DOMESTIC SCIENCE TEXT BOOK

Baking Powder

A HEALTHFUL CONVENIENT LEAVENING AGENT

By

THOMAS G. ATKINSON, B. Sc., M. D.

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By
THOMAS G. ATKINSON, B.Sc. (Lond.), M.D., L.R.C.P. (Lond.)

Professor of Physiology, Jenner Medical College, Chicago, Illinois; Formerly Professor of Physiology and Physiological Chemistry, Chicago College of Medicine and Surgery, and in the American Medical College, St. Louis, Missouri. Staff Editor *American Journal of Clinical Medicine.*

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TABLE OF CONTENTS

CHAPTER I

LEAVENING AGENTS

THE common leavening agents in use in the home are yeast and baking powder. Yeast is a microscopic plant which, in the leavening process, produces changes which finally result in the breaking up of sugars into alcohol and carbon dioxid gas. Baking Powder is a mixture of several substances which produce this same gas by chemical action. This gas, by forming in small bubbles throughout the dough mass, lightens or leavens it. Carbon dioxid gas is sometimes called carbonic acid gas. This is the gas which is present in all carbonated waters, whether natural or artificial, as in soda fountain waters.

DISADVANTAGES OF YEAST

IN the case of yeast, the fermentation which produces the gas is never of a single kind, as many different fermentations are going on at the same time. It is impossible, commercially, to control these different fermentations so that they will always exist in the same proportions; hence, we find that the flavors from different bakings vary greatly and are sometimes objectionable. Moreover, several hours must be allowed for the process of fermentation before the food can be placed in the oven. Fermentation does not take place readily in the presence of large quantities of butter, lard or eggs.

ADVANTAGES OF BAKING POWDER

WITH a properly compounded baking powder, on the other hand, the chemical reaction will always be the same, and any influence which it may exert upon the flavors of the finished food will always be the same. Baking powder has, moreover, these two further advantages over yeast: The gas is given off at once upon the addition of water or in the oven during the heating; there is no waiting. And the presence of butter, lard or eggs does not hinder the chemical action.

The leavening, from whichever source, is always the result of the same gas, carbon dioxid, and in the study of baking powder we are interested in learning how this gas is produced by chemical action.

SOURCES OF CARBON DIOXID

CARBON dioxid is found in nature combined chemically with many metals, and these combinations are known as salts of carbonic acid, or more commonly as carbonates. Those with which one is most familiar are chalk, marble and limestone, all of which are different forms of calcium carbonate. If any of these are heated to a very high temperature, carbon dioxid gas is set free and lime remains; but this very high temperature is never reached in baking. Baking soda is another carbonate with which all are familiar.

CHAPTER II

THE INGREDIENTS OF BAKING POWDER

SODA

SODA is the carbonate which is used at home for cooking purposes; it is also commonly known as saleratus, or baking soda. This is the carbonate used almost exclusively in the manufacture of baking powder and always named on the label as soda. It is sometimes referred to as the alkali of the baking powder. It is a white crystalline substance of very high purity, being as free from impurities as the granulated sugar used at the table. It is manufactured from common salt through the action af acid ammonium carbonate.

The reaction is represented by the following equation:

$$\underset{\text{Salt}}{NaCl} + \underset{\text{Acid Ammonium Carbonate}}{NH_4\,HCO_3} = \underset{\text{Soda}}{NaH\,CO_3} + \underset{\text{Ammonium Chloride}}{NH_4\,Cl}$$

Soda, when heated, readily gives off carbon dioxid gas, and hence may be, and often is, used in cooking without the addition of any other substance for the purpose of leavening. The heat, however, does not drive off all of the gas. The reaction which takes place is represented by the following formula:

$$\underset{\text{Soda}}{2NaH\,CO_3} = \underset{\text{Normal Sodium Carbonate}}{Na_2\,CO_3} + \underset{\text{Water}}{H_2O} + \underset{\text{Carbon Dioxid}}{CO_2}$$

The residue of normal sodium carbonate thus left in the bread gives it a disagreeable, alkaline taste, and also colors the bread an objectionable yellow; hence, soda by itself is unsatisfactory for use as a leavening agent.

AMMONIUM CARBONATE

AMMONIUM carbonate has been sometimes used as a leavening agent. This, upon being heated, breaks up into two different gases, ammonia gas and carbon dioxid gas. Some of the ammonia gas remains in the bread when cooked; therefore, its use in baking powder has been almost entirely discontinued.

MAGNESIUM CARBONATE

MAGNESIUM carbonate is the only other substance at present used for the purpose of furnishing carbon dioxid gas. The heat of the oven is not sufficient in this case to cause all the gas to be set free. Magnesium carbonate is a very light powder. One pound will occupy as much space as six pounds of soda. The purpose of those who use this ingredient in the manufacture of baking powder is mainly to add to the bulk of the powder and thus make the thoughtless purchaser believe she is getting more for her money.

OTHER SUBSTANCES NECESSARY

IT will be seen from what has just been said, that none of these carbonates are, of themselves alone, satisfactory for baking purposes. Something else is necessary.

If one has ever dropped a little vinegar on some soda, he has noticed that a gas was set free. This is carbon dioxid gas. Vinegar contains an acid, acetic acid, and it is the action of this acid upon the soda that sets free the gas. Any soluble acid will have this same action on soda, hence, if we unite such an acid with the carbonate, soda, we have the necessary substances with which to produce carbon dioxid gas.

THE ACID SUBSTANCE

FOR the making of baking powder, both acid and carbonate, however, must be dry substances, and not liquid, as acetic acid or vinegar is. The acid should also dissolve in water. There are many such dry acids, most of them organic substances. Citric acid, the principal acid contained in lemons, is one of these. Tartaric acid is another.

Beside the true acids, there are some salts which have an acid nature and which are called acid salts. Of these, calcium acid phosphate, commonly called acid phosphate, is one, and potassium acid tartrate, commonly known as cream of tartar, is another. There are some salts which are not acid salts (inasmuch as all of the hydrogen atoms of the acid have been replaced by a metal) *which nevertheless act as very weak acids.* The most common of these is sodium aluminum sulphate, sometimes called "Alum."

Any of these three kinds of substances, the acid, the acid salt, or the salt with acid properties, acts upon soda and sets free carbon dioxid gas. The action takes place almost as quickly as the "acid" or salt dissolves. These substances just mentioned, acid phosphate, "alum," tartaric acid and cream of tartar, together with the soda, are the active principles in baking powder. In addition to these there is generally a quantity of starch and sometimes dried white of egg. Soda has been studied. The other substances must now be considered.

TARTARIC ACID AND CREAM OF TARTAR

TARTARIC acid is manufactured from Argol, which is the sediment that separates out at the bottom of the wine vat during the fermentation. This substance is colored by the color from the grapes, and is a mixture of tartaric acid, calcium tartrate, cream of tartar and all kinds of organic impurities. This mixture is dissolved in water, precipitated with powdered chalk and calcium chloride, filtered and then the precipitated calcium tartrate is dissolved in sulphuric acid.

This solution is again filtered and treated with some decolorizing agent, such as bone black or infusorial earth, and the subsequent clear, colorless solution evaporated and the tartaric acid allowed to crystallize. Cream of tartar is also obtained from the same sediment, Argol. It is decolorized by heating with animal charcoal filtered and recrystallized.

ACID PHOSPHATE

CALCIUM Acid Phosphate is prepared from the same source as is much of the "Phosphate," used at soda fountains. The bones from healthy cattle are heated in large revolving cylinders until they are thoroughly charred. In this condition the mass is black and is known as bone black, although in reality it consists of both calcium phosphate and charcoal. This substance is used to decolorize the juices of the cane in the manufacture of cane sugar. In the manufacture of phosphate it is again heated to a very high temperature whereby all charcoal is burned off and only the calcium phosphate remains. This is then dissolved in dilute sulphuric acid and the calcium acid phosphate thereby obtained, purified by filtration. It is then further purified, concentrated, crystallized, and dried to a white powder.

A more recent process is the manufacture of phosphate for food purposes from phosphate rock. This material was not formerly used on account of the great difficulty of excluding from the finished acid phosphate the harmful impurities, fluorides, always found in the rock. Bone phosphate is the better on this account and is always used by the careful manufacturer of high-grade baking powder.

Calcium acid phosphate for baking powder is prepared in two degrees of fineness, powdered and granular. The granular* is much more expensive but has the great advantage of making a baking powder that will keep longer than one made from powdered phosphate.

"ALUM"

THE so-called "Alum" used in baking powder is not the alum which is sold at the drug store by that name. The common alum of trade, which is also used as medicine, contains potassium, an element that is toxic in very small quantities, and water of crystallization; it is, in fact, potassium aluminum sulphate, combined with water of crystallization, $K\ Al\ (SO_4)_2\ 12(H_2O)$. The so-called "alum" of baking powder is a different thing and is more properly named sodium aluminum sulphate, being a mixture of sodium sulphate and aluminum sulphate, both of them harm-

*The acid phosphate as found in Calumet Baking Powder is of the granular type.

less and non-toxic. It contains neither potassium nor water of crystallization. The term alum has been used for this article on baking powder labels at the request of some food commissioners who felt that this word would be better understood by the common people as showing in a general way the character of the substance. Unfortunately, it has largely had the very different effect of misleading the public into the erroneous idea that it actually is the alum of commerce and of medicine—a mistake of which certain manufacturers have not failed to take advantage in decrying baking powders containing alum.

It is prepared by mixing solutions of the two sulphates, sodium sulphate and aluminum sulphate, concentrating the mixture and fusing the resulting dried mass. This leaves a mixture which for our present purposes we may designate by the formula:

$$\underset{\text{Sodium}}{Na}\ \underset{\text{Aluminum}}{Al}\ \underset{\text{Sulphate}}{(SO_4)_2}$$

There is no potassium in this substance at all, as there is in the common alum, and no ammonia as in the less common ammonium alum.

STARCH

WE also find that besides the soda and "acid," starch is used in baking powder. This starch is corn starch of the highest grade of purity and specially prepared for food purposes.

The starch serves three purposes, two of which play an important part in keeping the baking powder from spoiling, while the third adds to the efficiency of its use.

First: It separates the soda from the acid or acid acting salt and thus by mechanically separating them retards such chemical action as could be brought about by moisture. The air is never dry. It always contains moisture. This is very noticeable on rainy days, but it escapes attention in fair weather. Not only is carbon dioxid set free when water or milk is poured on the baking powder, but even the moisture in the air gradually causes the change. Moisture from any source thus spoils the powder.

Second: Starch absorbs water and thus prevents moisture from bringing the active ingredients in contact with each other. In this way it aids materially in keeping the powder from spoiling. Starch is, for these reasons, a necessary ingredient of baking powders, and most especially necessary in the case of straight phosphate powders, which, even when starch is present, deteriorate very rapidly.

Third: Starch also dilutes the strength of the baking powder, so that it may be made to produce the amount of gas desired for efficiency and for convenience in household methods of measurement.

The laws of a few States require that a baking powder shall produce at least 10% of its weight of carbon dioxid gas. Almost all baking powders are made stronger than this. The majority of those upon the market yield 12% of gas, while the best produce between 14% and 15%.

WHITE OF EGGS*

THERE is one ingredient mentioned above, as being sometimes used in baking powder, which has not yet been discussed. That is Dried White of Eggs, sometimes called egg albumen. It is prepared by drying the white of fresh hens' eggs at a low temperature, and then grinding to a fine powder. Fourteen pounds of whole eggs will produce about one pound of this dry powder. It dissolves easily in cold water and the viscous, egg-white nature of this solution holds the bubbles of gas as they are set free from the baking powder. White of eggs is used by many manufacturers of baking powder. This increases the efficiency of the carbon dioxid gas evolved by a baking powder to an extent of 2.5% to 3.2% when used in strong baking

*Calumet and Crescent Baking Powders are the two most widely known that contain white of eggs. It is used in about thirty different brands of baking powder.

powders. It is extremely beneficial in producing light biscuits when the oven temperatures are not properly controlled or when the dough has to stand for some time before baking.

The amount of dried white of eggs used in baking powders is very small, being 15/100 of 1%. Even in this small proportion it has the effect above mentioned. It also makes possible a simple test whereby the freshness of baking powder may be determined, by the salesman in testing the stock upon the retailers' shelves, by the grocer himself, or by the housewife in the home. Both the increase in lightness and the possibility of the test are due to the viscous nature of the white of eggs, whereby the bubbles of gas are imprisoned as soon as they are set free by chemical action. This test is described by one manufacturer as follows:

"First take an ordinary drinking glass holding one half pint, or in other words, the quantity that is usually known in the household as "one cupful." All that is needed is this empty glass, which must be dry, an ordinary teaspoon and a little water of the ordinary room temperature (not ice water nor hot water.) Place 2 level teaspoonsful of the powder in the dry glass, to which add the same quantity (2 teaspoonsful) of water quickly; stir rapidly for a moment (while counting five), just long enough to thoroughly moisten the powder; remove the spoon and watch the mixture rise. Note the action of the powder. It rises slowly and evenly, requiring 2 minutes to show the full strength. If the powder is of full strength, and you have proceeded properly, the gas released will form bubbles sufficient to half fill the glass.

"Caution:—Don't attempt to make the mixture rise by continued stirring, as whipping or beating the mixture breaks the gas bubbles that are formed and allows the gas to escape. Allow the powder to rise of its own strength.".

Manufacturers make the following use of this test. Whenever complaints are made to the grocer or when goods appear to have been stored in damp places, or too near the stove, the salesman tests the baking powder as above described and if it is found to have deteriorated, it is at once exchanged for fresh goods without cost to the retailer.* Without this simple test it would be necessary to send the goods complained of to the factory for chemical analysis. As a result of such tests by the salesmen, deteriorated goods may be entirely removed from the market so that the consumer will never receive a baking powder which does not do its work perfectly. *Of course, the above test cannot be made unless the white of eggs is present.*

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*The Calumet Baking Powder Company, more than any other company, uses this method in testing its goods on the grocer's shelf to keep its powder in perfect condition.

CHAPTER III

CHOICE OF AN "ACID" INGREDIENT

IT has been seen that there are several different substances available to set the carbon dioxid gas free from the soda, but the question arises, "How shall one decide which is best for that purpose?"

APPARENT DIFFERENCE IN BAKING POWDERS

THE principal difference between different baking powders is in the "acid" used, some containing one, some another and some a combination of two of these "acids." This difference is apparent to anyone reading the labels. All the ingredients are named there.

The first things to consider are:

(1) Which is the most healthful?

(2) Which will set free the most gas?

(3) Which will make a powder that will keep best?

(4) And, which gives off its gas at a speed best adapted for cooking purposes?

The study of the first two of these questions involves a knowledge of chemical action that takes place between each of the "Acids" and the soda. From the chemical equation we can determine just how much of the "acid" ingredient is necessary to set free all the gas from the soda and also just how much gas is set free, and just how much soluble residue is left from the reaction.

CHEMICAL ACTION

THE following equations show the formulæ of the "acids" and soda, and of the substances produced by the chemical reaction. Underneath each formula is the name of the substance. Underneath each name is the number of parts by weight that react or result from the chemical reaction. Underneath these is given the per cent of soluble residue and the per cent of carbon dioxid gas produced.

$H_2C_4H_4O_6$ +	$2NaHCO_3$ =	$Na_2C_4H_4O_6$ +	$2CO_2$ +	$2H_2O$
Tartaric Acid	Soda	Sodium Tartrate	Carbon Dioxid	Water
150	168	194	88	36
		61%	27.7%	

$KHC_4H_4O_6$ +	$NaHCO_3$ =	$KNa\,C_4H_4O_6$ +	CO_2 +	H_2O
Cream of Tartar	Soda	Rochelle Salts	Carbon Dioxid	Water
188	84	210	44	18
		77.2%	16.2%	

$3CaH_4(PO_4)_2$ +	$8NaHCO_3$ =	$Ca_3(PO_4)_2$ +	$4Na_2HPO_4$ +	$8CO_2$
Calcium Acid Phosphate	Soda	Calcium Phosphate	DiSodium Phosphate	Carbon Dioxid
702	672	310	568	352
			41.3%	25.6%

+ $8H_2O$ (Water), 144.

$2NaAl(SO_4)_2$ +	$6NaHCO_3$ =	$2Al(OH)_3$ +	$4Na_2SO_4$ +	$6CO_2$
"Alum"	Soda	Aluminum Hydrate	Sodium Sulphate	Carbon Dioxid
484	504	156	568	264
			57.5%	26.7%

The amount of "acid" and soda given in each case show the proportions by weight in which they should be mixed to make the best baking powder. If more "acid" is used just that much "acid" would be left in the food unchanged. If more soda were used, just that amount would be unacted on by the "acid" and would leave the food alkaline and yellow.

Put in words, the above equations represent the chemical action as follows:

One hundred and fifty parts by weight of tartaric acid act upon 168 parts by weight of soda. Both compounds are completely changed and there is formed 194 parts of sodium tartrate, 88 parts of carbon dioxid gas and 36 parts of water. The weight of the sodium tartrate is 61% of the sum of the weights of tartaric acid and soda, and the carbon dioxid is 27.7%.

One hundred and eighty-eight parts of cream of tartar act upon 84 parts of soda. Both compounds are completely changed and there is formed 210 parts of Rochelle Salts, 44 parts of carbon dioxid gas and 18 parts of water. The weight of the Rochelle Salts formed is 77.2% of the sum of the weight of cream of tartar and soda, and the weight of the carbon dioxid gas is 16.2%.

Seven hundred and two parts by weight of acid phosphate act upon 672 parts of soda. Both compounds are completely changed and there is formed 310 parts of insoluble calcium phosphate, 568 parts of sodium phosphate, 352 parts of carbon dioxid gas and 144 parts of water. The weight of the soluble sodium phosphate is 41.3% of the sum of the weights of the acid phosphate and soda, and the carbon dioxid gas is 25.6%.

Four hundred and eighty-four parts by weight of "alum" act upon 504 parts by weight of soda. Both compounds are completely changed. There is no "alum" and no soda left. There is formed 156 parts of insoluble aluminum hydrate, 568 parts of sodium sulphate and 264 parts of carbon dioxid gas. The weight of sodium sulphate is 57.5% of the weight of "alum" and soda and the carbon dioxid gas is 26.7%.

The above chemical actions show what takes place between the "acid" substance and the soda. The percentages given show how much soluble residue would be left and how much gas produced if a baking powder were made *without adding any other substance.*

AMOUNT OF GAS SET FREE

THE different "acids" with soda set free the following amounts of gas:

Tartaric acid	27.7%
"Alum"	26.7%
Acid phosphate	25.6%
Cream of tartar	16.2%

Each one produces more gas than is desired for ordinary household purposes and methods of measurement. In fact, another substance, starch, is added, which plays no part in the production of gas but in the presence of which the same weight of the mixture produces less gas than before. Enough starch is generally added to reduce the gas strength of the powder to between 12% and 15%. The amount of gas that can be produced by an "acid" acting on soda gives us no information as to the strength of a baking powder containing that "acid," for the reason that starch is always added, and in different proportions by every manufacturer. (There is one baking powder sold in the dry, mountain States that contains no starch.)

THE AMOUNT OF THE RESIDUES

THE per cent of soluble residue shown in the preceding equations by the different "acids" acting on soda, are as follows:

"Acid"		*Soluble Residue*
Acid phosphate	41.3%	Sodium acid phosphate
"Alum"	57.5%	Sodium sulphate
Tartaric acid	61.0%	Sodium tartrate
Cream of tartar	77.2%	Rochelle salts

Inasmuch as the powders always contain added starch* and are reduced in gas strength, a fairer comparison of the amount of the different residues may be obtained if one compares the amounts of soluble residue left from the different kinds of powders of the same gas strength. The following table shows the number of parts by weight of soluble residue produced by 100 parts of a baking powder that would produce 12% of gas.

Kind of Powder		*Residue*
Acid phosphate††	19.4 parts	Sodium acid phosphate
"Alum"**	25.8 parts	Sodium sulphate
Tartaric acid	26.4 parts	Sodium tartrate
Cream of tartar†	57.2 parts	Rochelle salts

This shows that Cream of Tartar powders, or the mixture of Cream of Tartar and Soda used in many households, leaves more than twice as much objectionable residue as any other kind of baking powder for the same amount of leavening.

THE HEALTHFULNESS OF THE RESIDUES

THE healthfulness of these substances is discussed in Bulletin No. 103 of the United States Department of Agriculture, professional paper, entitled "Alum

*Shillings' is a baking powder that does not contain starch.

**Bon Bon and Good Luck are types of baking powder containing only "alum" as an acid ingredient.

†The principal powders leaving Rochelle salts in the food are Cleveland, Royal, Price's and Shillings'.

††Rumford baking powder is the most prominent of this class.

in Foods," this being the decision of the Referee Board after a long extended investigation. The members of this board were selected by the President of the United States because their high scientific knowledge, the eminent positions they occupy, and the complete facilities for investigation at their command, were such as to render their conclusions respect-impelling and final. The following are a few quotations from the report:

"Alum, as such, is not present in the food when eaten."

"There is no evidence in our results to indicate that the occasional and ordinary use of bread, biscuits, or cake prepared with aluminum baking powder tends to injure the digestion. The amount of saline cathartic that would be ingested under conditions of normal diet would be very small and would provoke no catharsis or symptoms of any kind."

"In short, the board conclude that alum baking powders are no more harmful than any other baking powders."

"We must not, however, be oblivious to the fact," says Dr. Taylor, who conducted part of these investigations, "that a saline cathartic residue results from the reaction of every form of known baking powder now commonly employed. The use of cream of tartar or tartaric acid baking powder leaves in the alimentary tract a residue of tartrates which exhibit the action of a saline cathartic and of diuresis (excessive excretion of urine) as well. The so-called phosphate baking powder leaves as a residue of reaction sodium phosphate, again a saline cathartic. And aluminum baking powder leaves as a residue of reaction sodium sulphate, a saline cathartic. Apparently, therefore, at present at least, the use of baking powder is associated with the introduction into the alimentary tract of a certain amount of saline cathartic, the salt differing with the use of the particular type of baking powder."

This last paragraph from the report shows the character of the residues from the different kinds of powder to be as follows:

Kind of Powder	*Character of Residue*
"Alum"	Cathartic
Phosphate	Cathartic
Cream of tartar	Cathartic and Diuretic

If one uses 9 grams of a 12% baking powder to a pint of flour and makes therefrom 8 biscuits, then the number of such biscuits that it would be necessary to eat to take in the food enough of the residue from different powders to equal the minimum dose as given in the U. S. Dispensatory is shown by the following table:

Dose in Grams	*Kind of Powder*	*No. Biscuits*
31.1	Phosphate	142
15.5	"Alum"	53
17.7	Cream of tartar	28

From the above facts it will readily be seen that there is no basis in fact for the continual advertisement by the manufacturers of cream of tartar baking powder that alum baking powders are injurious, and that the cry against "alum" is merely an unjustified appeal to the desire for health in order to sell their own baking powder, which produces *not only cartharsis but diuresis as well.*

It is this latter effect which is most worthy of remark and study, for it indicates (what is, indeed, the fact) that the tartrates are absorbed into the blood and excreted through the kidneys, while sodium sulphate exercises what slight action it has upon the intestinal tract alone.

The quantity of residue in either case is so small, as shown by the above table, that its effect upon the body is probably inconsiderable and in this respect alone the "alum" powder would have the advantage, even if the residue were identical, since its residue, having regard to its dosage, is only about one-half that of the tartar powder.

But in quality the difference is still more marked. Recent experiments* have shown that tartrates, in larger quantities, have an injurious effect upon the kidneys, often causing nephritis. Whether small, continued doses have a proportionately mischievous effect, is still a matter for investigation. Certainly no such action has been ascribed to the non-toxic sodium sulphate. Whatever question, therefore, may yet remain as to the healthfulness of the respective residues is plainly in favor of the "alum" product.

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*Journal American Medical Association, Vol. LXII, No. 8, Feb. 21, 1914, p. 616. Underhill, F. P.: The Influence of Tartrates on Phlorhizin Diabetes, Proc. Soc. Exper. Biol. and Med., 1912, IX, 123; The Influence of Sodium Tartrate on the Elimination of Certain Urinary Constituents During Phlorhizin Diabetes, Jour. Biol. Chem., 1912, XII, 115. Underhill, F. P.; Wells, H. G., and Goldschmidt, S.: Tartrate Nephritis, with Especial Reference to Some of the Conditions Under Which It May Be Produced, Jour. Exper. Med., 1913, XVIII, 322. Salant, W., and Smith, C. S.: The Toxicity of Sodium Tartrate, with Special Reference to Diet and Tolerance, Proc. Soc. Exper. Biol. and Med., 1913, X, 170. Pearce, R. M., and Ringer, A. I.: A Study of Experimental Nephritis Caused by the Salts of Tartaric Acid, Jour. Med. Research, 1913, XXIX, 57.

Added Potassium Salts in Food, A. Cressy, Morrison, N. Y.

KEEPING QUALITIES.

ATTENTION has already been called to the fact that the chemical action which sets free the carbon dioxid gas and which should take place only in the dough, is in fact brought about to some extent by the moisture of the air. We have also seen that the starch present aided in two different ways in retarding such action. The "acid" used is also a very important element effecting the keeping qualities of a baking powder. Baking Powders in which acid phosphate is the only "acid" ingredient, spoil most rapidly. There is a comparatively small amount of this kind of baking powder on the market because of this fact. The housewife cannot depend on the goods being of proper strength when the goods are purchased. When purchased in the best condition, they are liable to deteriorate to an inefficient mass, even in the home, before the contents of the can are entirely used. Deterioration of any baking powder is often marked by caking or the formation of lumps. Cream of Tartar Baking Powder has good keeping qualities, but the powders containing "alum" keep best of all.

SPEED OF ACTION

THE total amount of gas from a baking powder may be produced either immediately on the addition of cold water, or only after a long time and after application of heat. This is because the "acid" dissolves more quickly or more slowly in water. The amount of gas that is given off quickly before the mix is placed in the oven can be shown in the following manner:

Three level teaspoonsful of baking powder are placed in a glass, a little white of egg added, and three teaspoonsful of water added. The whole is then immediately stirred until all of the baking powder is moistened. If this is done with the "alum" baking powder it will be found that very little gas is given off. A powder in which phosphate is the only "acid" ingredient acts very quickly as does also one containing tartaric acid or cream of tartar. The speed of action or the amount of gas thus given off is very important with reference to the handling of the baking.

A baking powder that gives off nearly all of its gas in the cold, as does a straight phosphate or a tartaric acid and a cream of tartar baking powder will produce a large dough biscuit before being placed in the oven. The dough in this case is already much distended and the gluten of the flour will not hold much more gas without breaking and allowing the gas to escape. Practically all of the gas has been set free before it is placed in the oven. If placed in an oven of a low temperature, any jarring of the floor or slamming of the door of the oven is likely to cause a fallen cake. This danger applies especially to straight phosphate and to cream of tartar and tartaric acid powders.

Note.—Most of the widely advertised "pure cream of tartar" baking powders contain tartaric acid.*

On the other hand a biscuit prepared from a straight "alum" powder which gives off almost none of its gas in the cold, would produce a flat dough biscuit, which, if placed in the oven, would have very little surface upon which the heat could act to penetrate the soggy mass and cause the powder to set its gas free. As a result, if placed in a very hot oven, the high tempera-

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*Cleveland, Royal and Price Baking Powders contain tartaric acid. Shillings' is a straight cream of tartar powder.

ture would crust the outside of the biscuit before the gas had been liberated, thus resulting in small, heavy, poorly leavened biscuits.

PROPERLY BALANCED ACTION

A STUDY of the keeping qualities and of the speed of action has resulted in the production of baking powders containing a combination of two of these "acids." The most notable are those containing phosphate and "alum." The aim has been to produce a baking powder with a correctly balanced action, giving off a *proper* amount of gas in the cold, with a sufficiently large amount of gas that will only be given off on heating the mix in the oven, and, at the same time, a powder that will not easily spoil. As a result of such consideration and extensive experiments, baking powders have been produced superior to any made with a single "acid" ingredient. Properly proportioned powders, of the "phosphate-alum" type, are not only the best in keeping quality, but, when they contain sufficient phosphate,* have also the best balanced speed of action, and insure the housewife against the dangers either of fallen biscuits on the one hand or of biscuits which have crusted over too quickly to obtain the desired lightness, on the other hand.

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*Calumet Baking Powder is the principal powder of this type.

CHAPTER IV

THE MANUFACTURE AND USE OF BAKING POWDER

THE manufacture of the different ingredients necessary to make a good baking powder has now been considered. The manufacture of baking powder itself begins with the ingredients as they are received from the different manufacturers. There is a general impression that the manufacture of baking powder consists of merely weighing out and mixing the different ingredients. This opinion is shared by most of the small, and even by some of the large manufacturers. It is, however, far from the truth.

The manufacture of baking powder requires the greatest care and most thorough chemical supervision. A perfect baking powder cannot be made by one who relies upon the manufacturer of the ingredients to always furnish him goods of the same purity, the same dryness, or the same strength.

In the study of chemical action it was seen that where a certain weight of soda was used, a fixed amount of the acid ingredient was necessary to set free all the gas. If more acid were used, just that much acid would be left unchanged in the finished food. If less acid were used, then to that extent there would remain soda (or sodium carbonate, an alkaline residue), rendering the food yellow and disagreeable to the taste. The excess of acid is especially undesirable on account of the physiological effect of such soluble substances. Accordingly, the first work of a manufacturer of baking powder is to test the ingredients he purchases and determine their strength. For this a well-equipped laboratory is essential. The weights of the ingredients are then adjusted so that the reaction will be complete and so that the product turned out today will be the same as that turned out yesterday, neither more acid nor more alkaline. Only by knowing the exact strength of the different ingredients can the mix be thus perfectly proportioned.

It is because these quantitative relations between the amount of soda and the amount of acid substances used must exist for the production of a proper and perfect baking powder, that the custom of mixing soda and Cream of Tartar still used in many homes is so objectionable. It is safe to say that the proper proportions are never obtained in the home except by accident, and not more than once in a thousand times. A good baking powder is, therefore, from this consideration alone, much to be preferred to such a mixture. It is also customary in some homes to use soda and sour milk in place of baking powder. Here again the proper proportion is impossible. In general, too much soda is used, as the milk ordinarily contains insufficient sourness (lactic acid) to set free all the carbon dioxid gas from the soda.

Besides the analysis for strength, the manufacturer must take every precaution, by analyses, to determine that the ingredients are of proper dryness. This is particularly true with reference to the starch used, as starch rapidly absorbs moisture, and even though in perfect condition when it left the starch factory, may have absorbed sufficient moisture during transit to be unsuitable for the manufacture of baking powder.

To introduce wet starch in the manufacture of baking powder would have the same effect as to pour water upon the powder itself. The powder would be spoiled at once, before reaching the consumer. This same precaution with reference to moisture must be taken with reference to the other ingredients, as these are frequently shipped in rainy weather and in leaky cars.

Then, too, it is necessary to analyze all the ingredients for other accidental impurities which may have been introduced. Chemical analysis is always carried out to make sure that heavy metals, and other objectionable substances, are absent from each ingredient.

MANUFACTURING APPLIANCES

THE manufacturing appliances in use vary according to the size of the plant and the progressiveness of the manufacturer. The object of these should be not only increased convenience, but above all, the highest order of sanitation. Baking powder is a food product and the progressive manufacturer treats it as such. He insists on the most modern sanitary buildings, free from dust, flooded with sunlight and fitted with the latest specially-constructed machinery, so that none of the ingredients nor the powder itself ever comes in contact with the human hand. This perfect protection should be demanded in every food product. The machinery in such a building consists of tightly enclosed elevators and conveyors so constructed that the powder is completely protected from moisture and contamination. Large, almost airtight bins are used for temporary storage of the ingredients, which empty directly into special containers standing on modern, accurate scales. A single container is used for each ingredient and no other substance ever enters it. These are emptied by gravity into the mixers through fine screens, so that any lumps are removed. These tightly closed mixers contain many flights of conveyors working in different directions, so that all the ingredients are perfectly mixed. From the mixer the powder passes by gravity into screw conveyors, which carry it to the automatic filling and weighing machines (a further sanitary protection), where it is weighed into the can. There then remains the labeling of the cans and the boxing and packing to make it ready for shipment. The modern manufacturer of baking powder pays strict attention to the health and hygiene of his employes. They are clothed in white uniforms and required to keep scrupulously clean.

THE USE OF BAKING POWDER

THE use of baking powder has become very general throughout the United States. The Memorial of the American Baking Powder Association presented in Congress in 1900 shows that at that time there was produced annually baking powders of the different types, as follows:

	Tons used per annum	*Mfg. concerns*
Alum	50,000	544 alum and alum-phosphate
Cream of tartar	9,000	10
Phosphate	300	1

The directions for the use of baking powder in general call for two heaping teaspoonsful to a quart of flour. This amount is unnecessary with the stronger powders, and makes a poorer instead of a better biscuit. The housewife will obtain better results if she uses *the smaller proportion called for in the directions given by the manufacturer.* With the stronger baking powders one heaping teaspoonful to a quart of flour is a great sufficiency. To use more than directed means to introduce an unnecessary amount of the residues in the finished food.

HOW TO MEASURE

ALWAYS measure the baking powder by the level teaspoonful. Scrape the straight edge of a knife across the spoon, keeping the blade pressed to the sides of the bowl. In this way you will always get the same amount.

A rounding teaspoonful = 2 level teaspoonsful.
A heaping teaspoonful = 4 level teaspoonsful.

One cannot expect to get the same result each time she cooks, unless she is accurate.

CARE OF BAKING POWDER

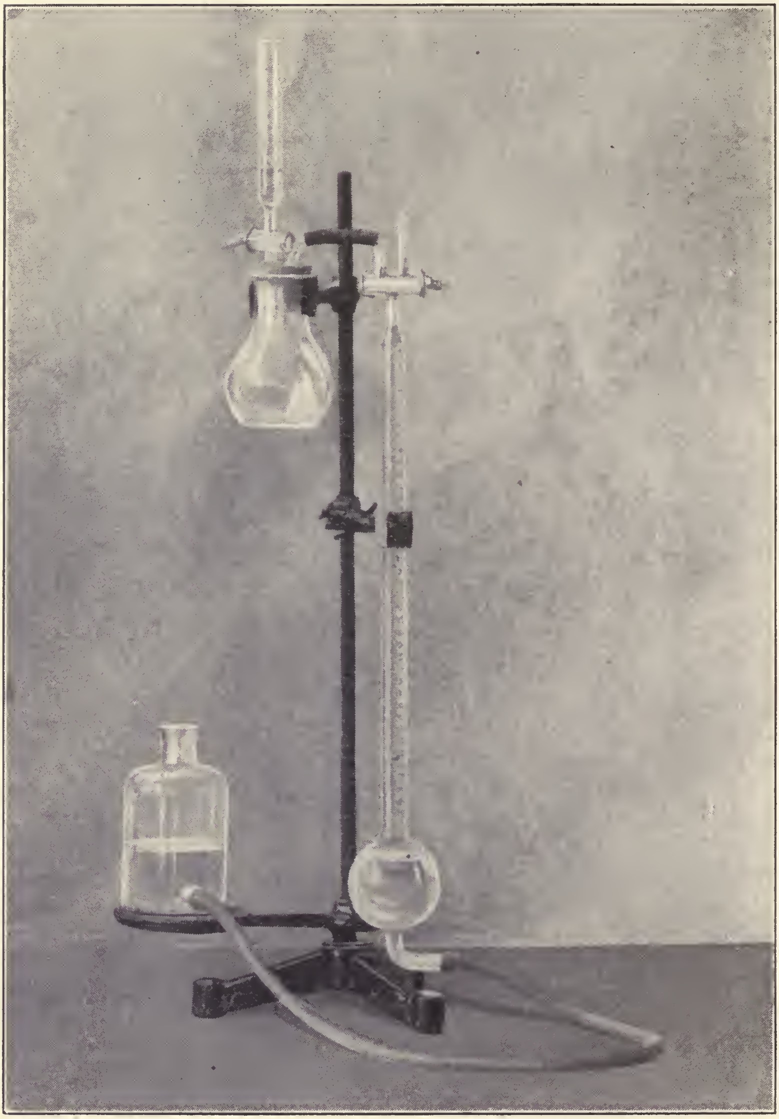
B*AKING Powder should always be kept in a dry, cool place.* We have seen in the study of soda that heat alone will cause this ingredient to lose a portion of its gas; hence, it is essential that the finished powder should be kept in a cool place. It has also been seen that moisture from any source will bring about the reaction between the soda and "acid," which it is desired should take place only in the dough. These precautions in storage should be taken *even before the can is opened.*

The cans used for baking powder are not hermetically sealed, and moisture from the air will gradually work its way into them. All baking powders will spoil if subjected to moist conditions of storage. The absurd claim of some manufacturers that their goods will not spoil is an insult to the intelligence of the consumer. If moisture will not spoil the baking powder when it is in the can, moisture will not activate the bakng powder (set free the carbon dioxid) when water or milk is added to the dough. If a manufacturer truthfully represents that his baking powder will not spoil, then he is selling something that is useless.

SELF-RISING FLOUR

SELF-RISING flour is nothing more than a mixture of flour and salt with soda and an "acid" ingredient, or in other words, with ingredients such as are used in making a baking powder. This mixing is almost done without any chemical control of the purity or strength of the ingredients or of the proportioning of the ingredients. The soda and "acid" are purchased of the manufacturers, with a formula for mixing them. The formula is never changed, no matter how much the purity or strength of the ingredients may vary. Such a product subjects the user thereof to every inconvenience and disappointments as to flavor and color in the finished food, such as would result from the use of the cheapest baking powder, manufactured without chemical control. Inasmuch as excessive quantities of the soda and acid are frequently added, the housewife is also preparing food containing excessive amounts of residue, when she uses self-rising flour.

Because of the large amount of water contained in flour, and the lack of protection from atmospheric moisture through the use of cloth bags as containers, the keeping qualities of the self-rising mixture are seriously impaired.



Harrison's Apparatus

CHAPTER V

THE DETERMINATION OF AVAILABLE CARBON DIOXID

MR. BENJAMIN HARRISON has devised the following rapid volumetric method for this determination:* (See cut.)

"In determining the percentage of available carbon dioxid in a baking powder, one-half gram of the sample is weighed into the small flask which is then put in place on the apparatus. The stopcock is now turned so as to connect the flask with the eudiometer, and the gases put under atmospheric pressure by bringing the saturated salt solution in the leveling bulb even with the solution in the eudiometer. The stopcock is now turned so as to connect with the tube leading into the air, and the gases in the eudiometer driven out by raising the leveling bulb. The stopcock is turned again so as to connect the flask and eudiometer, and the leveling bulb lowered to the table, giving a slight vacuum in the flask.

"Two cubic centimeters of previously boiled, distilled water are now run into the flask from the small graduated burette, and the apparatus shaken or rotated so as to mix the water thoroughly with the powder. Heat

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*Proceedings of the Seventeenth Annual Convention of the Association of American Dairy Food and Drug Officials, 1913, p. 158.

is then gently applied to the flask until the water just reaches the boiling point. Care must be taken here not to char the powder or boil off the water. The whole apparatus is allowed to cool to room temperature, the gas in the flask and eudiometer brought under atmospheric conditions by raising the solution in the leveling bulb and its volume read. The temperature and barometric pressure are also taken.

"We now have a volume which represents the gas from the baking powder plus two cubic centimeters from the water added. Experiment has shown that the equivalent of one cubic centimeter of carbon dioxid is retained by the water and powder in the small flask, so if we subtract one cubic centimeter from the observed reading we have the available gas equivalent of the sample taken. The corrected volume of the gas is reduced to 0° C. and 760mm. pressure, and the number of cubic centimeters found multiplied by the weight of one cubic centimeter of carbon dioxid, giving the weight of carbon dioxid in the sample. This weight, if divided by five-tenths and multiplied by one hundred, gives the percentage of available carbon dioxid in the sample.

"In the *Journal of the American Chemical Society,* Vol. 31, February, 1909, on page 237, is a table by Prof. S. W. Parr, giving the weight of one cubic centimeter of carbon dioxid at various temperatures and pressures, which saves considerable calculation."

The above method has been found to be accurate to within one or two-tenths of 1%, and is sufficiently accurate for almost all work.

A more accurate method is the one in which the amount of gas set free is absorbed by a caustic potash solution, or by soda lime and then weighed.

ABSORPTION METHOD*

THIS method is carried out by the use of Knorr's apparatus, the potassium hydroxide solution used has a specific gravity 1.27. This is prepared by dissolving 36.8 grams of solid potassium hydroxide in 100 cubic centimeters of water. The apparatus is shown in the accompanying illustration. The solution in "F" and "J" is the potassium hydroxide solution just mentioned. "E" and "H" contain concentrated sulphuric acid. "C" contains soda lime. The small tubes of "E" and "F" are filled with calcium chloride and "L" contains layers of calcium chloride, and soda lime.

The analysis is conducted as follows:

Place 7/10 of a gram of the baking powder in the perfectly dry distilling flash "A." Weigh the tubes "F" in which the carbon dioxid is to be absorbed and "H" and attach to the apparatus.

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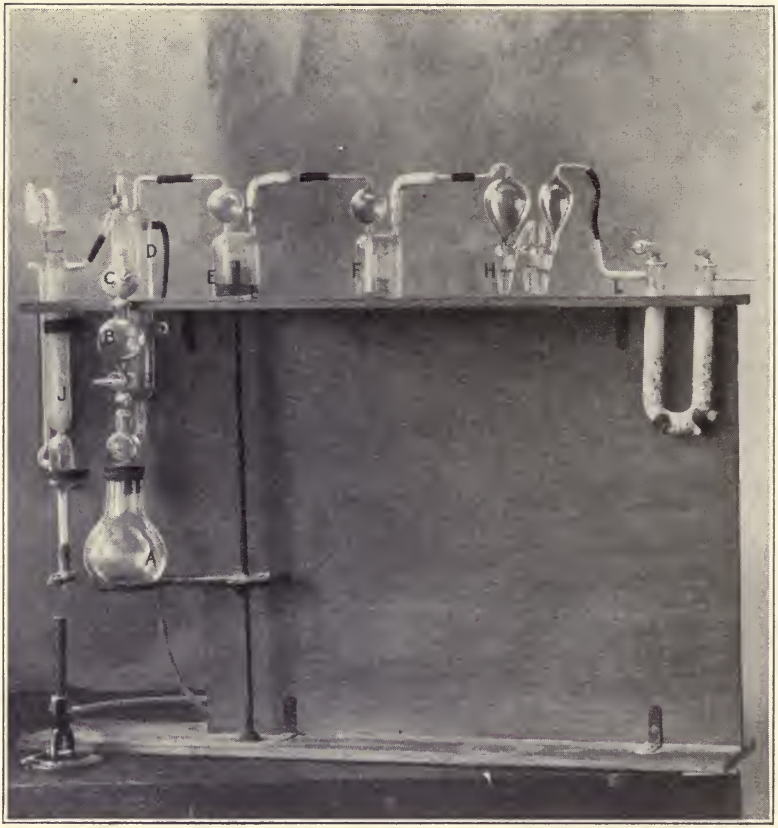
*Methods of Analysis, Association of Official Agricultural Chemists. Bureau of Chemistry Bulletin No. 107 (Revised), p. 169.



Modified Knorr Apparatus

Nearly fill the tube "B" with recently boiled distilled water and place the tube "C" in position. Then start the aspirator at such a rate that the air passes through the Liebig bulbs at about the rate of 2 bubbles per second. Open the stopcock of the funnel "B" and allow the water to run slowly into the flask, care being taken that the evolution of gas shall be so gradual as not to materially increase the current through the Liebig bulb.

After all the water has been introduced, continue the aspiration and gradually heat the contents of the flask to boiling, the cock in tube "B" being closed. Continue the boiling for a few minutes. After the water has begun to condense in "D," remove the flame, open the valve in tube "B" and allow the apparatus to cool while continuing the aspiration. Air should be drawn through the apparatus for a considerable time in order to completely remove all the carbon dioxid from flask "A." The whole operation should take at least two hours. Tubes "F" and "H" are then removed from the apparatus and weighed. The total increase in weight is due to the carbon dioxid set free from the baking powder.

CHAPTER VI

COST OF BAKING POWDER

THE cost of any material used for a piece of work must be figured on the cost of that material for a single unit of the work to be done.

So account must be taken in the case of baking powder, both of the cost per pound of the powder itself and the amount of work it will do. The price per pound varies from 10 cents to 50 cents. The amount of work each powder will do can be compared after a determination of the amount of available gas, or after scientific comparative bakings. Neither of these is necessary, however. We may take it for granted that the manufacturer in giving directions for the use of his powder has taken the strength into consideration in stating what amount of baking powder should be used. The directions uniformly give the amount to be used to leaven *one quart of sifted flour*. The amount of baking powder to be used as stated on the labels varies from one heaping teaspoonful, or two rounded teaspoonfuls, to two heaping teaspoonsful. Some manufacturers use the term "rounded teaspoonful" and others "heaping teaspoonful." One can always compare these by remembering that—

2 level teaspoonsful = 1 rounded teaspoonful.

4 level teaspoonsful = 1 heaping teaspoonful.

An example of the difference in cost of baking powder is the following:

"A." sells baking powder at 50 cents per pound and directs that you use 2 heaping teaspoonsful to the quart of flour.

"B." sells baking powder at 25 cents per pound and directs that you use 2 rounded teaspoonsful to the quart of flour.

What does it cost to leaven a quart of flour with "A.'s" powder as compared with that of "B.'s"?

Answer—Four times as much.

CAUTION—Never use more baking powder than recommended by the manufacturer. By following directions you will get the best results.

BAKING POWDER A NECESSITY

IN conclusion it should be stated that baking powder has done much to lighten and decrease the hours of labor of the housewife. It has made possible the easy and rapid production of many new, dainty and nutritious foods. The best powder may be purchased at a moderate price and the wholesomeness of the food prepared therefrom need not be questioned. That it is a convenience that cannot be dispensed with is appreciated most by those who use it most intelligently.

QUESTIONS

1. Name two common leavening agents.
2. What is yeast?
3. What is baking powder?
4. What is the active leavening agent produced by both yeast and baking powder?
5. Name three disadvantages in the use of yeast.
6. Name three advantages in the use of baking powder.
7. What are the natural sources of carbon dioxid gas?
8. What is soda?
9. How is it made?
10. What happens when soda is heated?
11. Why is its use alone unsatisfactory as a leavening agent?
12. Why is the use of ammonium carbonate unsatisfactory as a leavening agent?
13. What is the purpose of magnesium carbonate in cheap baking powders?
14. What substance with soda is necessary in baking powder for the production of carbon dioxid?
15. What two conditions must the acid and alkali fulfill?
16. Name an acid commonly found in so-called cream of tartar baking powder.
17. Name two acid salts in baking powder.
18. Name a salt which acts as an acid to soda but which is neither an acid nor an acid salt.
19. What substances other than acid and soda are used in baking powder?
20. What is the source of tartaric acid?
21. How is it purified?
22. How is cream of tartar obtained?
23. What are the sources of calcium acid phosphate?
24. What is the process of making bone phosphate?
25. Why is bone phosphate preferable to rock phosphate?

26. What advantage has granular phosphate over powdered phosphate?
27. In what powder is the phosphate of the granular type?
28. What is alum?
29. What is the so-called "alum" of baking powder?
30. What is the difference between these two?
31. Why is the latter called "alum"?
32. How is it made?
33. What three purposes does starch serve in baking powder?
34. What per cent of gas do good baking powders produce?
35. What are the most widely known baking powders that contain white of egg?
36. What is dried white of egg?
37. Does it increase the efficiency of baking powder?
38. If so, to what extent?
39. How much egg albumen is generally used in baking powder?
40. What other purpose does egg albumen serve in baking powder?
41. Describe the water-glass test.
42. To what use is this test put?
43. What company uses this test most in testing its goods on the grocer's shelves.
44. What must be present in baking powder to make the water-glass test?
45. What constitutes the difference between the classes of baking powder?
46. What four items should be considered in the choice of an acid ingredient?
47. Why should chemically equivalent amounts of acid and alkali be used in baking powder?
48. What is formed by the action of tartaric acid on soda?
49. What is formed by the action of cream of tartar on soda?
50. What is formed from the action of calcium acid phosphate on soda?
51. What is formed by the action of "alum" on soda?

52. If the different substances be mixed with soda in proper proportions, which mixture will produce the least amount of gas?
53. How much?
54. How much gas will the mixture of "alum" and soda produce?
55. How much gas will the mixture of calcium acid phosphate and soda produce?
56. What is the purpose of starch in baking powder in relation to the amount of gas?
57. What baking powder contains no starch?
58. What class of baking powders leave the greatest amount of objectionable residue? Name four such powders.
59. Name two baking powders having only "alum" as an acid ingredient.
60. Is "alum" present in foods prepared from "alum" baking powder?
61. Do "alum" baking powders injure digestion?
62. What is the final decision of the Remsen Board as to the harmfulness of "alum" baking powder?
63. What is the nature of the residue from every baking powder when taken in very large quantities?
64. What residue is left from cream of tartar baking powders?
65. What residue is left from phosphate baking powder?
66. What residue is left from "alum" baking powder?
67. What baking powder is most liable to produce catharsis?
68. Which then is the least desirable from a health standpoint?
69. Is the cry against "alum" in baking powders based on prejudice or fact?
70. What is the effect of tartrates on the kidneys?
71. What is the effect on other baking powder residues?
72. Why are there not more straight phosphate baking powders on the market?

73. What is the most prominent baking powder of the straight phosphate class?
74. What causes baking powder to spoil in the cans?
75. What baking powders keep best of all?
76. What causes the difference in the speed action of baking powder?
77. What is the disadvantage in the use of straight phosphate and cream of tartar baking powders?
78. Name three so-called pure cream of tartar baking powders that contain tartaric acid.
79. Name a cream of tartar baking powder.
80. What is the disadvantage in the use of straight "alum" baking powder?
81. What is the best and most common type of combination powders?
82. Which is the leading powder of this type containing sufficient phosphate?
83. What is its action?
84. Why is chemical supervision necessary in the manufacture of baking powder?
85. What would be the result of the use of wet starch in the manufacture of baking powder?
86. What attention should be given to sanitation in baking powder factories?
87. What class of baking powder is in widest use?
88. What is meant by level teaspoonful?
89. What is equivalent to a "rounding" teaspoonful?
90. What is equivalent to a "heaping" teaspoonful?
91. Why should baking powder be kept in a cool dry place?
92. Why will baking powder eventually spoil?
93. What caution should be borne in mind in the use of baking powder?
94. What has baking powder done for the housewife?

ANSWERS

1. Yeast and baking powder.
2. Yeast is a microscopic plant which in the leavening process breaks up sugars into carbon dioxid gas and alcohol.
3. Baking powder is a mixture of substances which produce carbon dioxid gas by chemical action.
4. Carbon dioxid gas.
5. (a) The different fermentations resulting from yeast produce different and sometimes objectionable flavors.
   (b) It takes several hours for fermentation to take place before the dough can be put in the oven.
   (c) Yeast does not act readily in the presence of large quantities of butter, lard or eggs.
6. (a) With a good baking powder the action is always the same, and therefore the flavors are always the same.
   (b) The gas is given off at once on the addition of water, or in the oven; there is no delay.
   (c) The action takes place readily in the presence of butter, lard or eggs.
7. Carbon dioxid occurs in nature combined with metals, as carbonates, such as chalk, marble and limestone. It is set free from these by means of acids.
8. Soda is saleratus or cooking soda, sometimes called the alkali of baking powder. It is chemically known as sodium bi-carbonate.
9. Soda is made from common salt by the action of acid ammonium carbonate.
10. On heating, soda breaks up, giving off carbon dioxid gas and leaving normal sodium carbonate.
11. Normal sodium carbonate is left in the food. It produces an objectionable flavor in the food and colors it yellow.
12. Ammonium carbonate leaves traces of ammonia gas in the food.
13. Magnesium carbonate is used as a filler because of its extreme light weight. The great volume of such powder often

makes the purchaser think she is getting more baking powder.

14. An acid or an acid-acting salt to release the carbon dioxid gas.
15. The acid and alkali should be dry substances and dissolve readily in water.
16. Tartaric acid.
17. Calcium acid phosphate and cream of tartar.
18. Sodium aluminum sulphate, sometimes called "alum."
19. Cornstarch and white of egg.
20. Tartaric acid is made from argol, the sediment from wine vats.
21. It is purified by treating with chalk and calcium chloride, and filtering the resulting mixture of the calcium salt. The calcium tartrate is dissolved in sulphuric acid, after which the solution is filtered and the tartaric acid allowed to crystallize.
22. Cream of tartar is also obtained from argol, the source of tartaric acid. The chemical treatment of this, however, differs from that of tartaric acid.
23. Calcium phosphate is obtained from the bones of healthy cattle and sometimes from natural rock.
24. The bones are burned and then treated with sulphuric acid. The solution is purified by filtration, crystallized and dried.
25. Phosphate from bone is preferable to that from rock because it does not contain the harmful impurities, fluorides, present in rock.
26. Granular phosphate makes a baking powder which will keep better than that made from the powdered phosphate. Granular phosphate is more expensive.
27. In Calumet Baking Powder.
28. Alum is potassium aluminum sulphate with water of crystallization.
29. The so-called "alum" is a mixture of sodium sulphate and aluminum sulphate with no water of crystallization.

30. Alum contains potassium and water of crystallization. It is used as a medicine. The so-called "alum" of baking powder contains neither potassium nor water of crystallization and has no medicinal use.

31. The latter is called "alum" because some food commissioners thought this word better showed the general characteristics of the substance to the public.

32. It is made by mixing solutions of sodium sulphate and aluminum sulphate, concentrating the mixture and fusing the resulting mass.

33. Starch serves three purposes in baking powder:
    (a) To separate the soda and the acid mechanically.
    (b) To absorb water from the air and prevent deterioration of the baking powder.
    (c) To dilute the baking powder to a strength convenient for purposes of household measurement.

34. Good baking powders produce from 12% to 15% available gas.

35. Calumet and Crescent Baking Powders.

36. Dried white of egg is the dried white of fresh hen's eggs.

37. It does materially increase the efficiency of the baking powder.

38. From 2½ to 3 2/10% when used in strong powder.

39. Baking powders generally contain 15/100 of 1%.

40. Egg albumen furnishes a means of estimating the strength of the baking powder.

41. Take an ordinary drinking glass holding one-half pint, or in other words, the quantity that is usually known in the household as "one cupful." All that is needed is this empty glass, which must be dry, an ordinary teaspoon and a little water of the ordinary room temperature (not ice water nor hot water); place two level teaspoonsful of the powder in the dry glass, to which add the same quantity (two teaspoonsful) of water, quickly; stir rapidly for a moment (while counting five), just long enough to thoroughly moisten the powder; remove the spoon and watch

the mixture rise. Note the action of the powder.

42. This test is used to insure the freshness of the grocer's stock and protect the consumer. Deteriorated goods are detected by this test and replaced with fresh by the manufacturers free of charge.
43. The Calumet Baking Powder Co.
44. White of egg must be present before the test can be made.
45. The difference between baking powders is in the "acid" or "acids" used to release the carbon dioxid from the soda and in the proportions of the same.
46. The four items to be considered in the selection of an acid for a baking powder are the healthfulness of the residues, the amount of gas it will release, the keeping qualities of the resulting baking powder and the speed of action.
47. Chemically equivalent amounts of acid and alkali should be used in baking powder because an excess of acid leaves that much acid unchanged in the food and an excess of soda causes an alkaline flavor and a yellow color in the foods.
48. Sodium tartrate, carbon dioxid gas and water.
49. Rochelle salts, carbon dioxid gas and water.
50. Calcium phosphate, sodium acid phosphate, carbon dioxid gas and water.
51. Aluminum hydrate, sodium sulphate, and carbon dioxid gas.
52. Cream of tartar and soda sets free the least amount of gas.
53. 16.2%.
54. 26.7%.
55. 25.6%.
56. Starch is then added to baking powder to reduce the amount of gas given off. Without starch, too much gas would be evolved in the case of "alum" and phosphate powders.
57. Shillings'.
58. Cream of tartar baking powder leaves the largest amount of objectionable residues; 77.2% Rochelle salts when no

starch is present; 57.2% Rochelle salts is left from a powder producing 12% of gas. Shillings', Royal, Price's and Cleveland Baking Powders.

59. Bon Bon and Good Luck.
60. No.
61. No.
62. Alum baking powders are no more harmful than any other baking powders.
63. A saline cathartic.
64. Rochelle salts, which act as a saline cathartic and a diuretic as well.
65. Sodium phosphate, a mild cathartic.
66. Sodium sulphate, a mild cathartic.
67. Cream of tartar or tartaric acid baking powders are twice as likely to produce catharsis as any other baking powder.
68. Cream of tartar or tartaric acid powders.
69. The cry against "alum" is based on prejudice.
70. Tartrates produce nephritis.
71. The residues from other baking powders have been declared to be non injurious.
72. Because straight phosphate baking powders keep only for a short time.
73. Rumford Baking Powder.
74. Moisture from the air or from any other source, or excessive heat.
75. The baking powders containing "alum" keep the best of all.
76. The difference in the solubility of the acid constituents in water.
77. Straight phosphate and cream of tartar powders give off their gas quickly, therefore are liable to cause fallen biscuits if the oven is not at the optinimum temperature.
78. Cleveland, Royal and Price's.
79. Shillings'.
80. Straight alum baking powder gives off practically no gas in the

cold resulting in small, heavy and poorly leavened biscuits if placed in too hot an oven.

81. "Alum"-phosphate is the best and most common type of combination powders.
82. Calumet Baking Powder.
83. The best "alum"-phosphate powders give off the proper amount of gas in the cold with sufficiently large amount of additional gas when placed in the oven. They keep best and produce better results in cooking.
84. To insure a perfect product, always of the same strength, neither acid nor alkaline, and above all to insure its purity.
85. Wet starch in baking powder would cause its immediate spoilage.
86. Baking Powder is used in the preparation of foods, and therefore its manufacture should be carried on under the strictest sanitary conditions.
87. "Alum"-phosphate powders have the widest use.
88. A straight knife blade moved over the spoon filled with powder, keeping the blade pressed to the sides of the bowl, leaves a level teaspoonful.
89. Two level teaspoonsful are equivalent to a rounding teaspoonful.
90. Four level teaspoonsful are equivalent to a heaping teaspoonful.
91. Baking powder should be kept in a *cool, dry* place. Moisture will spoil the powder, and heat decompose the soda.
92. Baking powder will eventually spoil because the cans are not hermetically sealed and moisture enters from the air.
93. One should always follow the directions given by the manufacturers, using no more than is recommended, for different baking powders are of different strengths.
94. Baking powder has lightened and decreased the labor of the housewife. It has made possible the easy and rapid production of dainty and healthful foods.

BULLETIN OF THE
U.S. DEPARTMENT OF AGRICULTURE

No. 103

Contribution from the Referee Board of Consulting Scientific Experts, Ira Remsen, Chairman. April 29, 1914.

(PROFESSIONAL PAPER.)

ALUM IN FOODS.

EXPLANATORY STATEMENT.

A report on the influence of aluminum compounds on the nutrition and health of man has been submitted by the Referee Board of Consulting Scientific Experts, in answer to questions put to it by the department. The report of the board itself, signed by each member, is brief, but it is accompanied by three elaborate reports giving the results of three sets of extensive experiments on human subjects conducted independently by three members of the board. To get the board's conclusions before the public at this time, it is considered advisable to publish its findings, but to omit the extensive reports of the three experimenters, giving only their final conclusions.

QUESTIONS SUBMITTED TO REFEREE BOARD.

The questions submitted to the board were as follows:

1. Do aluminum [1] compounds, when used in foods, affect injuriously the nutritive value of such foods or render them injurious to health?

2. Does a food to which aluminum compounds have been added contain any added poisonous or other added deleterious ingredient which may render the said food injurious to health? (*a*) In large quantities? (*b*) In small quantities?

3. If aluminum compounds be mixed or packed with a food, is the quality or strength of said food thereby reduced, lowered, or injuriously affected? (*a*) In large quantities? (*b*) In small quantities?

CHARACTER OF EXPERIMENTS CONDUCTED.

In order to base their report upon first-hand knowledge, the board instituted three sets of experiments, each independent of the others. One set of experiments was conducted by Dr. Russell H. Chittenden, of the Sheffield Scientific School, Yale University, New Haven; another by Dr. Alonzo E. Taylor, of the Medical School of the University of Pennsylvania, Philadelphia; and the third by Dr. John H. Long, of the Northwestern University Medical School, Chicago. In

[1] Aluminum is a synonym for aluminium, the metal used for cooking utensils and other implements. Alum or sodium aluminum sulphate is a salt of this metal.

each case tests were made on healthy young men by including aluminum in some form in their food. The food was all carefully measured and weighed and the amounts of its principal ingredients were determined by analysis. The excretions of the men's bodies (both urine and feces) were carefully collected, examined, and analyzed. Daily records of body weight, temperature, respiration, and pulse were kept for each man, and notes were made of any unusual symptoms. Any disturbance in health or physiological processes was thus detected.

Each experiment included three periods, in the first and last of which no aluminum was administered. During the middle period aluminum compounds were administered, the "dose" increasing as the experiment progressed. In this way the effect of large quantities was compared with that of small quantities In Dr. Chittenden's and Dr Taylor's experiments some of the men who served as "control" subjects received no aluminum at any time, so that any disturbances due to other causes might be checked up.

Dr. Chittenden's experiments included 12 men and continued from January 15 to June 22, 1912. During 130 days the diet contained bread raised with an alum baking powder made in the laboratory.[1] The dose of aluminum compound was increased from time to time, at first by increasing the quantity of bread and later by increasing the quantity of the baking powder used in making the bread. In this way the alum [2] used per man per day was increased from 0.578 gram [3] (8.920 grains) at the beginning to 2.287 grams [4] (35.295 grains) at the close of the dosage period; the actual aluminum contained in this dosage ranged from 0.065 gram (1.003 grains) to 0.257 gram (3.966 grains) per man per day. Eight men used the alum bread, while four had no aluminum in their food.

Dr. Long's experiments ran from February 8 to June 7, 1911, and included six men, all of whom received the dosage. Baking powder bread was not used, but instead for 40 days a mixture of the same composition as the residue left in such bread by alum baking powder was administered in the form of a powder in water or milk. For 30

[1] This bread was made fresh every day and contained in one baking of two loaves approximately:

Sifted flour	quarts	2
Baking powder (25 per cent calcined alum)	heaping teaspoonfuls	4
Salt (approximately one rounded teaspoonful)	ounce	½
Butter	do	1
Water, sufficient quantity.		

Later in the experiment a greater proportion of alum baking powder was used in the making of the bread in order to facilitate administering larger amounts of alum.

[2] The term "alum" as used under the heading "Character of experiments conducted" refers to the calcined sodic aluminic sulphate commonly used in alum baking powders and not to the ordinary crystallized alum.

[3] Equivalent to approximately two-thirds of a level teaspoonful of baking powder containing 25 per cent of alum. All the figures in this and succeeding footnotes must of necessity be approximate, since teaspoons vary in size and baking powders in composition.

[4] Approximately equivalent to 2⅔ level teaspoonfuls of alum baking powder.

days the quantity of alum used was 2 grams[1] (30.866 grains) a day for each man; in the next 10 days the dose was doubled. Afterwards for 30 days the baking powder residue was treated so as to wash out everything except the compounds of aluminum with hydrogen and oxygen (aluminum hydroxide), the dose at first being the amount obtained from 4 grams[2] (61.732 grains) of alum per man per day, which was increased in the second 10 days to 6 grams[3] (92.598 grains) and in the third 10 days to 10 grams (154.330 grains) of alum. Finally, in a period of 10 days, the dose was the sodium sulphate consumed when 4 grams of alum were used, this compound being the cathartic ingredient which is left in bread by alum baking powder.[4]

Dr. Taylor conducted experiments with a squad of eight men from October 8, 1911, to May 10, 1912, with an intermission from December 16 to January 14. In this case also the powder was not used in bread, but was administered in wafers or dissolved in water. Six of the subjects took the aluminum compounds, while the other two took milk sugar, the men themselves not knowing which they were taking. There were two groups of experiments in which the whole squad took part. In the experiments of the first group, which ran from October 8 to December 16, tests were made with alum alone. The dose at first was such as to give each man 0.1 gram[5] (1.5433 grains) of aluminum a day and was increased from time to time until the daily dose was 0.298 gram[6] (4.599 grains) of aluminum for each man. The second group ran from January 14 to May 10. Tests were made with the residue from alum baking powder; tests were also made with certain aluminum compounds (aluminum hydroxide and aluminum chloride) which may be found in the residues from alum baking powders of different kinds, and with sodium sulphate, the purgative salt left in bread by alum baking powders. The smallest dose of the compounds containing aluminum gave each man 0.227 gram[7] (3.503 grains) of aluminum a day, while the largest dose gave 0.969 gram[8] (14.954 grains) of aluminum a day. The dose of the purgative salt (sodium sulphate), in which there is no aluminum,

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[1] Approximately equivalent to 2½ level teaspoonfuls of alum baking powder. Equivalent to about 0.223 gram (3.44 grains) of aluminum.

[2] Approximately equivalent to 4½ level teaspoonfuls of alum baking powder.

[3] Approximately equivalent to 6 7/8 level teaspoonfuls of alum baking powder. These amounts of alum are equivalent to about 0.44 gram (6.86 grains), 0.67 gram (10.29 grains), and 1.11 grams (17.15 grains) of aluminum.

[4] Editorial note: Sodium sulphate or Glauber's salt is a substance derived from the interaction of alum and baking soda in making bread with alum baking powders and is of itself a cathartic, formerly much used medicinally. Cream of tartar baking powder, when used in bread, by a similar interaction produces a cathartic substance known as sodium tartrate. Phosphate baking powders when used in making bread produce a cathartic substance known as sodium phosphate. Cream of tartar and phosphate baking powders produce catharsis, similar to that produced by alum baking powders, when used in quantities.

[5] Approximately equivalent to a level teaspoonful of alum baking powder.

[6] Approximately equivalent to 3 level teaspoonfuls of alum baking powder.

[7] Approximately equivalent to 2½ level teaspoonfuls of alum baking powder.

[8] Approximately equivalent to 10 level teaspoonfuls of alum baking powder.

was 5.23 grams [1] (80.714 grains) per man per day. Following these experiments four men took 1 gram (15.433 grains) of aluminum a day each for several days,[2] and then their blood was tested to detect any aluminum that might be present in it. No aluminum was found in the blood. As a further indirect test to determine whether aluminum was resorbed, one man took for five days enough aluminum hydroxide to furnish 0.660 gram (10.186 grains) of aluminum a day and another took enough to give 0.540 gram (8.334 grains) a day for five days. The men were fed a diet of low and known phosphorus content and the excrementa analyzed for phosphorus, in order to detect, if possible, signs of abstraction of this element from the tissues by resorbed aluminum. This test failed to demonstrate resorption of aluminum.

CONCLUSIONS OF INDIVIDUAL INVESTIGATORS.

Dr. Chittenden concludes from his experiments that small quantities of aluminum compounds, and even comparatively large quantities, when taken daily with the food, have no effect upon the general health and nutrition of the body. "In other words," as he sums up his conclusions, "aluminum compounds when used in foods—as in bread—in such quantities as were employed in our experiments do not affect injuriously the nutritive value of such foods or render them injurious to health, so far as any evidence obtained in our experimental work indicates."

Dr. Long, in concluding his report, calls attention to the fact that alum is rather generally used in the manufacture of cucumber pickles. This is an old practice which had its origin in the household rather than in the factory and is still common in the household. The hardening effect of the alum is believed to help in keeping the pickles. In the factory the cucumbers are first soaked for several weeks in strong brine, then in fresh water overnight, this process being sometimes repeated. Then the cucumbers are put into an alum liquor in which the weight of alum used is about one-fourth of 1 per cent of the weight of the cucumbers. The cucumbers and liquor are heated up to 120° or 140° F., then cooled and allowed to stand for from 6 to 24 hours. Then comes a bath in fresh water and afterwards the final treatment with vinegar. The vinegar takes out some of the alum from the pickles, so that usually the alum left in them amounts to less than two-tenths of 1 per cent.

Alum is also used in the preparation of maraschino cherries, and perhaps some other fruits. But the quantities of aluminum that might be consumed either in pickles or in the fruits referred to are so small, compared with the quantities actually consumed in baking powders, that the study of alum baking powders may be taken to cover the entire field.

[1] About one-fifth ounce of Glauber's salt. (See footnote, p. 3.)

[2] This corresponds to approximately 10 level teaspoonfuls of alum baking powder.

Alum, as such, is not present in the food when eaten. In the process of baking, the alum and soda in baking powder break up and recombine into several compounds. One product is the carbonic acid gas, which does the work of leavening. This gas passes off, leaving in the bread an aluminum compound and a compound called sodium sulphate. Dr. Long concludes that the cathartic action of large residues from the alum and soda combination—for instance, the residue left when the large dose of alum, 4 grams[1] (61.732 grains), was used—must be considered objectionable when administered daily. But this is much above the consumption in actual practice, and amounts of alum not above 2 grams[2] (30.866 grains) a day—a liberal allowance—do not appear to be harmful in any practical sense. Since the quantities of aluminum compounds consumed with other foods are insignificant compared with the quantities consumed in foods prepared with baking powder, the findings from the study of baking powder residues must be held to cover all cases. Keeping in mind that the aluminum compounds actually in the food when consumed are comparatively inert, Dr. Long declares that "it can not be said that when mixed with foods in the small quantities actually considered necessary, they add a poisonous or deleterious substance, or injuriously affect the quality of the food with which they are used."

Dr. Taylor's conclusions agree in effect with those of his associates. He says, "We have had, unquestionably, evidences of the catharsis caused by the administration of large doses of baking powder." With the large doses used in his experiments, the stools are increased in weight and frequency, the movements are loose, and colic is apt to attend the evacuations. This condition is the result of sodium sulphate, which, though not an aluminum compound, is a residue of the alum baking powder. But with very large doses of aluminum compounds occasional dry colic may also be noted.

"I personally," says Dr. Taylor, "do not believe that it would be healthful for anyone, in camp or out of camp, to live upon a diet of baking powder biscuits. I do not believe that the regular ingestion of sodium sulphate in doses of from 3.5 to 5 grams[3] (54 to 77 grains) per day, with the normal diet, resulting in distinct looseness of the bowels, is a procedure to be recommended. Prolonged administration of saline cathartics even in small dose tends to leave behind a condition of constipation; and it is certainly the experience of the medical profession that the practice of the regular administration of saline cathartics is not to be recommended. This aspect of the question is of course not peculiar to aluminum baking powder, but applies to all baking powders, since to a greater or less extent a saline cathartic remains as the residue of the reactions of all known baking powders,

[1] Approximately equivalent to 4½ level teaspoonfuls of alum baking powder.
[2] Approximately equivalent to 2¼ level teaspoonfuls of alum baking powder.
[3] One-eighth to one-sixth ounce of Glauber's salt.

as demonstrated in direct tests with different baking powders on human subjects[1] There is no evidence in our results to indicate that the occasional and ordinary use of bread, biscuits, or cake prepared with aluminum baking powder tends to injure the digestion. The amount of saline cathartic that would be ingested under conditions of normal diet would be very small and would provoke no catharsis or symptoms of any kind."

One other effect of the administration of compounds of aluminum is noted by Dr Taylor, namely, a distinct decrease of phosphates in the urine and a corresponding increase of phosphates in the stools. But the extent of this change is too slight for it to have any material meaning or effect.

CONCLUSIONS OF THE REFEREE BOARD.

With the results of these independent experiments agreeing so well, the Referee Board were enabled to draw up a unanimous report, signed by all the members, namely: Ira Remsen, president of Johns Hopkins University, chairman; Russell H. Chittenden, professor of physiological chemistry in Yale University and director of the Sheffield Scientific School; John H. Long, professor of chemistry in the Northwestern University Medical School; Alonzo E. Taylor, Benjamin Rush professor of physiological chemistry in the University of Pennsylvania; and Theobald Smith, professor of comparative pathology in Harvard University.

In their report the board first define their understanding of the terms "small quantity" and "large quantity," as applied to alum baking powders, as follows:

> By the term "small quantity" we understand such an amount as may be ingested in the normal use of biscuits, pastry, or other articles leavened with baking powder, as these foods are practically used in the ordinary American family. This amount will not average more than 25 to 75 milligrams[2] (0.39 to 1.16 grains) of aluminum daily for the days of consumption of such articles.

[1] "We must not, however, be oblivious to the fact," says Dr. Taylor, who conducted part of these investigations, "that a saline cathartic residue results from the reaction of every form of known baking powder now commonly employed. The use of cream of tartar or tartaric acid baking powder leaves in the alimentary tract a residue of tartrates which exhibit the action of a saline cathartic and of diuresis [excessive excretion of urine] as well. The so-called phosphate baking powder leaves as a residue of reaction sodium phosphate, again a saline cathartic. And aluminum baking powder leaves as a residue of reaction sodium sulphate, a saline cathartic. Apparently therefore, at present at least, the use of baking powder is associated with the introduction into the alimentary tract of a certain amount of saline cathartic, the salt differing with the use of the particular type of baking powder."

[2] This is approximately equivalent to one-quarter to three-quarters of a level teaspoonful of alum baking powder.

By the term "large quantity" we understand such an amount of aluminum as would be ingested only under very unusual conditions, as for example, where the flour consumption is mainly in the form of biscuits or other articles leavened with aluminum baking powders. This amount may reach 150 to 200 milligrams [1] (2 31 to 3 09 grains) of aluminum per day A person subsisting mainly on baking-powder biscuits, as may happen in camp life, might ingest an amount in excess of 200 milligrams per day. With this possibility in mind, we have also studied the effects of amounts up to and exceeding 1,000 milligrams [2] (15 4 grains) of aluminum per day

With this understanding of the terms, the board give the following answers to the questions submitted to them

Aluminum compounds when used in the form of baking powders in foods have not been found to affect injuriously the nutritive value of such foods

Aluminum compounds when added to foods in the form of baking powders, in small quantities, have not been found to contribute any poisonous or other deleterious effect which may render the said food injurious to health. The same holds true for the amount of aluminum which may be included in the ordinary consumption of aluminum baking powders furnishing up to 150 milligrams (2 31 grains) of aluminum daily.

Aluminum compounds when added to foods, in the form of baking powders, in large quantities, up to 200 milligrams (3 09 grains) or more per day, may provoke mild catharsis

Very large quantities of aluminum taken with foods in the form of baking powders usually provoke catharsis This action of aluminum baking powders is due to the sodium-sulphate which results from the reaction

The aluminum itself has not been found to exert any deleterious action injurious to health, beyond the production of occasional colic when very large amounts have been ingested.

When aluminum compounds are mixed or packed with a food, the quality or strength of said food has not been found to be thereby reduced, lowered, or injuriously affected.

In short, the board conclude that alum baking powders are no more harmful than any other baking powders, but that it is wise to be moderate in the use of foods that are leavened with baking powder.[3]

[1] This is approximately equivalent to 1½ to 2 level teaspoonfuls alum baking powder.

[2] Approximately equivalent to 10 level teaspoonfuls alum baking powder.

[3] See footnotes, pages 3 and 6.

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