A NOTE ON ALUM PHOSPHATE BAKING POWDERS.

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The point of view from which healthfulness or unhealthfulness has been predicated for the combinations usually employed as leavening agents has been shifted considerably during the last few years. The main contention has been, and continues to be, in regard to the advisability of alumina compounds in such food products, but the positions assumed by both advocates and opponents have been not only modified, but on some points reversed.

It will be conceded, we think, that much of adverse opinion in regard to the employment of burnt alum in baking powders has arisen from confusion concerning two very distinct purposes for which alum has been used.

Its peculiar action upon flour producing a whiter and lighter bread from inferior and in some cases unsalable flour than could otherwise be obtained, early led to its adoption in England and on the Continent, for the purpose of enhancing the value of bread products beyond their legitimate value. It was thus a fraud upon the consumer, calling for and being met by legislative restriction; nor should it be forgotten that the alum was added to the bread as crystallized alum possessing, when in the bread, all the properties of that salt, and being extracted therefrom in large proportion by water.

In the use of alum in baking powder the conditions are entirely changed; the powder being used by the buyer, the purpose for which legislative interference was first invoked is no longer a factor and from a sanitary point of view the question is no longer centered on alum as such, but on hydrate and phosphate of alumina.

In the celebrated Norfolk baking powder case (*Analyst* **4**, *page 231*) it was contended that the phosphate of alumina was entirely insoluble in the human system, that thus the flour was deprived of its phosphatic constituents by the alumina in the powder forming insoluble residues, and on that account alum baking powders should be condemned. With the advent of acid phosphate of lime as used in combination with burnt alum for liberating the carbonic acid of sodium bicarbonate such objections were forestalled, since much more phosphoric acid was introduced than could possibly be removed from the flour.

The reversal of opinion to which we alluded was now taking place and statements and calculations made were based upon the assumption that all of the alumina left in the residues of bread and biscuit was taken up in the system, whereas it had been claimed before that they were insoluble.

Direct experimentation made on a typical phosphate and alum composition seemed, however, to be at variance with such assumptions since in the nearest approach possible to the actual conditions the factor arrived at for the solubility of residues from phosphate and alum powders in the mouth and stomach was found to be $\frac{1}{5}$ to $\frac{1}{6}$ of the alumina present (*Pitkin, Journal American Chem. Soc.* **9**, *p. 27*).

The consideration of the effect of the residues from the various powders upon digestion now began to be taken up, and much attention was bestowed upon that aspect of the question in the various State Boards of Health and Government reports. Some comparative figures on the action of the various combinations have been published (*Pitkin, Journal Am. Chemical Soc.*, Vol. 12, 8) which seem to indicate that, in albuminoid digestion at least, there is little difference between the action of residues from cream of tartar and alum phosphate powders, while sour milk and soda also seems to exercise an almost identical inhibitory action. The basis upon which these results were obtained was a comparison of residues from neutralization of the same quantities of sodium bicarbonate—in other words, equal leavening equivalents of the residues were employed.

In glancing over a late Government Report (Food and Food Adulterants, Part 5th, Bulletin No. 13, p. 575) we find the following table :

Powders.	Carbonic Acid Gas. Per cent.	Total residue of the weight of Chemicals used. Per cent.
Tartrate	16.	104
Phosphate	22.	123
Alum	27.	128
Alum and Phosphate	17.	111

As will be seen at a glance the alum and the phosphate powders give the least residue per unit of gas evolved, while the alum and phosphate combination is credited with the greatest percentage of residue to carbonic acid. When it is remembered that it is upon the amount as well as upon the character of residues that attention is now specially directed, it is obvious that the ratio is a matter of no little importance.

One would naturally suppose that such a combination powder would be somewhat intermediate in its leavening action between the two classes to which it is related.

Looking over the report to see upon what data the figures quoted were obtained we find, p. 571 :

"A case in which the character of the powder appears to be improved by such mixing, however, is furnished by the alum and phosphate powders.

This combination seems to be a favorite one with manufacturers. In fact there are now comparatively few "straight" alum powders in the market, most of the cheaper grades being made of mixtures in various proportions of the alum with acid phosphate of lime, the reaction it is intended to obtain is probably the following :

$$\underset{\text{Ammonia alum.}}{\overset{475}{(NH_4)_2\,Al_2(SO_4)_4}} + \underset{\substack{\text{Acid phosphate}\\ \text{of lime.}}}{\overset{234}{CaH_4(PO_4)_2}} + \underset{\substack{\text{Bicarbonate of}\\ \text{soda.}}}{\overset{336}{4NaHCO_3}} = \underset{\substack{\text{Phosphate of}\\ \text{aluminium.}}}{\overset{245}{Al_2(PO_4)_2}} +$$

$$\underset{\substack{\text{Sulphate}\\ \text{of lime.}}}{\overset{136}{CaSO_4}} + \underset{\substack{\text{Sulphate of}\\ \text{aluminium.}}}{\overset{132}{(NH_4)_2SO_4}} + \underset{\substack{\text{Sulphate of}\\ \text{soda.}}}{\overset{284}{2Na_2SO_4}} + \underset{\substack{\text{Carbonic-}\\ \text{dioxide.}}}{\overset{176}{4CO_2}} + \underset{\text{Water.}}{\overset{72}{4H_2O}}$$

On page 567 in discussing phosphate powders, 234 parts of $CaH_4 (PO_4)_2$ is credited with the power of liberating 88 parts of carbon dioxide: on page 569, 475 parts of $(NH_4)_2 Al_2 (SO_4)_4$ liberates 264 parts of carbon dioxide, but by the equation used in discussing alum phosphate powders only half enough sodium bicarbonate is given to the above quantities of "acid phosphate" and burnt alum to liberate the 88+264 parts of carbon dioxide which they would separately set free.

We think the published analyses in the report conclusively prove that while the combination may be "a favorite one with manufacturers," they certainly do not intend to obtain the reaction with which they are credited. No such ratio is found to exist between the ingredients in a single one of the fifteen complete analyses of alum phosphate powders printed in the bulletin.

All baking powders lose more or less carbonic acid on keeping, depending upon the amount of moisture absorbed, quantity of "filler" present, length of time elapsing since manufacture, etc. It will therefore be advisable to examine the ratios between, for instance, the sulphuric anhydride and sodium oxide (both being proportionally increased by any loss in carbonic acid gas) called for by the formula and that found in actual analysis.

By the formula $(SO_3)_4$ corresponds to 4 Na or 2 Na_2O by weight 320 parts of sulphuric anhydride should be found for each 124 parts of sodium oxide or the ratio of SO_3 to Na_2O should be more than 2.5 to 1.

In the analyses we find:

No. 5510........So_3 = 9.79% Na_2O = 12.25%
" 5511........ " = 11.02% " = 12.58%
" 5512........ " = 11.57% " = 14.04%
" 5515........ " = 13.01% " = 9.83%
" 5516........ " = 12.26% " = 9.21%
" 5517........ " = 13.18% " = 8.33%
" 5519........ " = 8.78% " = 7.26%
" 5520........ " = 10.51% " = 11.92%
" 5521........ " = 11.54% " = 11.20%
" 5524........ " = 10.14% " = 10.87%
" 5525........ " = 8.93% " = 12.15%

No. 5530........ " = 10.57% Na_2O = 10.32%
" 5532........ " = 11.30% " = 11.36%
" 5533........ " = 10.66% " = 12.69%
" 5534........ " = 13.23% " = 12.29%

By averaging the above it will be seen that the percentages of sodium oxide and sulphuric anhydride are practically equal, instead of corresponding to the ratio demanded by the formula, nor is ratio of phosphoric acid to sodium oxide much closer to what is demanded. There is evidently a mistaken assumption therefore upon which the high ratio of residue to leavening power has been asserted of this class of powders, and the influence attaching to such an exhaustive report from such a source forms a sufficient excuse, I trust, for calling attention to the error.