are natural and non-toxic. Enzymes are able to react under appropriate conditions of temperature and pH, contributing to the construction of covalent bonds between polypeptide chains within a protein molecule or between many of protein polymers[32, 1]. Glucose Oxidase catalyses the oxidation of glucose to gluconic acid and hydrogen peroxide. Another study indicate that hydrogen peroxide produced during Glucose Oxidase reaction causes the oxidation of the free sulfhydryl units from gluten protein helpful to form disulfide bonds a protein molecule, gelation of water soluble pentosans and altering rheological properties of wheat flour batter[12, 21].

Microwave heating

Microwave heating treatment is a valuable alternative for manufacturing unchlorinated cake flour which develops the capability of starch to gelatinize which affords the soft structure, improves crumb tenderness; give somewhat dry texture and increase of fine-grained cells of the baked cake[2].

Mixing wheat flour

In Jordan a study on 10 cake flour samples that are often produced from hard wheat recommended to the millers, they can produce cake flour with practically specifications of soft wheat flour compositions but the rheological properties aren't appropriate for cake making in a high quality cakes. Also the study also recommended applying a special heat treatment or using any of alternative additives by the flour miller or producers of cake to improve the rheological properties cake flour which almost is produced from hard wheat flour[3].

CONCLUSION

Chlorination treatment needs to be alternating because of the potential carcinogenic effect of chlorination. Developing a useful alternative should start with a study of the mechanism of flour chlorination. Many of treatments and Additives are applied by the millers of cake flour producers or during cake making to get better rheological properties cake flour which is produced from hard wheat. Xanthan gum L-cysteine, and hydrogen peroxide plus peroxidase to heat-treated flour and obtained volumes equivalent to cakes produced using chlorine-treated flour. Ozone treatments also are applied in cake flour with some benefits instead of chlorination.

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