THESIS.

EXPERIMENTAL INVESTIGATIONS OF FLOUR MIXTURES.

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THESIS

The object of this thesis is to try to determine by experiment, the nature of the various materials combined in flour mixtures and some of the reasons for their use. The materials we shall have to deal with will, of course, include: butter, sugar, eggs, flour, milk or water, and some means of lightening.

Eggs.

Aside from their nutritive value, eggs seem to be used in flour mixtures (1) to thicken by their property of coagulation and (2) when in the beaten form, to introduce air to assist in the lightening process.

Coagulation:- Egg albumen is coagulated in two ways, (1) by action of an acid, and (2) by heat. This last is what takes place in cooking. Egg begins to coagulate in hot water at 120° F., is softly coagulated at 170° F. - corresponding to the "soft-boiled" stage - and becomes very hard and tough at 190° F. In custard which is really water + various solids and soluble materials, the mixture coats the spoon at 175°F., corresponding to about the 170° F. stage in water.

Beating for introduction of air:- Eggs are beaten to introduce air which, upon the application of heat, expands and thus "raises" the mixture into which the beaten eggs are introduced. I tried the following experiment to determine the relation of heat and cold to the time required to beat an egg stiff.

(a) Warm egg on a warm plate, beaten in a warm place,- it took several minutes and was not then very stiff.

(b) Cold egg on cold plate placed on ice and beaten - became stiff immediately. Age of egg in both cases the same.

Another demonstration of this same principle may be seen in the following experiments concerning the solubility of albumen in water.

(1). Egg albumen plus cold water. While the albumen was certainly found to be soluble to some extent in the cold water, yet the albumen soon began to harden. This shows the action of cold.

(2) Egg albumen plus luke-warm water. The albumen was found to be much more soluble than in (1).

(3) Egg albumen plus hot water. The albumen immediately began to coagulate, thus giving no opportunity for dissolving.

From these two experiments I deem it conclusive that cold has a hardening action upon the egg while a low degree of heat has the opposite effect. In the case of the beaten egg, then, the cold doubtless caused the beaten albumen to become and remain stiff while, on the other hand, the heat applied caused it to become soft and toneless.

Age of the egg:- The most noticeable difference between an old and a fresh egg to many minds, is in the taste. I found that an old egg could not be beaten to so stiff a froth as a fresh one, also that the meringue was coarser in texture and broke down more quickly. On the other hand, I also found a very fresh egg, a few minutes old, incapable of making a stiff meringue. The reason for this peculiarity of a very fresh egg seems to be the presence of the animal heat in the egg, for if the new egg is immediately chilled

on ice or other cold medium, it will be found to become perfectly stiff after beating. The specific action of a low degree of heat has already been mentioned. An egg about twenty-four hours old gave the best results.

Eggs in cake:- Recipes for cake invariably state that for the best results the egg must be "well beaten", usually separately. Since in mixing the eggs with the other ingredients, the air cells must almost of necessity be broken down, it is difficult to see why this should be so. From my experiments I found that it made no difference in the degree of lightness of the cake, whether the eggs were beaten at all, together or separately, when either the whole egg was used, or merely the whites, or the yolks only. When only the whites were used, the texture of the cake was a very little more flaky when the egg was beaten than when it was not. When only the whites are used the cake is more delicate; when only the yolks, it is richer. I found that a cake could stand more white of egg to a constant amount of sugar and butter without becoming objectionably eggy than it could yolks alone. If one desires to beat the eggs, the cake must not be stirred after the beaten eggs are added for reasons previously stated. By much stirring, a cake becomes finer grained and flakier but is light and delicate without it, if properly mixed.

Egg in cookies:- Some cooky recipes call for egg, others do not. In ginger or molasses cookies, I found that there was no difference in taste by this treatment of egg while in white sugar cookies there was. I grouped my work under three heads and noted

the following points under each:

(1) Cookies in which a given amount of egg was used, mixed soft and rolled 3/8 inch thick. Were of ordinary texture and crisp.

(2) Cookies treated same as (1) but with egg omitted. Were much harder than (1) when cool, spread out considerably in baking and were consequently thinner in diameter when done.

(3) Same as (1) but with double the amount of egg. They had lost the characteristic cooky taste - were of closer texture, much thicker in diameter. The egg seemed to hold the dough together so that it would not spread out. When more flour than the above was used the cookies were hard instead of crisp and short. I preserved samples of the above three experiments in a tight tin box, for over two months and tasted them again for the action of the egg. I found that those without egg had become soft, very stale and unpalatable; those with the normal amount of egg were not nearly so soft and were of fair flavor; those with the most egg were in the best condition of all.

Toughness of Angel's Food.

Angel's food should be soft and moist, yet we often find it tough and soggy. I tried to find the reason of this. I came to the conclusion that it was especially essential to use only the very best materials in the cake and that these four points were especially to be noted: (1) the freshness of the eggs, (2) the character of the flour, (3) care in mixing, and (4) a proper oven temperature. The necessity for fresh eggs will be seen from the fact that there is no baking powder or other chemical means of

leavening used. It is made light entirely by the physical action of the expansion of the air, confined in the beaten eggs, by heat. It is of prime importance that only PASTRY FLOUR be used; by numerous trials, I found when every other precaution and care was taken but patent flour used, that the cake was invariably of a tough, bread-like character. This was true even when smaller amounts of this flour were used than was called for in the recipe. I thought that this fact might be explained by the difference in the weights of the two flours. The gluten flour being heavier than the pastry or starch flour, would not allow the confined air to expand as much as it would were pastry flour used, and we would consequently have a sticky, glutenous mass without sufficient means of lightening it. The mixing is also important. The air cells must not be broken down, yet the flour and sugar must be well blended with the egg and not distributed through the mixture in patches. To mix correctly, I found it a good plan to beat the sugar in with the egg-beater and to fold in the flour with a spoon. Next to the character of the flour, it seems to me that the temperature of the oven is of first importance. It must not be so hot as to cause immediate coagulation of the egg and thus prevent the confined air from expanding, and yet it must be of a temperature sufficiently high to expand the air enough. I found that the best way was to put the cake into an oven too cool for ordinary cooking, that of the first stage of the soft coagulation of egg, 130° - 135° F.; the heat should then be increased very gradually for about an hour until for the last ten minutes the tem-

perature is about 210°F. This process gives the desirable delicate brown color but no crust.

Length of Time That a Baking Powder Mixture Can Stand Before Baking.

Relative to this question, I made the following experiments:

(1) Baking powder plus cold water; gives no visual effervescence but a faint sound of escaping gas is heard.

(2) Baking powder plus warm water; gives a decided effervescence.

In accordance with the results of these two experiments I proceeded thus.

(a) Let a baking powder mixture stand in a warm kitchen about three and a half hours; then, after removing the dried crust, baked it. It did not rise at all.

(b) Let a baking powder mixture stand out of doors at 3° F. for same length of time as (a). Then thawed it out quickly and baked. It rose nearly as light as that baked at once.

I concluded that not the mere wetting but some heat at least was necessary for the liberation of the gas. This same fact is shown in doughnuts and cookies, which usually have to stand some time before cooking.

Sugar in Cake.

Granulated sugar gives a thicker, more shining, sugary crust, and a coarser texture than did confectioner's sugar; it also seemed to have a tendency to help the mixture to separate when the milk was added, which may account for the coarser texture.

Action of Soda in Cookies.

CO_2 gas is liberated from cooking soda by an acid, hence when soda and molasses, soda and sour milk, etc., are called for we can readily see the reason. But it may be observed that soda in small quantities is often called for in various recipes for cookies and wafers where there is no acid ingredient used and in which we cannot account for any produced by chemical reaction in the process of cooking. What then is the especial value of the soda in such a recipe? We know from chemistry that carbonates are broken down by heat as well as by acids. So, thinking that CO_2 gas might be ~~found~~ *formed* and used as a leavening agent - by the mere heat employed in the process of cooking - I made the following experiments:

(1) Soda plus cold water; gives no visual effervescence.

(2) Soda plus boiling water; gives rapid effervescence.

After (2) had become quiet and the soda had entirely dissolved, I added a very few drops of weak acid; rapid effervescence again took place and lasted while several larger portions of acid were added. This proved to me that the mere heat of the oven would not liberate enough CO_2 gas to account for the use of soda as a leavening agent, especially considering the small quantity of soda used and the large quantity of dough. I then tried several of the recipes of the nature mentioned. I made two measures of each, in one of which I used the soda and in the other did not. I found that in all cases, the two were equally light but that when the soda was used they were crisp, crumbly and easily broken; that in the second case, they were not crisp, but hard - as if too much

flour had been used - yet in reality the amounts of flour were the same in both cases.

Summary.

In conclusion I would especially emphasize the importance of proper temperatures in mixtures in which eggs predominate. The eggs themselves, next to freshness, must be free from heat, either animal or acquired; owing to the low coagulation point of egg albumen, the temperature of the oven must be adapted to the amount of egg in the mixture to be baked.

Eggs are essential to all flour mixtures, especially if they are intended to be kept for any length of time, but the method by which they are best combined with the other ingredients must be determined by the other ingredients and the manner of mixing. If no lightening agent is used, they should be well beaten.

Soda must not be universally considered a lightening agent. Combined with an acid of some kind it is; when used without an acid it is not. In the latter case, it merely adds tenderness and crispness to the article into which it is introduced.