THE EFFECTS OF NITROGEN-PEROXIDE ON THE CONSTITUENTS OF FLOUR IN RELATION TO THE COMMERCIAL PRACTICE OF BLEACHING FLOUR WITH THAT REAGENT.

By BENJAMIN MOORE, M.A., D.Sc., F.R.S.,
Johnston Professor of Bio-chemistry, University of Liverpool,

AND JOHN T. WILSON, M.D., D.P.H.,
Medical Officer of Health for the County of Lanark[1].

The process of subjecting flour to the whitening action of dilute nitrous fumes has grown so extensively during the past ten or twelve years, that it is estimated that more than half of the enormous amount of flour utilised for making bread and for other purposes is now bleached or tinted by this method. Yet none of this bleached or artificially whitened flour is sold to the public as such specifically, or marked by any distinctive label, to show that it has passed through a chemical process.

This is an extraordinary condition of affairs, and as the matter concerns one of the most important of all our foodstuffs, and indeed that one which especially forms a preponderating constituent in the daily diet of the teeming millions of poorer inhabitants in the country, the urgency of a national consideration of the whole situation becomes obvious.

It is about time that the question was asked, "Why is flour bleached in these enormous quantities and who benefits by the process, the miller,

[1] The experiments recorded in this paper were carried out in collaboration at the Johnston Bio-chemical laboratory of the University of Liverpool and at the laboratories of the County Council of Lanark, and were part of the evidence in the complaint heard in 1912 by Sheriff Shennan of Dr Wilson against Uddingston Co-operative Society, in which judgment was given for the defendants.

the baker, or the consumer, or do they all share in the benefits of bleaching?"

The question has very broad economic and public health aspects, when it is remembered to what a large extent infants over six months of age and our vast population of school-children rapidly growing and requiring the most nutritious and wholesome food that can be given to them, are brought up on bread and food prepared in various ways from flour.

The money spent annually by millers in setting up bleaching plant and sending flour through the bleaching process if spent instead upon the solution and applications of health problems would probably suffice to provide all the school clinics, open-air schools and medical treatment required by our growing population. Even if it cannot be proven clearly in our present state of knowledge that bleaching, as commercially practised, is directly injurious to the chief constituents of flour, or exercises a slow chronic injurious effect upon the young and growing animal organism, still if no positively beneficial effect of the bleaching agent upon the flour can be demonstrated which makes it a better foodstuff, then the large sum spent on bleaching can only be set down as a national waste which ought to be prevented on the grounds of national economy, if for no other reason.

Now, the supporters of the process of flour bleaching have not been able to produce one shred of evidence that bleaching renders flour a healthier or more nutritious foodstuff than it would be in its natural unbleached condition. The most that can be claimed here is that there is a popular demand for a white bread which better suits some aesthetic taste, so that bleaching enables the miller to produce for the baker a white flour yielding a white loaf which pleases the eye and secures a preferential market for the product. A uniformity of colour at different times of year is also said to be established, and power of better utilizing and finding a market for the flour derived from darker-coloured foreign wheats. These things do not however mean any intrinsic improvement in the nature of the foodstuff and by so raising more highly coloured flours to the level of naturally white first-class flour a manipulation of the market is set in operation, causing the appearance of more fictitiously white high-class flours, and, for this whiteness, artificially produced, millers, bakers and consumers amongst them must pay. It is a curious fact that the supporters of bleaching claim that bleaching does not enable the miller to obtain a better price for the bleached product, but only secures for him a better and a more uniform market. A little study of economics would soon teach those who advance such an argument that these two effects in the end amount to the same thing. A miller who cannot obtain a market must lower his prices, and if the lowering of his prices will not command a market, then the introduction of bleaching has gone still further than raising prices on behalf of those who do bleach, namely, it has spoiled the market for those who still persist in avoiding bleaching and wish to provide flour in its natural condition.

A miller is a business man, he is offered a process which will cost him roughly, say, one shilling per sack of flour to apply; if he takes up that process he will naturally expect to benefit by it to the extent, say, of one shilling and sixpence per sack in the flour he turns out. In the long run it matters little whether he uses his advantage to raise his price or to oust a rival from a market. When the market has adjusted itself, as it must do in a year or two, the cost of the bleaching must be found from somewhere, and either the millers and bakers are making less collectively, or the public is paying more for its bread, which means that the children are probably getting less. There is no escape from this economic position, and in the adjustment there is little doubt that a little of the imposed cost of bleaching, just like a tax, is borne by everybody along the line, from the sower of the wheat to the eater of the bread.

Before leaving the purely economic aspect of the question and passing to the action of the bleaching reagent on the flour, it may be of some interest to enquire briefly into the reason for this public fancy for white bread which is catered for by bleaching so as to give it artificially. An enquiry into its history will demonstrate two things: first, that the taste for the white bread had a reasonable and natural basis in the old purely mechanical process of milling before the introduction of chemical bleachers, and secondly that there is an intrinsic difference between first-quality white unbleached flour and the yellower second-quality flour now caused by bleaching it to simulate the former. This subtle difference is shown by the location of the oil. The difference cannot be clearly demonstrated by chemical examination of the constituents of the two qualities of flour, but microscopic examination demonstrates that the colour is an outward and visible sign of lack of ripeness in the endosperm, the oil and colour adhering to the younger, less completely developed granules, and it is for this reason that in the sifting or bolting process the whiter flour first separates at what is known as the head of the mill, and the yellower flour at the lower machines.

The wheat in the process of milling is passed through various sets of rollers of different grades, where in the earlier crushings the coarser offal is separated and the interior of the grain, or endosperm, is broken into coarse particles called semolina. In the later rollings the semolina is "reduced" or broken down by degrees into very fine powder and there are also present with it very fine microscopic particles of seed-hairs, epicarp and seed-coat.

These finely ground or rolled mixtures are passed after each rolling through a fine silk sieve or bolting, the portion which passes through being kept as a "stock" while that not passing through is sent on to the next machine. In this way a considerable number of "stock" fractions arise from the various machines and their attached sifters, which are numbered 1, 2, 3 etc. up to 12 or more, or in other cases as *A*, *B*, *C*, *D*, to *J*, or even *M*.

It may be mentioned that at the earlier stages of comminution of the grain it is not desired to crush the wheat grain completely. If this were done it would be difficult or impossible to separate the coarse offal from the fine part, and much of the valuable endosperm would be lost by it adhering to the offal. The first rollers are so designed and spaced that they only crack or *break* the grain and so yield coarse offal, as well as large or coarse particles of the flour-forming material.

In these first processes of breaking, however, small quantities of fine powder are unavoidably formed. These constitute the so-called "break" flours, and at various stages in comminution three or four "break" flours so arise in addition to the "stocks" mentioned above. These are poor products containing a good deal of microscopic offal, and a lesser amount of visible offal and unripe endosperm.

It has been necessary to give this brief account of the process of milling, because an understanding of the economics of bleaching turns upon it, and also the real differences between first and second grade flours are shown much more readily by following this process carefully than by any minute chemical examination of the various products. It also will become discernible, presently, what exactly bleaching has done for millers, bakers and the public.

When the products of the various sifting machines *A* to *J* are examined by the eye alone, it is seen that these become progressively yellower in colour, or "darker" as the miller usually calls it. The top machines give the highest commercial quality in colour and although they are the whitest and most devoid of colour, the miller calls it the "highest" colour, which has led to a good deal of confusion, and to bleaching being called "tinting" the flour, although in reality it is the removal of tint.

The art of the miller before the introduction of "tinting" or "bleaching" consisted in skilfully blending the products of these various siftings. He made what was called a "divide" and the "top of the mill" or products[1] *B* to *E* or *F* formed the finest, superfine or "patents" flour, and portions of these mixed with lower siftings formed "households" or "machine grades." The latter were of lower price, and were usually regarded as of lower quality. They might undoubtedly be quite nutritious, but were of coarser quality, just as pease-meal is most nutritious but less appetising than flour, cheaper to produce, and sells on the market for a lower price.

Now bleaching by removing the visible index given by the colour allows the miller to mix more of the product of the lower sifting machines with the upper and so obtain what is technically known as a "longer divide."

That this is so is shown by the advertisements of the "Flour Oxidising Co., Ltd.," who sell "tinting" or "bleaching" plant to millers, and as an inducement to purchase state *inter alia* in their advertisement[2]:—"The Corona[3] gives you a better flour divide." "The Corona lifts the colour of your residue."

There is also evidence given by microscopical examination which clearly shows that lower "stocks" or fractions are in commercial practice so lifted or raised in colour that they can be included in the higher or "superfine" portion of the divide.

But before passing to this the question may be discussed—Is there any difference whatever save colour between the "stocks" or siftings, *B, C, D,* and *E* to *J,* which formerly made the first regarded as "patents" and the second as "households," and was it solely due to a difference in colour that one was commercially more valuable than the other? An examination will we believe show that there were, and are, other differences, and that the artificial removal of the colour by the process of "tinting" or "bleaching" has taken away a valuable guide which assisted the baker, or consumer, in purchasing a high-grade flour.

First, it may be asked, why do the top machines separate from the

[1] The product of the first machine *A* after the "Break" machines is not so good as *B*, *C*, *D*, which are regarded by millers as yielding the "cream of the wheat." Since this difference depends on other matters than colour and does not concern flour bleaching, the consideration of this point need not be entered on.

[2] *Milling*, Jan. 13th, 1912. [3] The nam of the plant.

crushed grain a white product, and the lower machines a yellow product? The meshes of these silk sieves have no eyes to see colour and so would allow to pass indiscriminately a white or yellow powder. It is not the whiteness or yellowness that separates the fractions *A* to *J* as the grain is rolled down to flour, but the colour follows some difference of a physical character in the component parts of the mixed product from the crushed wheat. These component parts must differ physically in size or form or other property, which gives them greater or lesser facility for passing through the sieve. The colour properties are correlated to these properties which the sieve picks out, and so the colour is only a visible indicator of other differences between the first and second qualities. Removal of the colour will therefore disguise these other differences and render them invisible, but the separation in the sifting processes show they exist. Why else should there be a separation? It is absurd to claim that the products of the upper and lower machines differ only in colour, for that alone could not give passage to one particle through a sieve and refuse it to another.

A careful microscopic examination of the products of the different machines *A* to *J* discloses the cause of the separation and the intrinsic differences between first- and second-quality flours.

A minute quantity of each fraction or "stock" of flour is taken, mixed with a drop of water, and examined under the microscope. A cursory examination shows quantitatively the same main constituents in each case, but the *qualitative* distribution of the constituents differs progressively as the mill products are followed down, and a careful examination reveals that the ripest and best products of the endosperm are contained in *A* to *D*, and that the unripe, only partially developed, portions of the wheat appear in increasing quantity from *E* onward. "Tinting," by removing the colour index, allows the unripe to be mixed with the ripe and fully developed particles. In addition, while vegetable hairs and microscopic fragments of epicarp are practically absent from *A*, *B*, *C* and *D*, these commence to appear about *E* and are found in increasing quantity as the mill is descended from *E* to *J* or beyond. These, unlike the colour, are not removed by bleaching and form a valuable index as to whether by the aid of "tinting" first and second qualities have been mixed for the market.

The microscopic examination thus reveals in an interesting way why the various products have separated in the process of sifting and amply confirms the reasoning above that it is not colour that causes them to separate, but other intrinsic differences.

The chief objects seen when mixed flour, as sold, is examined under the microscope, are large numbers of ripe fully-formed starch granules and smaller numbers of incompletely developed starch granules. Both of these are separate from anything else as round particles like microscopic pebbles; then there are agglomerations of tissue from the wheat cells containing minute granules of starch and oil. The masses containing these minute granules are much larger than the individual ripe starch granules existing separately. They vary enormously in size and shape and are irregular in form. They have the appearance of cell debris crushed out of shape and adherent. It is quite obvious on looking at them that these masses would have more difficulty as a rule, especially when they are larger, in getting through the mesh of a sieve.

Now, on making a microscopic examination separately of the various "stocks" or fractions from *A* to *J*, while these constituents are plentiful in all the fractions, there is a greater preponderance of the ripe starch granule in *A* to *D*, while more, comparatively, of the cell debris, with its unripe granules embedded in it, is found in *E* to *J*.

The *colouring matter* of the flour is contained in the small amount of oil present in the cellular matter, and hence the oil and the colour distribution follow the unripe material. Ripe starch granules predominate in the stocks from the higher machines which are thus poorer in oil and accordingly less coloured. It is therefore easy to see why the ripe starch granules predominate accompanied by lighter colour in the part which passes more readily through the bolting sieves, and why the cellular debris and less ripe part accompanied by the colour predominate in lower machines.

In addition to these differences in the relative distribution of the chief constituents of the flour, it is also observable that seed-hairs, small fragments of epicarp and of seed-coats, on account of their form, tend to be retained by the sieves, and passed on to the next machines, so that while the fractions of *A*, *B*, *C*, and *D* of the top of the mill are practically free from them, they occur in increasing abundance in the lower fractions *E* to *J*.

These microscopic particles are not changed by the bleaching process and hence may be utilized to determine how a given flour has been blended, in spite of any bleaching, or "tinting," which may have been employed either upon the lower fractions or the blended flour as a whole. In this way also a really top-grade flour may be distinguished from a lower grade bleached product.

At our request Dr J. Hume Patterson[1] made a microscopical examination of the "stocks" from the separate machines of the mill which are blended to form commercial flours. Dr Patterson also devised a method for counting the numbers of hairs, epicarp and seed-coat particles in these, and in various commercial flours, based on the same principle as that used by the physiologist for counting blood corpuscles, and by the bacteriologist for counting bacteria in a culture.

His results, which are reproduced in the accompanying tables, clearly show how these particles increase in numbers in the lower grade machines, and also the interesting and important fact that artificial "tinting" can be utilized to blend lower with higher grade flours, and so "give a better divide" as the Corona advertisement has it. It is certainly a better divide commercially for the miller, whether it is also a better divide for the baker and consumer is another question.

The method of enumeration consists in weighing out three milligrams (or 0·003 gramme) of flour, dividing this into five portions on as many microscope slides, wetting with water, covering with cover slips, and then counting under the microscope the numbers of hairs, epicarp and seed-coat particles in the five slides. The numbers given in the tables are those actually counted. To obtain the corresponding numbers in one gramme of the flour, these must be multiplied by 1000 and divided by 3, since 3 milligrams are taken.

TABLE I. *Numbers of microscopic offal particles in the different machine fractions or "stocks" from a milling of wheat contained in 3 milligrams of each stock.*

Machine	Hairs	Epicarp	Seed-coat	Total
A	Nil	Nil	Nil	Nil
B	,,	,,	,,	,,
C	,,	,,	,,	,,
D	5	,,	,,	5
E	7	,,	,,	7
F	13	5	,,	18
G	18	26	,,	44
H	25	26	,,	51
Break (1, 2, 3)	28	24	3	55
Break (4)	38	30	13	81

The value of the method was next tested by applying it to the investigation of the "first" or "superfine" and the "second" or

[1] Bacteriologist to the County Council of Lanark.

"standard" quality of four well-known commercial brands of flour. The trade names of these are not given here, they are simply indicated by four numbers.

TABLE II. *Differences in first and second quality flours.*

Flour		Hairs	Epicarp	Seed-coat	Tota
No. 1	First	1	Nil	Nil	1
	Second	39	13	5	57
No. 2	First	Nil	Nil	Nil	Nil
	Second	75	13	1	89
No. 3	First	6	Nil	2	8
	Second	22	7	1	30
No. 4	First	Nil	Nil	Nil	Nil
	Second	23	10	7	40

This table shows clearly the difference between first- and second-quality flours. The information so obtained was turned to the investigation of reputed first-grade superfine or patent flours obtained from mills where no "tinting" is used, and from mills where bleaching was known to be carried out, or where the higher content in nitrites suggested that the flour had been "tinted" or artificially bleached.

TABLE III. *Unbleached first-grade flours.*

Flour	Hairs	Epicarp	Seed-coat	Total
No. 1	Nil	Nil	Nil	Nil
No. 2	1	,,	,,	1
No. 3	2	,,	,,	2

All three of these flours are obviously shown to be *true* first-grade by this test.

TABLE IV. *Bleached first-grade (?) flours.*

Flour	Hairs	Epicarp	Seed-coat	Total	Nitrites per million
No. 1	Nil	Nil	1	1	0·98
No. 2 *a*	23	18	13	54	3·4
No. 2 *b*	20	12	3	35	4·7
No. 2 *c*	10	12	3	25	3·8
No. 3	17	6	2	25	3·8
No. 4	10	Nil	3	13	2·8
No. 5	18	8	11	37	1·2
No. 6	10	12	10	32	3·7
No. 7	13	5	10	28	2·1

Out of these seven brands of flour all of which are well known commercially, *and sold as first-grade flours*, it is evident that the first one alone is really a high class flour. The others had evidently been prepared from a very "long divide" by including products of lower machines which would have been impossible before the introduction of bleaching.

Dr Patterson sums up the results of his examinations as follows:—"The lower grade qualities are both higher in yellow colour and contain hairs, epicarp and seed-coat particles. The bleaching removes the colour of the mass of lower grade material as a whole, but these particles are left unaltered and form a guide to the microscopist that the admixture has been disguised to the naked eye, and to a simple lens, by the bleach. It is not claimed that the offal particles are bleached, but that they form an invariable accompaniment of lower grade yellow coloured flour which must be bleached before it can be added to the rest of the flour. Hence either a high quality bleached or unbleached flour does not contain such particles, but a low quality flour bleached to represent a high quality flour does contain these particles, and my experience is that the majority of so-called high class bleached flours on the market are flours which are mixtures and would be low grade without bleaching."

If these differences revealed by the microscope really do exist between first and second qualities of bleached flour, and if examination of so-called "first" qualities of bleached flours now on the market reveals the fact that these are in reality mixtures of first and second qualities, the question arises, in the interests of the public, whether legislation ought not to be introduced compelling the open labelling and selling of such flours as "Bleached Flours."

The demand for white flours had its origin in the fact that originally, *before* bleaching was introduced, the white flour represented the "cream of the wheat," and that which possessed the better flavour and baking qualities, and this has recently been attested on oath by competent bakers.

There is also little question that the majority of bakers and other competent judges would say that bread baked from first quality or "patents" was better than that baked from an entirely "household" quality. This proves that in the unmixed condition there is really a superiority in the first quality and one resting on other factors than colour. This must also hold in comparative degree between varying mixtures of first and second qualities, that is to say the more first quality and the less second quality there is in a given blended flour the more valuable that flour must be. Now, on the admission of the advertisement, the bleaching process allows more second quality to be mixed with first quality. Bakers and the public are entitled to know that this increased admixture of second quality is being made in a given case by an artifice.

The case cannot be met under the existing Food and Drugs Act, which only provides that the article supplied shall be of the nature, substance, and quality of the article demanded.

This legal point was pressed in the case tried at Hamilton, and witness after witness was asked, and pressed to answer, whether he regarded bleached flour as "genuine flour" and as to whether it was anything else but "flour."

The real point is, that there are various qualities of flour, and that one quality should not be treated artificially so as to simulate another, without being branded as having been so treated.

The question is a serious one, because bleaching is becoming so universal that the decreasing number of millers who attempt to supply unbleached flour only are placed at a disadvantage, and the public as a whole are unaware of the true state of affairs. A precedent for legislation outside the provisions of the principal Food and Drugs Act exists in the case of butter and margarine, where two Acts of Parliament have been passed, one controlling the sale of margarine, and the other the conditions of manufacture and importation of butter, margarine, and milk-blended butter and admixture of margarine and butter.

It is almost universally admitted that margarine is a good and wholesome food, perhaps as much so as butter, but it is a much *cheaper* food than butter, and ought not to be admixed with butter and sold as "butter." Yet this could be done, and actually was done on a large scale, until adequate legislation was introduced for the prevention of the practice. Margarine must now be sold with a label on it, and handed to the customer labelled as such. In addition, in order to preserve it absolutely distinctive as a cheaper food, and to enable the analyst to follow the matter up, it has been enacted that not more than ten per cent. of butter fats shall be added to margarine. In this way the public are protected both in the sale and manufacture of margarine.

The case of flour presents many analogies, the only difference being that both "superfine" or "patent" and "standard" or "household" flour are manufactured from wheat, while margarine is made from other fats than those of milk. But the difference is only a superficial one, for

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chemically these other fats are the same, as to over 95 per cent. of their mass, as the fats of milk. They are also just as nutritious, and the main differences are colour and flavour, just as they are between the two qualities of flour, and the breads made from them. Curiously enough, the aesthetic tastes in colour are the opposite way round in the two cases, the yellow colour is desired in the butter, and is a disadvantage in the superfine flour, and to add to the absurdity it is the *same* colouring matter in the two cases, a substance called "carrotene," soluble in oils.

Now, second-quality flour is a good and nourishing food just as is margarine, but that is scarcely a sufficient reason why it should be bleached, mixed with first-quality flour and the whole sold as first-quality flour.

This is precisely what was being done with margarine and butter previous to legislation, the only difference being that the same colouring matter was being put in instead of being bleached out.

The excuse moreover was the same, the satisfaction of a public aesthetic taste, and it may be added that it is less questionable to add an undoubtedly harmless vegetable colouring matter like carrotene than to bleach that same harmless colouring matter out with a chemical agent which in fairly small doses possesses marked injurious effects. It is a disputed point in the matter whether the small amounts of nitrites developed in the flour in the bleaching process are, or are not, actually harmful, and it is practically impossible at present to settle the question one way or the other. But no one has ever claimed that they do any good, and in our present state of knowledge it would certainly be better to leave them out and allow the harmless and possibly beneficial carrotene to remain in.

For example, recent advances in medical knowledge have taught us clearly that an important disease, called beri-beri, common in eastern countries amongst those sections of the population who subsist almost wholly on rice, is due to the removal of quite minute traces of substances in the outer layer of the rice grain which are a necessary constituent of the food. The individual who is better off and can afford to eat a varied diet can eat polished rice with impunity because he obtains this necessary constituent from other sources in his varied diet, but the poor coolie, if he substitutes an almost entire diet of polished rice for his less aesthetic "paddy," which contains portions of the outer layer attached to the endosperm, often suffers from beri-beri.

We do not as yet know whether carrotene may not possess an important function in a very restricted diet. It is closely allied to, if not identical with, a yellow pigment found in the blood serum and in nearly all the cells of the blood. It is found in the majority of the foods we eat on a mixed diet, and so the person who can afford a liberal and varied diet can afford to dispense with it in his bread. But in milk it is only present in the fats or cream globules, and when it is remembered that the children of the poor in our community are largely brought up on milk impoverished in fat, and upon bread, it is questionable whether we do wisely in allowing the carrotene to be bleached out of the flour from which their bread is to be made.

Knowledge is imperfect in these matters, and, until it is more complete, artificial interference with a staple food supply and its treatment for commercial purposes with chemicals, should be scrupulously watched and guarded.

It is interesting to observe in regard to legislation what has been done in other countries, and we may note here the action taken by one of the greatest flour producing countries of the world, the United States of America.

The following is a statement of Food Inspection Decision[1] (No. 100) issued by the Board of Food and Drug Inspection of the United States Department of Agriculture, December 10th, 1908 :—

"Flour bleached with nitrogen peroxide[2] as affected by the Food and Drugs Act of June 30th, 1906, has been made the subject of a careful investigation extending over several months.

"A public hearing on this subject was held by the Secretary of Agriculture and the Board of Food and Drug Inspection, beginning Nov. 18th, 1908, and continuing five days. At this hearing those who favoured the bleaching process and those who opposed it were given equal opportunities to be heard.

"It is my opinion, based upon all the testimony given at the hearing, upon the reports of those who have investigated the subject, upon the literature, and upon the unanimous opinion of the Board of Food and Drug Inspection, that flour bleached by nitrogen peroxide is an adulterated produce under the Food and Drugs Act of June 30, 1906;

[1] This Decision seems still to be in force, but on account of the result of the legal proceedings in a case brought before the Courts in June, 1910, it is meantime practically in abeyance.

[2] It is now admitted, whether produced electrically or not, that the bleaching agent is nitrogen peroxide although, so late as Jan. 1912, the Flour Oxidising Co., Ltd. claimed in their advertisement that "The Corona produces electrified air of the finest quality." "The Corona is a natural process—only the elements (electricity and air) are used." *Milling*, Jan. 13, 1912.

that the character of the adulteration is such that no statement upon the label will bring bleached flour within the law; and that such flour cannot be legally made or sold in the District of Columbia, or in the Territories, or to be transported or sold in interstate commerce; or be transported or sold in foreign commerce except under that portion of Section 2 of the law which reads:

".........*Provided*, That no article shall be deemed misbranded or adulterated within the provisions of this Act when intended for export to any foreign country and prepared or packed according to the specifications or directions of the foreign purchaser, when no substance is used in the preparation or packing thereof in conflict with the laws of the foreign country to which said article is intended to be shipped.........

"In view of the extent of the bleaching process and of the immense quantity of bleached flour now in hand or in process of manufacture, no prosecutions will be recommended by this Department for manufacture and sale thereof in the District of Columbia or the territories or for transportation or sale in interstate or foreign commerce, for a period of six months from the date hereof."

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D.C., *December* 9, 1908.

In other words, bleached flour is not to be supplied under any conditions to the American citizen, but can be sent abroad to those foreign countries whose laws allow it to be dumped upon them—of these, our own country is one. In contrast to this pronouncement is the judgment of Sheriff Shennan in the case heard at Hamilton, Lanarkshire, at the instance of the County Council of Lanark.

The decision given was in favour of the defendants, although Sheriff Shennan found that the flour in question had been bleached by nitrogen peroxide, and the conclusion of his summing up may be quoted:—"As I stated at the outset, this is not a matter of pure science. My natural sympathies are all with the prosecution. I do not see why these artificial changes should be produced in articles of food for aesthetic reasons. I appreciate the medical stand-point that where there is even the apprehension of danger because you are working with materials which under certain circumstances may produce noxious results, such processes should be prohibited. But such operations do not necessarily involve an offence against the Sale of Food and Drugs Act. My decision here is not based on the smallness of the amount used. As

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was pointed out, an infinitesimal amount of formalin will produce deleterious chemical changes in milk. My judgment is rested in this, that adequate proof has not been tendered of deleterious results due to bleaching the sample of flour before me. I am afraid I must hold that the prosecution is based on apprehended evils rather than on proved deterioration. It will not do for the purposes of a prosecution to argue that the process should be prohibited, unless it can be proved that the effect is noxious. That would be an excellent argument to address to the legislature, but in these proceedings the Prosecutor must prove his case. I sympathise with the spirit which has induced the prosecution, and possibly its purpose may to some extent have been effected by the resulting publicity. But I come without any hesitation to the conclusion that the contravention alleged has not been proved."

The contravention alleged was that of the Section in the Act stating that "no person shall sell to the prejudice of the purchaser any article of food or any drug, which is not of the nature, substance, and quality of the article demanded by the purchaser." The failure of the Prosecution turned on not being able, with the quantities of nitrogen peroxide used commercially, to demonstrate unequivocally alteration in nature, substance or quality coming within the meaning of the Act.

The point of quality being inferior is discussed by the learned sheriff, who points out that there is no fixed standard for flour, and also that it had not been proved that the sample in question was of an inferior quality to that demanded. His Lordship was also of the opinion that other qualities of the different flours than colour appearing in the baking and use of the bread would in the general case prevent the substitution of lower for higher grades.

There is, however, here the direct evidence of Dr Patterson from the microscopic tests that in a large number of cases bleached flours sold as first-grade are in reality admixtures with second-grade. This, however, was held to be only general evidence, and it was not accepted as proven that the particular flour in court was of an inferior grade.

The question before us now in this paper is not that of a particular flour, but the question of whether in general the bleaching process allows lower priced grades to be mixed with higher, and on this point there exists not only the evidence of Dr Patterson, but the admission of the advertisers of the process themselves that bleaching gives the miller "a longer divide," which in plain English means enables him to admix more lower priced products into his superfine flour.

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The present Food and Drugs Act does not touch this position, because this mixture is still "flour" and held to be "genuine flour," and as to its being "superfine flour" that again is a variable standard. The only way the public can be protected against this artificial interference with a natural standard is by new legislation, enacting two things. First, the proper labelling of bleached flour, and secondly, the regulation of the manufacture and bleaching of flour, in the same way as the manufacture of margarine is now regulated. If this were done, it would be quite certain that no bleached superfine flour would be manufactured in future, because with its label on it could not compete with the natural "cream of the wheat," and secondly, that portion of the British public which required whiteness in a lower class product would soon realize that it was obtained by artificial bleaching, and if it still used it from a desire to ape the superior article would do so knowingly, and not in ignorance as at present.

The contention that there are other differences between superior and inferior flour which appear in the baking and in the flavour and quality of the bread, and can act as a natural remedy against substitution of the inferior for the superior after bleaching, is not a valid contention against the introduction of protective legislation. Otherwise, if the superior article can stand on its own merits, there would be no need for legislation whatever, and all work against adulteration of food might forthwith be suspended.

Butter has superior qualities in the cooking, and flavour in eating, as against margarine, yet before the introduction of special legislation in this instance, margarine and butter were mixed and the product sold as butter, and the public were deceived in the matter and paid more than the proper value.

In an exactly similar manner, if our evidence given above is worthy of credit, inferior priced flour is mixed with more expensive flour, the product bleached before or after admixture, and the mixed product is sold as "superfine flour," "patents" or "firsts" and at the price of these dearer commodities.

In our opinion, therefore, and on a purely economic basis, there never was a clearer case proven for special legislation in the public interest.

Finally, it may be added that allowance here of artificial interference with this most important of our foodstuffs opens the door to other artificial chemical treatments of foods on the pretext of bettering them and catering for the public taste.

This is shown by the more recent introduction of chemical "improvers," which are now being added to flour in a wholesale fashion all over the country. This question is at present perturbing the whole milling and baking industries, although it has not yet come to wide public knowledge.

We have recently examined several samples of commercial flours which were found to contain as much as ten ounces of added "acid phosphate" to the sack.

The excuse is that a better "rising" flour is obtained in this way, so yielding from the same quantity of flour a larger loaf or scone. It is said by those who have "improvers" to sell, that addition of "acid phosphate" only gives in "weak" flours, that is those which rise poorly, the same good natural qualities that are found in good, naturally strong, flours. It is claimed that the substance added is one always present in wheat which happens to be deficient in the "weak" flours. This argument strongly recalls that of those who bleach flours, namely, that nature is only being imitated by an artificial ageing brought about by the bleaching, and that all that is being done is the hastening of a quite natural process.

Even if these statements be accepted—and they are highly questionable in both cases—does it follow that these artificial products should be sold as the natural articles? The commercial problem is here undoubtedly that of obtaining a higher price for a naturally lower-priced article by adding or taking away something which distinguishes the two. If this is to be allowed at all, the process ought to be publicly known and recognized, and the artificial product should be properly labelled and branded in a distinctive way. Also, if there be, as there undoubtedly is, danger of excess in the matter, the process of manufacture should be properly supervised and regulated by law, as is done in other similar cases.

Chemical Alterations in Flour caused by the Bleaching Agent.

Nitric oxide (NO) has no bleaching action upon flour, it only acts after it has taken up oxygen and formed nitrogen peroxide (NO_2). This gas in presence of water decomposes and forms nitrous and nitric acids in equi-molecular proportions. The bleaching probably arises from the action of the nitrous acid upon the colouring matter, carrotene, of the flour. This substance is present only in very small quantity. It is present in less amount than is sufficient to react with the whole of the nitrogen peroxide used commercially for bleaching, although that is also but a small quantity. As a result it follows that the excess of nitrogen peroxide, or the nitrous and nitric acids formed by the action of water in the flour upon it, must combine with the organic and inorganic constituents of the flour to form nitrites and nitrates.

In commercial bleaching an amount varying from one-third up to nearly all the colour is bleached out, according to the market for which the flour is intended. The recent work of Monier-Williams proves that with a strength of bleach removing about one-third of the colouring matter, not more than one-fourth of the nitrogen peroxide employed unites with the colouring matter, the remaining three-fourths must accordingly unite with other constituents of the flour.

This has been an important point to settle, as it now has been settled by these important experiments of Monier-Williams, for it was actually contended by experts examined in the trial at Hamilton, that the colouring matter alone was attacked by the nitrogen peroxide added, and that the other constituents were left entirely unaltered. This view was accepted by the court although it is contrary to all chemical theory.

When any active chemical substance is added to a mixture of several ingredients upon which it can act, it is a well-known and universal application of the fundamental chemical law of "Mass action," that the active agent will react, and distribute itself amongst these several ingredients in proportion to the product of its affinity for each and the amount of that constituent present, and it would be a breach of all chemical law that when present in insufficient quantity to satisfy all of them, it should unite exclusively with one and leave all the others wholly untouched. This however was argued in court and accepted by the court, and undoubtedly produced an effect in the finding arrived at.

It is necessary in order to study effectually the action of nitrogen peroxide upon the other constituents of flour, such as the proteins and fats, and to obtain definite workable alterations, to employ considerably larger quantities of nitrogen peroxide experimentally than are commonly used commercially.

This is a perfectly legitimate proceeding, quite valid in scientific work and one which has been used in other cases of the addition of noxious or poisonous substances to foodstuffs. For example, the deleterious action of formaldehyde upon foodstuffs can only be demonstrated with many times larger amounts than would be allowed in any article of food.

Yet this method was discredited as a " method of exaggeration " by the learned sheriff (quoting a witness for the defence) which could not legitimately be used as a process of proof.

The inference of the prosecution, on the other hand, was that the chemical methods of detection of change in these constituents (proteins and fats) were not sufficiently delicate to demonstrate them at the level of commercial use of nitrogen peroxide, but that they could be demonstrated clearly at higher amounts of nitrogen peroxide (although still small amounts), and therefore the logical inference was that they occurred in diminished degree with the smaller quantities. Probably few chemists would dispute this inference.

It was claimed, however, by the defence that a chemical substance at high dilutions often acts differently from its action at greater concentrations, and hence it might be, that at the very high dilution of chemical bleaching of flour the nitrogen peroxide acted only on the colouring matter, and left the other constituents quite untouched. In fact, figures provided by prosecution witnesses were extra-polated down to weaker concentrations, in an attempt to prove that this actually occurred.

The case selected by the defence to illustrate the fact that a substance may have different actions at different dilutions was a very curious one. It was claimed that the charring of sugar by strong sulphuric acid which does not occur with diluted acid was a parallel case, and this was apparently accepted by the court.

There is, however, nothing in common between the two types of reaction. The concentrated sulphuric acid acts when free from water as an energetic dehydrating agent, and when previously supplied copiously with water it obviously cannot have this action. Neither at the commercial bleaching strength, nor at that used in the experiments produced in proof by the prosecution, has nitrogen peroxide such an action, and in both concentrations nitrogen peroxide is being used as a highly diluted reagent. The true parallel would have been that of two different but high dilutions of sulphuric acid upon cane sugar, as compared with two different high dilutions of nitrogen peroxide upon flour. Diluted sulphuric acid has, as is well known, an effect upon cane sugar, in that it hydrolyses it into dextrose and laevulose, and no one has ever claimed that at a certain point, short of zero, this *entirely* ceases, which is the claim put forward in the case of nitrogen peroxide and flour.

In view of this point it is exceedingly interesting that the more recent experiments of Monier-Williams have now clearly demonstrated that the greater part of the nitrogen peroxide is actually taken up by other constituents than the colouring matter. In fact, in order to reach the colouring matter at all, as was pointed out in court, the nitrogen peroxide must first be absorbed by the oil of the flour in which the colouring matter is dissolved. For this oil it possesses a high affinity and it is unthinkable that some of it should not combine with the oil.

The so-called "method of exaggeration" is accordingly a perfectly valid one to employ for studying the reaction of the flour constituents to the bleaching reagent, and one which is often used in other cases of similar study, and it may logically be assumed that these changes, although of course in lessened amount, occur to these constituents in the commercial process of bleaching.

By the use of these methods it is found that the chief constituents altered are the colouring matter, the fats, and the proteins, and these will now be separately considered.

Changes in the Colouring Matter.

The colouring matter of flour belongs to a class of yellow coloured pigments which are very closely related chemically and are found widely distributed in both the plant and animal kingdom. These yellow pigments are known as "luteins" or "lipochromes," and chemically they are highly unsaturated compounds, which form colourless addition products either with oxygen or nitrogen peroxide. The latter substance does not appear simply to oxidize them catalytically, but to form addition compounds with them. This is an important point since it shows that artificial bleaching and slow oxidation in the air are essentially different processes, as will be pointed out later.

The yellow pigments of this group are insoluble in water, but are soluble in oils, and in protein containing solutions such pigments are present in the animal kingdom in egg-yolk, blood serum, body fats and milk fats, and all oils of animal origin. In the vegetable kingdom they occur in all vegetable fats, flowers, seeds, fruits, and many other plant tissues.

One of the commonest "luteins" or "lipochromes" is the substance called "carrotene," from having been isolated in pure condition from the carrot (*Daucus carota*); it occurs in many seeds, fruits and flowers. The amount of colouring matter in flour is excessively small, amounting according to Monier-Williams in unbleached flour to only two parts in a million or less, and for this reason it is impossible to separate workable quantities from flour, but a close comparison of the two absorption spectra as carried out by Monier-Williams clearly shows its identity with carrotene, and spectroscopic and colorimetric comparisons with pure carrotene solutions enables its amount in flour before and after bleaching to be determined with accuracy.

By the use of these methods, Monier-Williams found that flour before bleaching contained 1·4 to 2 parts per million of carrotene and after the degree of bleaching used for the London markets contained 0·9 to 1·3 parts per million, so that roughly one-third of the carrotene was decolourized by the bleaching process. The increase per million in nitrites after bleaching amounted in these cases to about 1·2 parts per million, and as the quantity required for combination with the bleached carrotene only amounted to approximately 0·33 part per million it becomes obvious "that only a small proportion of the nitrogen peroxide used is concerned in the actual bleaching."

When flour is exposed to the air in thin layers, it takes up considerable amounts of nitrites and at the same time becomes whitened, though never so much so as when bleached with nitrogen peroxide, although the amount of nitrite acquired, especially in a vitiated atmosphere, may be considerably more than after moderate bleaching with peroxide. For example, experiments made in connection with the Hamilton case showed that thin layers exposed for some weeks acquired no less than 11 parts per million, calculated as sodium nitrite.

It is important to consider this air effect carefully, because of the argument that nitrogen peroxide bleaching is the same as natural air bleaching. The evidence may therefore be briefly summarized.

1. Flour can be whitened in pure air, without increase of nitrites, and Monier-Williams has shown that carrotene exposed to air bleaches with uptake of oxygen and without acquiring nitrite. Moreover, when carrotene is bleached with nitrogen peroxide, the colourless product produced is an addition compound with nitrogen peroxide and not one with oxygen, so differing essentially from the natural oxidation compound formed in air.

2. When flour is allowed to stand in air the bleaching effect is much smaller than corresponds to the nitrite uptake as shown by the experiments of Thomson made in the Hamilton case.

3. There is no evidence that free nitrogen peroxide exists in air. The rain water even of town districts is alkaline in reaction and there is always more than enough ammonia to neutralise any acids present,

so that there is no evidence that the nitrite taken up is taken as nitrogen peroxide, or produces any bleaching effect. All the tests employed and supposed to show nitrogen peroxide in air would be given equally by traces of combined nitrites, or by ozone. So that there is really no valid evidence of nitrogen peroxide bleaching by exposure to the atmosphere. On the contrary pure carrotene exposed to the air in samples at London (and even at Widnes, Lancs.) by Monier-Williams showed not a trace of nitrite to the most delicate reagent (Griess-Ilosvay reagent) even after two months exposure, and did not contain nitrogen in any form.

Although this increase of nitrites on exposure to air has nothing in all probability to do with natural bleaching, it is important, in regard to judging from the nitrite content, whether the flour has been bleached in any given case. The amount taken up will be increased when the flour is exposed for sale in small packets but even then it is only a skin-layer which is affected, and it is probable that anything under commercial conditions lying above one part per million calculated as sodium nitrite indicates artificial bleaching. The figure is placed somewhat higher by Monier-Williams, namely at 1·5 to 2 parts per million, and from the large series of figures accumulated by Clark, and by Thomson, each independently checking the other, it may be said that this is really a maximum limit.

It scarcely needs pointing out, however, that the effective legal check would be a prohibition, or regulation, of bleaching at the mills, much more than relying on after-detection in purchased samples, where legal points can be raised over period and manner of storage, so that much vexatious litigation might be produced by using any arbitrary standard.

Moreover, as shown both by our own experiments and those of Monier-Williams, the nitrite content of highly bleached flours decreases, while that of unbleached flours increases, which again interferes with the setting of a standard maximum allowable content of nitrite.

It is the process of bleaching and all it involves which requires regulation, the amount of nitrite while an important matter in itself is secondary to this.

Effects of Nitrogen Peroxide on Oils or Fats.

Unsaturated fats and lecithins combine with nitrogen peroxide with great avidity to form addition compounds containing nitrogen. The gas is rapidly absorbed by the oils or fats in the cold, and a very large volume can be taken up. The properties of the fats and oils are entirely changed in the process, as is shown by the following experiments:—

Experiment I. A quantity of olive oil, weighing 18·1 grammes, was introduced into a Winchester quart bottle, provided with a double bored rubber cork and exhausted of air. Nitric oxide gas (NO) and oxygen in the proper proportions to form nitrogen peroxide (NO_2) were then admitted, and the peroxide was found to be absorbed almost as soon as formed, until about 3870 c.c. of nitric oxide and 1850 c.c. of oxygen had been taken up. The oil acquired a green colour from dissolved nitrogen peroxide, in addition to that chemically combined, but on removing the altered oil, and heating the mixture, the dissolved peroxide was driven off leaving a pale yellow product. The physical properties were changed from those of olive oil to a thick viscid semi-solid mass. The weight had increased by approximately four grammes. The oil constants of this addition product were determined when the following changes were found:—saponification value = 325, that of the olive oil being 184; iodine value, less than zero, that of the olive oil being 87. This effect of an apparently negative iodine value arose from NO_2 set free having decomposed potassium iodide in the titration, for the control required 20·5 c.c. of thiosulphate solution, while the altered oil required 22·3 c.c.

It is thus obvious that the reagent used in flour bleaching is one which attacks and completely alters oils, and this to a small extent must occur in commercial bleaching, although it cannot be directly detected. The effects of continued uptake of minute quantities of organic nitro-bodies is unknown, and it would be difficult, or even impossible, to demonstrate such effects of continued use of small amounts, but it is known in pharmacology that organic nitro-bodies, such for example as amyl nitrite and nitro-glycerine, are most powerful agents.

Experiment II. A quantity of lecithin prepared by the usual methods from egg-yolk, and weighing 20·7 grammes, was similarly saturated with nitrogen peroxide, and took the gas up greedily. The weight increased from 20·7 to 23·6 grammes and the semi-fluid lecithin had changed to a solid substance. The original iodine value of the lecithin was 77·5, and this changed to 16·6, showing that nearly all unsaturated groups had become occupied by peroxide of nitrogen, and that the lecithin had become nitrated. The saponification value, which had been 276, changed to 341. Thus, again, the lecithin like the olive oil has been profoundly changed by the bleaching gas.

Experiment III. In this experiment a flour known to be unbleached was taken. This flour was guaranteed by the millers to be unbleached and this was also attested by its low content in soluble nitrites as shown by the Griess-Ilosvay test, namely 0·3 part, as sodium nitrite, per million. Bleaching operations were carried out on this flour by introducing known quantities into the Winchester quart as described above, and then bleaching with known volumes of nitrogen peroxide gas to the kilogram of flour. Bleaches were used of 20 c.c., 30 c.c., 100 c.c., and 4500 c.c. to the kilogram of flour, the latter high quantity being used to develop the full effect of nitrogen peroxide on the flour, and clearly demonstrate its nature.

The results shown below indicate that the smaller amounts only differ in degree of action from the larger quantities, and qualitatively act in the same fashion.

After bleaching the flour, the fats were extracted from weighed samples of each degree of bleaching, by thorough extraction with ether, and the constants determined in each case, as well as the percentage of nitrogen. The results are shown in the following table :—

Constants of flour-oils before and after bleaching.

	Bleach per kilogram	Nitrogen, percentage	Iodine value	Saponification value	Free fatty acid, percentage
1	Unbleached flour	0·68	111·4	200	10·8
2	Bleached with 20 c.c.	0·74	107·4	174	9·9
3	,, ,, 30	0·82	96·5	155	8·5
4	,, ,, 100	0·97	85·8	162*	7·6
5	,, ,, 4500	1·26	82·5	245*	28·5

* These subsequent rises in saponification value with high degrees of bleach are due to nitrous acid in previous combinations with the fat being split off and neutralizing alkali.

Regarding colour of the extracted fat this is orange yellow in the extract from the unbleached flour, and the colour is diminished in the successive bleachings up to 100 c.c.; above this value the fat is browned by nitration products.

This experiment clearly shows that at these values of bleaching, the fats are altered, the degree of alteration increasing with the dosage. If it is to be claimed that the concentration of nitrogen peroxide used is higher than that employed in commercial bleaching, it may be answered that although lessened in quantity the results must qualitatively be the same at the lower level, although they pass into a region where they cannot be followed experimentally by methods of the delicacy lying at our disposal. But there is no doubt on all chemical analogy that persons who consume bleached flour are daily using small amounts of nitrated fats, and the action of these, even in small quantities used over periods of years, is a new factor the value of which in metabolism is at present unknown to us, and it may be legitimately asked, for what reason are we compelled to submit to this unknown risk, as we all are being submitted to it without our knowledge and consent?

The nitration of the fats is shown in the table above most clearly by the two columns particularly dealing with percentage of nitrogen, where the increase shows nitration, nitrogen locked into the molecule of fat by the bleaching, and by the iodine value, where nitrogen peroxide entering and nitrating leaves less place for iodine to combine when the iodine value is determined.

Effects of Nitrogen Peroxide on the Proteins of Flour.

It is well known that both nitrous and nitric acids combine with proteins and alter them so that they become impossible as foodstuffs, and since nitrous and nitric acids are formed when nitrogen peroxide comes in contact with water, and there is water in flour, it would seem inevitable *prima facie* that the exposure of flour to nitrogen peroxide gas must alter the proteins of the flour. This is also shown quite clearly by the experiments recorded below upon unbleached flour as compared with the same flour after varying degrees of bleaching. As in the case of the oils described above, the degree of alteration is small at the commercial level, but even a small amount of nitration of the proteins is undesirable, and it may again be asked why it is carried out, as there can be no pretence that it is for the good of our health?

In order to determine the effects of bleaching with known amounts of nitrogen peroxide upon the proteins of flour, an unbleached flour was taken, and, as in the case of the experiments on the fats, this was treated with volumes of 20, 30, 100 and 4500 c.c. respectively.

Two main effects were discovered which are really closely inter-related. First, the degree of acidity of reaction to indicators such as phenol-phthalëin is increased, and secondly, the amount of the flour protein soluble in water is increased at the expense of the insoluble protein or gluten. This latter result does not really mean that the gluten is changed into soluble protein, in the lower bleaches at any rate, but gluten has its water solubility increased by the presence of acid, as shown by Hardy, up to a given point above which degree of acidity it again decreases. The feeble bleaches alter the reaction in that direction which increases solubility. There is, however, along with this effect a change in the properties of the gluten, especially with higher quantities which show that it is attacked, and such changes undoubtedly occur in lessened degree at the lower bleaching strengths.

The acidity, mentioned above, is not due to free inorganic acids, but to acid salts, and salt-protein combinations, for which phenol-phthalëin is a most delicate indicator. Unbleached flour possesses, as shown by an aqueous extract, a reaction lying to the alkaline side of the neutral point, and the figures quoted as acidities only mean reactions to this particular indicator. The results show that bleaching with peroxide gives a disturbance towards the acid side.

The gluten may be separated from the starch and the soluble proteins by placing a weighed quantity of the flour on damped muslin, kneading into a dough with a small quantity of water, and then washing the excess of starch away through the muslin. The amount of insoluble protein or gluten may then be determined by estimating the amount of nitrogen by Kjeldahl's method and multiplying the nitrogen figure by a factor (usually taken at 5·8) which expresses the ratio of gluten weight to the nitrogen contained in dried gluten. The soluble protein may be determined in the aqueous extract by a similar method. It was by such methods that the figures given in the table below were obtained.

When 30 c.c. or over of nitrogen peroxide per kilogram is used as a bleaching agent upon flour, there arise changes in the gluten obtained by the method given above which are quite obvious to sight and touch, and although these are not visible when 5 c.c. or 10 c.c. are used, it is only because of diminished degree of action, for the total amount of nitrogen as nitrite and in combination with the colouring matter and fats is much below that known to be added in the bleaching process, so it is obvious that some must be in union with the protein. The affinity of protein for the reagent is well known. When less than 30 c.c. of peroxide is used, the amount of unchanged gluten disguises and conceals the smaller altered amount, but all chemical theory indicates that some portion must be altered at the lower bleaches similarly to what becomes manifest in the mass, when a greater quantity is changed or affected by the acids formed by the action of the peroxide.

Gluten as obtained from unbleached flour is a tenacious, stringy substance of a pale yellowish colour, since it contains enmeshed in it the oil and colouring matter. It resembles in its physical properties the fibrin of blood, and contracts in an elastic way like fibrin. It is this body which is so valuable in the baking and raising properties of flour in bread making, and distinguishes wheat flour as superior to all other ground-up cereals. It is a kind of natural rubber which coats the bubbles formed in the bread with a fine pellicle, holds the bread together and gives the fine skin of the bread.

Now nitrogen peroxide in sufficient quantity completely destroys these springy and elastic qualities, and gives an altered gluten which has no strength, does not stretch but breaks easily across, and in part dissolves and passes through the muslin.

Of course, in commercial bleaching nothing approaching this degree of alteration is produced, or the process of bleaching would have been killed in its infancy, for bread could not be baked with such a product. But an incipient degree of such a change must occur even with small quantities, and evidence was given at the Hamilton trial showing that the tenacity of bread made from bleached flour was not so great as that from unbleached and that the skin was not so excellent.

Additional evidence, if such were required, that change in lessened degree occurs with the smaller quantities of peroxide is given by the figures for increased soluble protein and diminished gluten in the experiments now to be quoted.

Experiment I.

Sample			Acidity to phenolphthalëin in c.c. of $\frac{N}{100}$ alkali per 100 grammes of flour	Gluten percentage	Soluble protein percentage
1	Unbleached flour		64	1·40	4·67
2	Bleached flour	100 c.c.	84	0·49	5·05
3	,, ,,	4500	1000	0·34	5·24

In addition to the gluten and soluble protein there is of course a certain amount of insoluble protein mixed with the starch which passes through the muslin.

Experiment II. In this experiment the gluten was not separated off. The sample of flour was simply thoroughly mixed up with a measured volume of water, viz. one of flour to ten of water, and allowed to stand with occasional agitation for 12 hours. The samples tested and results were as follows:

Sample			Acidity to $\frac{N}{100}$ alkali with phenol-phthalëin as indicator	Soluble protein percentage
1	Unbleached flour		108	1·20
2	Bleached flour	20 c.c.	124	1·25
3	,, ,,	30	126	1·27
4	,, ,,	100	136	1·48
5	,, ,,	4500	988	2·40

CONCLUSIONS.

1. Bleached flour is not known to be bleached by the great majority of those who consume it.

2. There does exist a demand for whiteness in flour, and previously to the advent of bleaching this was based on a real difference between white superfine flour and the cheaper yellower flour called "household" or "bakers" flour.

3. The difference consists in this, that the superfine contains the ripest and best part of the flour or "cream of the wheat," while the lower grade consists of less ripe or less developed endosperm and is richer in oil which contains the colouring matter carrotene, and so is yellow in colour.

4. Bleaching by decolorizing the carrotene removes a criterion of quality between the two grades of flour and allows the cheaper quality to be admixed with the dearer, and the whole to be sold as first quality.

5. That this admixture is made possible is shown in two ways: first, the sellers of the bleaching apparatus advertise in milling journals that the process enables the miller to increase his "divide," and secondly, there are minute microscopic particles of offal in the products of the lower machines which are not bleached or altered in the process, and which serve the microscopist as a guide to how the flour has been blended. Examination of commercial flours shows clearly that a large number of high-priced flours are such mixtures and could not be sold as such unless previously bleached.

6. Bleaching confers no advantage in nutritive properties or flavour upon the flour, and the large sum spent upon bleaching flour is really a national waste.

7. Bleaching flour with considerable amounts of nitrogen peroxide alters both fats and proteins by nitrating them. Although the changes at the level of commercial bleaching are small, there is no knowledge as to how the small amounts of organic nitro-bodies formed may affect the

human body in prolonged use for years, and as there is no counterbalancing advantage, and an addition also to the price obtained by simulating a superior article, it is suggested either that bleaching should be prohibited, or regulated and notified clearly by label to the purchaser.

8. Bleaching by nitrogen peroxide is not a more rapid achievement of a slowly occurring natural process, but is essentially distinct. For while natural whitening in pure air consists in an oxidation of the colouring matter, bleaching consists in the formation of addition compounds between nitrogen peroxide and the colouring matter.