THE CONVERSION OF AIR INTO A LETHAL MIXTURE OF GASES BY STORAGE OF TOBACCO AND OTHER VEGETABLE SUBSTANCES.

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In analysing some samples of air which had been sent for examination, the writer was struck by the presence of an altogether abnormal quantity of carbon dioxide associated with a very much diminished oxygen content. In view of this excess, the space from which these samples had been obtained was then thoroughly ventilated and after remaining closed for only four days the air was found to contain already 2·27 p.c. of carbon dioxide instead of the normal 0·03 p.c. No immediate explanation of the phenomenon was available and this paper contains a short account of the research made to discover the cause.

The space was an uninhabited and unventilated storeroom. Examination showed that the carbon dioxide could not have gained access from an external source and that it must have been derived from the contents of the store.

Amongst the stores was a considerable quantity of tobacco which was found to be very mouldy. Part was in the form of the whole loose leaf and the remainder was a prepared tobacco mixture contained in cardboard 'war-time' receptacles which could not be as hermetically perfect as the tins which they were temporarily replacing.

Experiments were made under conditions imitating those prevailing in the storeroom to ascertain if, and under what circumstances, tobacco could effect any marked alteration in the composition of the air in which it was stored. For this purpose air sample bottles of 60–70 c.c. capacity were used.

They were thoroughly flushed out with pure air and known quantities of tobacco of varied quality were placed in them. The vaselined stoppers were secured with rubber bands; the subsequent examination showed the necessity for this precaution as a very strong pressure was generated. These bottles were allowed to remain sealed for a period of 18 days (and longer) at temperatures of 12° C. and 37° C., at the end of which time they were opened under mercury and the residual air in them was analysed. The analytical apparatus employed was the Haldane for general air analysis together with the accessories already described for use with the Haldane apparatus for estimation of carbon dioxide only (*J.S.C.I.*, January 31, 1916).

In consequence of the first findings the research was extended to include the action of hay and potatoes.

The experiments and results are summarised below:

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SUMMARY OF EXPERIMENTS.

Series	Nature of sample employed	Number in series	Temperature at which stored	No. of days stored	Moisture in sample: per cent.	Bone dry weight of sample used: lbs. per cubic foot	Percentage of carbon dioxide found	Percentage of oxygen found	Percentage of carbon dioxide added to air	Percentage of oxygen removed from air	Percentage of total oxygen originally present removed	Combustible gases
A	Export tobacco mixture (prepared with glucose and treated with formaldehyde) very mouldy: wet	1	12° C.	18	54·7	1·27	49·95	0·21	49·92	20·72	99·0	Absent
		2	37° C.	18	54·7	0·76	39·85	0·29	39·82	20·64	98·6	Absent
B	Export tobacco mixture (prepared with glucose and treated with formaldehyde) very mouldy: air dried and friable	1	12° C.	18	9·7	1·29	0·25	20·63	0·22	0·30	1·4	Absent
		2	37° C.	18	9·7	1·54	2·52	18·97	2·49	1·96	9·3	Absent
C	Export tobacco mixture (prepared with glucose and treated with formaldehyde) free from ocular evidence of mould: wet	1	12° C.	18	39·39	1·22	17·47	3·72	17·44	17·21	82·2	Absent
		2	37° C.	18	39·39	1·35	23·73	1·26	23·70	19·67	93·9	Absent
		3	12° C.	41	39·39	1·27	28·05	—	28·02	—	—	—
		4	37° C. / 12° C.	18 / 23	39·39	1·21	35·61	—	35·58	—	—	—
D	Export tobacco mixture (prepared with glucose and treated with formaldehyde) free from ocular evidence of mould: air dried and friable	1	12° C.	18	8·31	1·65	0·05	20·88	0·02	0·05	0·2	Absent
		2	37° C.	18	8·31	1·41	0·53	20·14	0·50	0·79	3·8	Absent
		3	12° C.	32	8·31	1·52	0·08	—	0·05	—	—	—
		4	37° C. / 12° C.	18 / 14	8·31	1·58	0·60	—	0·57	—	—	—
E	Tobacco mixture, pure tobacco only: free from ocular evidence of mould: wet	1	12° C.	18	40·04	1·15	22·68	0·25	22·65	20·68	98·8	Absent
		2	37° C.	18	40·04	1·13	23·28	0·12	23·25	20·81	99·4	Absent
F	Tobacco mixture, pure tobacco only, free from ocular evidence of mould. Bone dry tobacco heated for 3 hours at 98° C. to effect sterilisation: sterile water added, and whole sealed under aseptic conditions: wet	1	12° C.	18	35·11	1·07	4·91	—	4·88	—	—	—
		2	37° C.	18	35·11	1·16	9·52	—	9·49	—	—	—
G	Tobacco mixture, packet of proprietary brand purchased in ordinary retail market. Sterilised and sealed under aseptic conditions as in Series F but more elaborate precautions taken to secure absolute sterility, and sterility confirmed by bacteriological examination commenced at time of analysis. Bone dry tobacco heated for 3 hours on each of three consecutive days at 98° C., moisture in form of 1/250 mercuric chloride added to bottom of bottle where it was absorbed by a small proportion of the tobacco; major proportion of tobacco made wet by subsequent vapourisation, condensation, and absorption of pure moisture	1	15° C.	18	37·0	1·61	3·80	—	3·77	—	—	—
		2	37° C.	18	37·0	1·61	9·79	—	9·76	—	—	—
H	Hay: wet	1	12° C.	18	52·75	1·02	21·92	0·25	21·89	20·68	98·8	Absent
		2	37° C.	18	52·75	0·87	24·83	0·26	24·80	20·67	98·8	Absent
I	Potato (peeled): inoculated with pure culture of mould (Aspergillus) from tobacco used in Series A		12° C.	40	78·6	0·14	24·21	0·21	24·18	20·72	99·0	Absent
J	Mould (Aspergillus) inoculated on maltose agar medium		12° C.	40	—	—	0·30	20·65	0·27	0·28	1·3	Absent
K	Blank control		12° C.	40	—	—	0·03	20·93	Nil	Nil	Nil	Absent

These experiments show that under certain conditions, and after elapse of sufficient time, tobacco stored in an unventilated space converts the air into a mixture of gases entirely incapable of supporting human life and therefore that anyone entering such a space after these conditions had prevailed would be almost instantly killed.

An essential condition for this reaction is that the tobacco be damp; air dried tobacco containing less than 10 p.c. of moisture is not productive of danger even after 32 days. It is to be noted that tobacco in this latter state gives an apparent physical indication of much less than 10 p.c. moisture content.

The degree of conversion is proportionate to time up to a maximum. The presence of mould and micro-organisms accelerates and increases the reaction but it is not the causative agent. The reaction is effected by the tobacco itself and is not due to any material which may be added in the course of manufacture.

The decomposition is increased by heat; the apparent deviation from this in Series A was due to the higher temperature evaporating the water which condensed on the shoulder of the bottle out of contact with the tobacco. Neither carbon monoxide nor any other combustible gas is produced by the reaction.

The same conversion occurs when hay or potatoes are stored in an unventilated space and probably also in the presence of a large number of other vegetable products.

The research has a practical application in showing the necessity for storing damp vegetable products only in spaces where efficient ventilation is assured.