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On the Effect of Oxidizable Substance upon the Gaseous Metabolism of Normal Healthy or Scorbutic Animals.

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On the Effect of Oxidizable Substance upon the Gaseous Metabolism of Normal Healthy or Scorbutic Animals.*

Hironori Hudino

Abstract

1. The gaseous metabolism of normal healthy guinea pigs was increased by the administration of lotus rhizome juice or platan leaves juice. 2. The gaseous metabolism of normal guinea pigs was slightly increased by the administration of testis extract, and more markedly so by the administration of lotus rhizome juice together with it. 3. The gaseous metabolism of guinea pigs fed with the basal diet free from vitamin C decreased with the diminution of their body weight, and it again increased transitorily by the administration of lotus rhizome juice. 4. The gaseous metabolism of the castrated male guinea pigs was increased by the hypodermal injection of "Spermatin".

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**On the Effect of Oxidizable Substance upon the Gaseous
Metabolism of Normal Healthy or Scorbutic
Animals.**

By

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Introduction.

According to the foregoing experiments¹⁾, the oxygen consumption and the carbon dioxide production of the castrated male guinea pigs were increased by the administration of oxidizable substance contained in certain plant juices, and moreover, it was markedly increased under the addition of the testis extract. Also, with regard to the castrated animals suffering from scurvy which had showed the diminished oxygen consumption it was more so than the healthy ones. Further the temporary increase of their oxygen consumption by the administration of oxidizable substance was noted.

The present investigation was undertaken to find how these plant extracts and testis extract increase the diminished gaseous metabolism.

Experimental.

I. Method used.

All the guinea pigs were separated into four groups and each group was fed ordinarily with a different diet according to the purpose of each experiment which will be stated in each said experiment. As to the oxidizable substance, as described in the previous paper, lotus rhizome and platan leaves were used. The testis extract was freshly prepared from the testis of male guinea pigs. As the organ preparation of testis, "Spermatin" made by Takeda Co, was used by means of subcutaneous injection. The apparatus and arrangement for the determination of gaseous metabolism followed the *Haldane's method*²⁾, described as in the previous paper.

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II. Results.

The following experiments were carried out and the results are given below:

1) Effect of oxidizable substance upon the gaseous metabolism of normal guinea pigs (Table 1 and 2).

Table 1.
(A) Normal value before experiment.

Date	Temperature of laboratory C°	Temperature of animals C°	Body weight g	Body surface cm ²	Carbon dioxide output		Oxygen intake		Resp. quot.	Remarks
					per kg, h	per M ² , h	per kg, h	per M ² , h		
					g	g	g	g		
26/7	27.8	39.2	487		1.181		0.996		0.8622	
27/7	27.5	39.0	482		1.183		1.131		0.7606	
2/8	29.0	39.1	463		1.134		1.079		0.7636	
9/8	31.0	39.5	448		1.227		1.060		0.8421	
Mean value			470	539	1.181	10.15	1.066	9.29	0.8071	

(B) After the administration of lotus rhizome juice.
since 10/8, daily dose 3 cc.

14/8	30.5	39.0	462		1.623		1.623		0.7272	5th day
15/8	31.0	39.0	448		1.395		1.283		0.7905	6th "
16/8	31.0	39.0	451		1.884		1.773		0.7727	7th "
Mean value			453	526	1.634	14.11	1.559	13.46	0.7634	
Compared with normal value					+38.35%	+39.01%	+46.24%	+44.88%		+increase

(C) After the cessation of the administration
of the juice. since 17/8.

18/8	29.0	39.5	441	515	1.587	13.59	1.360	11.65	0.8484	2nd day
Compared with the value of (B)					-2.88%	-3.68%	-12.77%	-13.44%		
20/8	28.5	39.0	425	503	1.117	9.44	0.882	7.44	0.9212	4th day
Compared with the value of (B)					-31.64%	-33.09%	-43.42%	-44.72%		-decrease

According to *Natalie Jarusowa*³⁾, the animals fed with oat flour showed a lowered gaseous metabolic rate and it increased through the addition of cabbage to the diet. *Kaneko*⁴⁾ stated that guinea pigs fed with only 'okara' became scurvy. Consequently the experiment was performed on the gaseous metabolism of guinea

pigs (male and female), which were fed with only 'okara' for several days.

The results obtained, in this way as described above, the value before experiment (A. in Table 1 and 2), show a somewhat lower value than the normal ones fed with 'okara' and vegetables: namely

Table 2.
(A) Normal value before experiment.

Date	Temperature of laboratory C°	Temperature of animals C°	Body weight g	Body surface cm ²	Carbon dioxide output		Oxygen intake		Resp. quot.	Remarks
					per kg, h	per M ² , h	per kg, h	per M ² , h		
					g	g	g	g		
10/9	27.5	39.3	461		1.041		0.824		0.9186	
"	27.7	39.5	460		1.065		0.826		0.9377	
Mean value			460.5	532	1.053	9.11	0.825	7.15	0.9281	

(B) After the administration of platan leaves juice since 11/9, daily dose 3 cc.

13/9	24.2	39.5	466		1.577		1.362		0.8418	3rd day
"	24.2	39.4	464		1.552		1.487		0.7588	"
Mean value I.			465	534	1.564	13.63	1.425	12.41	0.8003	
16/9	26.5	39.4	474		1.751		1.329		0.9581	6th day
"	28.0	39.3	468		1.666		1.250		0.9689	"
Mean value II.			471	540	1.709	14.92	1.289	11.26	0.9635	
Mean value (I.II.)			468	536	1.637	14.29	1.357	11.84	0.9635	
Compared with the normal value					+55.45%	+56.86%	+64.48%	+65.59%		+increase

(C) After the cessation of the administration of the juice. since 17/9.

19/9	25.5	39.1	444		1.373		1.148		0.8698	3rd day
20/9	26.0	39.1	443		0.903		0.835		0.7862	4th "
25/5	24.0	39.1	420		1.000		0.904		0.8038	9th "
Mean value			436	513	1.092	9.28	0.962	8.19	0.8199	
Compared with the value of (B)					-33.29%	-35.06%	-29.10%	-30.82%		-decrease

oxygen intake 1.066 g or 0.825 g per kg and hour; carbon dioxide output 1.181 g or 1.053 g per kg and hour. On the other hand guinea pigs fed normally with 'okara' and vegetables show a higher value

(referring to the previous paper of the same author), namely oxygen intake 1.178 g to 1.716 g per kg and hour; carbon dioxide output 1.443 g to 1.969 g per kg and hour.

In spite of such a slight diminution in the gaseous metabolism, there is no appearance of scorbutic symptoms, so that it should not be considered that this diminution is due to the lack of vitamin C. At any rate, the most interesting fact is that the slightly diminished metabolism was markedly increased through the addition of lotus rhizome juice or platan leaves juice to the diet lacking in vegetables, and then also increased slightly even in the body weight. Table 1 shows the oxygen intake increases 46 per cent, carbon dioxide output 38 per cent after the administration of lotus rhizome juice. Table 2 shows under the same manipulation (platan leaves juice) oxygen intake increases 64 per cent, carbon dioxide output 55 per cent; the body weight increased 5 to 8 g during the experimental period. Removing the plant juice from the diet, all the effects disappeared and the gaseous metabolism together with the body weight decreased to nearly former value.

Such being the case, the following considerations may be made; the oxidizable substance as lotus rhizome juice or platan leaves juice causes the gaseous metabolism of the normal healthy guinea pigs to increase. In other words, the oxidization mechanism in the animal organism owes much to the oxidization of the oxidizable substances itself.

2) *Effect of testis extract upon the gaseous metabolism of normal healthy guinea pigs (Table 3).*

The animals were fed with 'okara' and vegetables. According to the previous investigation, the gaseous metabolism of the castrated animals showed always a remarkable increase when testis extract was administrated. But in the case of the normal, not castrated, animals, as shown in table 3, it showed only a little increase; about 10 per cent increase of oxygen intake and 1 per cent increase of carbon dioxide output. However, supplying them with lotus rhizome juice and testis extract together, it increased obviously, though the rate of increase was not so high as in the case of the castrated animals. Oxygen intake increases by 30 per cent and carbon dioxide output, 35 per cent. It decreased again after the cessation of giving the extract and juice. Thus, the testis extract has little or no influence upon the oxidization in the body of the normal healthy animal, but it being given with lotus rhizome juice, a sufficient increasing effect was manifested.

3) *Effect of oxidizable substance upon the gaseous metabolism of guinea pigs in scurvy (Table 4).*

Table 3.
(A) Normal value.

Date	Temperature of laboratory	Temperature of animals	Body weight g	Body surface cm ²	Carbon dioxide output		Oxygen intake		Resp. quot.	Remarks
	C°	C°			per kg, h	per M ² , h	per kg, h	per M ² , h		
					g	g	g	g		
2/10	18.6	39.2	559		1.431		1.180		0.8815	
"	19.5	39.2	557		1.795		1.202		1.0853	
3/10	20.7	39.3	552		1.304		1.050		0.9028	
"	18.5	39.4	543		1.583		1.215		0.9476	
Mean value			553	600	1.528	14.08	1.161	10.66	0.9543	

(B) After the administration of testis extract
1-2 hours before experiment, ca. 3 cc.

3/10	19.1	39.4	549		1.528		1.202		0.9256	
"	19.5	39.4	550		1.675		1.455		0.8363	
4/10	21.8	39.3	558		1.290		1.111		0.8445	
"	22.5	39.5	556		1.655		1.439		0.8363	
Mean value			553	600	1.537	14.16	1.302	12.00	0.8606	
Compared with the normal value					+1.24%	+0.57%	+10.82%	+12.57%		+increase

(C) After the administration of testis extract 3 cc
and lotus rhizome juice 3 cc 1-2 hours
before experiment.

5/10	18.5	38.5	558		2.186		1.828		0.8698	
"	18.5	38.5	563		2.132		1.776		0.8727	
"	19.1	38.5	562		1.922		1.495		0.9350	
Mean value			561	606	2.080	19.24	1.699	15.72	0.8925	
Compared with the value of (B)					+35.32%	+35.77%	+30.41%	+31.00%		+increase

(D) After the cessation of the administration
of the extract since 6/10.

8/10	22.0	38.3	528		1.363		1.174		0.8445	3rd day
"	21.0	38.3	527		1.442		1.253		0.8374	"
Mean value			527.5	581	1.402	12.73	1.213	11.01	0.8409	
Compared with the value of (C)					-32.59%	-33.80%	-28.60%	-30.00%		-decrease

Table 4.
(A) Normal value.

Date	Temperature of laboratory	Temperature of animals	Body weight	Body surface	Carbon dioxide output		Oxygen intake		Resp. quot.	Remarks
					per kg, h	per M ² , h	per kg, h	per M ² , h		
	C°	C°	g	cm ²	g	g	g	g		
28/9	20.0	37.3	312		1.923		1.506		0.9284	
„	18.0	37.2	301		2.009		1.694		0.8627	
Mean value			306	404	1.966	14.91	1.600	12.13	0.8955	

(B) After the feeding with the basal diet free from vitamin C. since 29/9.

9/10	21.4	37.2	246		1.951		1.585		0.8951	11th day
„	21.7	37.3	243		1.891		1.687		0.7982	„
11/10	21.4	37.2	252		1.861		1.587		0.8545	13th day
„	22.5	37.0	250		1.920		1.640		0.8514	„
15/10	18.2	35.5	221		1.891		1.441		0.9545	17th day
Mean value			242	346	1.902	13.30	1.588	11.16	0.8707	
Compared with normal value					-3.25%	-10.79%	-0.75%	-7.99%		-decrease

(C) After the administration of lotus rhizome juice. daily dose 3 cc × 2.

16/10	18.2	36.0	222		1.936		1.531		0.9197	
„	18.0	36.0	222		1.981		1.846		0.7804	
„	18.0	36.0	222		1.981		1.576		0.9142	
Mean value			222	326	1.966	13.38	1.651	11.22	0.8714	
Compared with the value of (B)					+3.36%	+0.60%	+3.96%	+0.53%		+increase

Loewy and Grobble demonstrated the decrease in body weight and oxygen consumption of avitaminoses, especially on B-avitaminos. But there is scarcely found any references concerning the gaseous metabolism of scurvy. Knipping and

Kowitz⁵⁾, measuring the gaseous metabolism of a man who had fallen into scurvy with the general avitaminosis, observed an increase, and a decrease when lemon juice was given. Nils Söderstrom's and Nils Törnblom's⁶⁾ investigations show that the oxygen consumption of scorbutic guinea pigs fed with Scherman Göthlin's⁷⁾ basal diet free from vitamin C, is generally less than the normal healthy ones. Gö⁸⁾ established that the gaseous metabolism at the first stage of scurvy does not differ from that of the normal animals, but it decreases at the middle stage of scurvy. According to Nils Törnblom (1934)⁹⁾, guinea pigs which received nothing but the diet free from vitamin C, showed only at the end of the scurvy stage a somewhat lower oxygen consumption than the control animals put on the same diet plus 3 mg ascorbic acid or 3 cc lemon juice. In my previous experiment, it was established that the gaseous metabolism of the castrated guinea pigs fallen into scurvy, was inclined to decrease at the middle stage of scurvy.

In the present investigation on guinea pigs, after the determination of the normal value of gaseous metabolism, the animals were fed with the basal diet free from vitamin C of Scherman Göthlin (slightly modified in our laboratory). Our basal diet has the following composition: 1) 75 parts of oat powder and flour mixed in equal volume, 2) 25 parts of skin milk powder heated for two hours at 120°C, 3) each one parts of cod liver oil and sodium chloride 4) and some water. The determination was performed several times since the 11th day when the first symptoms of scurvy appeared. The value of gaseous metabolism measured on the 11th and 13th day of experiment was more or less than the normal, but on the 17th day distinctly less. On an average, it showed a slight decrease in oxygen consumption (0.75 or 7.99 per cent) and in carbon dioxide production (3.25 or 10.79 per cent). The oxygen consumption of the experimental scorbutic guinea pigs diminished when fully affected by the disease, and in accordance with this state, the general condition of the animals became worse, coinciding with the descriptions of Gö and N. Törnblom. Many investigators attribute the cause of the diminished oxygen consumption not to the scorbutic state but to the weakened general condition. Nevertheless it is interesting to note that the diminished gaseous metabolism with scurvy increased slightly and transitorily after the administration of lotus rhizome juice, as represented in table 4.

From these results noted above, it may be considered that the gaseous metabolism tends to decrease with scurvy, and obviously to increase after the administration of lotus rhizome juice.

4) *Effect of "Spermatin" upon the gaseous metabolism of the castrated male guinea pigs (Table 5).*

The decreased gaseous metabolism of the castrated male guinea pigs changes to an increase through the subcutaneous injection of "Spermatin" 1.0 cc per day, (oxygen intake increase about 53 or 55

per cent and carbon dioxide output increase about 48 or 49 per cent). Since the "Spermatin" showed a negative reaction for the oxidation test, it was considered that it does not contain any oxidizable substance in it. Therefore the action of "Spermatin" is to stimulate directly the oxidizative process in the animal-body.

Table 5.
(A) Value after the castration.

Date	Temperature of laboratory C°	Temperature of animals C°	Body weight g	Body surface cm ²	Carbon dioxide output		Oxygen intake		Resp. quot.	Remarks
					per kg, h g	per M ² , h g	per kg, h g	per M ² , h g		
3/8	31.0	39.5	403		1.032		0.868		0.8644	
7/8	31.5	39.8	408		1.019		0.938		0.8737	
Mean value			405	615	1.025	6.764	0.903	5.951		

(B) Value after subcutaneous injection of spermatin 1 cc daily.

13/8	33.0	39.5	414		1.487		1.449		0.7466	
14/8	32.0	39.5	421		1.504		1.353		0.8070	
15/8	33.0	39.5	416		1.562		1.360		0.8346	
Mean value			417	626	1.517	10.11	1.387	9.233	0.7960	
Compared with the value of (A)					+48.00%	+49.48%	+53.59%	+55.15%		+increase

(C) Value after the cessation of the injection.

18/8	30.0	39.5	425		0.945		0.748		0.9205	
„	31.5	39.5	422		0.971		0.812		0.8693	
Mean value			422.5	630	0.958	6.428	0.780	5.222	0.8949	
Compared with the value of (B)					-36.84%	-36.42%	-43.76%	-43.44%		-decrease

Summary.

1. The gaseous metabolism of normal healthy guinea pigs was increased by the administration of lotus rhizome juice or platan leaves juice.

2. The gaseous metabolism of normal guinea pigs was slightly

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increased by the administration of testis extract, and more markedly so by the administration of lotus rhizome juice together with it.

3. The gaseous metabolism of guinea pigs fed with the basal diet free from vitamin C decreased with the diminution of their body weight, and it again increased transitorily by the administration of lotus rhizome juice.

4. The gaseous metabolism of the castrated male guinea pigs was increased by the hypodermal injection of "Spermatin".

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