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UNIVERSITY OF LOUISVILLE

The Effect of Condensed, Dry, and Fresh Milk
in the Diet of Albino Rats.

A Dissertation,
Submitted to the Faculty
Of the Graduate School of Arts and Sciences
In Partial Fulfillment of the
Requirements for the Degree
Of Master of Science

Department of Chemistry

By

John T. Walsh

1922

INTRODUCTION

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Introduction.

Although much work has been done in determining the nutritional values of different milks, all of it has been carried on at different times by various men, and there is no published data demonstrating the relative values derived from experiments which were carried on simultaneously and in which all subjects were under the same conditions.

It is well known that rats show the effect of conditions to which they are subjected very easily and respond to them in the same manner in which man does. They are therefore a fit subject for nutritional experimentation.

The Albino rat lives three years as compared to man's ninety, the body composition and that of the urine being the same per centage as that of man. Therefore multiplying results by thirty gives the data for man, assuming that the normal span of man's life is ninety years.

The purpose of this paper therefore will be to show the relative nutritional value of different milks as found by simultaneous experiments with Albino rats subjected to the same environment.

REFERENCES

References.

Chemical Abstracts, Vol. 14, No. 11.

Thomas B. Osborne and Lafayette B. Mendel find that milk is not a good source for water soluble vitamins.

Journal American Medical Association, May 28, 1921.

M. Roseneau states that milk is rich in A and B antiscorbutic vitamins, that it is unusually rich in vitamin A, contains abundant amount of B and a variable but usually sufficient amount of antiscorbutic. He further states that dry milk retains its antiscorbutic property but loses after exposure to air.

Journal American Medical Association, April 16, 1921.

Editorial. Vitamin content of milk depends on the vitamin content of the food given to the cow, and that summer milk contains more vitamin than winter milk, due to the above reason.

Journal American Medical Association, May 14, 1921.

E.B. Hart, H. Steenbock, and N.R. Ellis working on the antiscorbutic potency of milk powders find that powders vary, due to the method of drying and to the vitamin content of the initial milk.

Chemical Abstracts, Vol. 14, No. 18.

Hidesaburo Bekine found that white mice when fed condensed milk alone thrive well for one hundred days but finally suffer from polyneuritis and anemia. They find that condensed milk is lacking in water soluble vitamin and in iron content.

Chemical Abstracts, Vol. 4, No. 20.

C. Kellick, Millard and Leicester recommend dried milk as food for infants because of (1) ease of digestion, (2) conservability, (3) bacterial purity, (4) cheapness (no waste), (5) convenience, (6) palatableness. Its disadvantages are of a theoretical nature and consist in the presumed destruction of the

antiscorbutic properties of fresh milk. This, however, can be compensated by the administration of fruit juices.

Chemical Abstracts, Vol. 6, No. 22.

A.W. Stewart analyzed sixty-seven dried milks and patent foods and considers the majority unsuited for infants on account of deficiency in fat and the large per centage of starch present,- the former causing rickets and the latter not being the proper form of carbohydrate for assimilation. Their mode of preparation also destroys the natural enzymes which are said to possess antiscorbutic properties. None effectually replace human milk.

Chemical Abstracts, Vol. 12, No. 22.

F.J.H. Coutts after experiments conducted on rats comes to the conclusion that dry milk is better than fresh milk and the evidence of the weight charts show that it has lost none of the characteristics of fresh milk; and he further states that its advantages over fresh milk are in its portability, keeping properties, especially dried skim milk,- convenience, and freedom from waste and bacteria, and its economy.

Chemical Abstracts, Vol. 12, No. 22.

G. Winfield experimented with forty rats and found that normal health remained for a period of sixteen months but growth fell below normal when one half to two thirds adult weight was reached and only renewed by mixed diet. With children he finds that growth is normal and even above.

Chemical Abstracts, Vol. 10, No. 7.

S.B. Trainer in reporting on methods of manufacturing and the uses of milk powder says that the methods are better than those used with condensed milk, and that they fill all milk wants.

Chemical Abstracts, Vol. 14, No. 9.

R.E. Barnes and E.M. Hume, after working with guineas find that dry milk does not contain antiscorbutic vitamine.

Chemical Abstracts, Vol. 14, No. 11.

Thomas B. Osborne and Lafayette B. Mendel find that milk is not a good source for water soluble vitamins and therefore dry milk is deficient in this vitamins.

Journal American Medical Association, May 14, 1921.

E.B. Hart, H. Steinbock, and N.R. Ellis state that milk powders vary, due to the method of drying and the vitamins content of the initial milk.

Chemical Abstracts, Vol. 4, No. 6.

E.C. Averagnet and M. Behu, Hospitals Paris and Lyons, find that raw milk of good quality and quantity is an ideal nourishment. Alert vigilance is required in its production, transportation, and distribution.

Chemical Abstracts, Vol. 7, No. 14.

Philip Rupp in research on pasteurization of milk finds that it does not change the chemical composition unless raised to 160 degrees Fahrenheit.

Journal Biological Chemistry, Vol. 44, 1920.

H.A. Mattill and Ruth E. Conklin find that rats fed on only fresh cows' milk or only on dessicated cows' milk have a good initial growth, but after the fiftieth to the hundredth day a decided retardation is noted, and no reproduction takes place. The lack of growth is due to the dilute form of food, as better growth is noted with dry milk and their average food consumption is considerably higher. The females are below normal at seventy-five days and again no reproduction takes place. The conclusion drawn is that milk is lacking both quantitatively and qualitatively in substances necessary for successful growth and reproduction, especially in the female, and it may contain substances that are inhibitory to the growth of an animal in the third or mature growth cycle.

They find that fifty-five per cent dry milk, forty per cent starch, five per cent butter fat produces practically normal growth, but no reproduction takes place.

Society of Biology and Medicine. Proceedings, 1919-20,
Vol. 17, No. 9.

H.C. Sherman, M.E. Rouse, B. Allen, E. Woods find that when rats are fed on milk and bread in which the milk is one fifth of the total number of calories, the young rats made normal growth, but females usually failed to breed and no young were raised. With whole wheat bread young were suckled at the cost of considerable loss in weight of the mother and grew at less than the normal rate.

Journal of Hygiene, 1909, Vol. 60, p. 233.

Lane Claypon finds that rats make more rapid gain when fed on dry milk than upon boiled, and these in turn more rapid than those fed on raw milk with bread as part of the ration.

Great Britain Local Board Food Rep. 1918, Vol.24,p.139.

G. Winfield fed rats exclusively on dry milk and found growth in both sexes below normal when one half to two thirds adult weight was reached and renewed only when a mixed dietary was put in place of dry milk. No data was given on reproduction.

Experimental.

Experimental.

The rats used in these experiments were descendents of three pairs of normal rats which had been fed on fresh, dry, and condensed milks, respectively, three weeks previous to breeding.

The young were separated when four weeks old and given all the food of their respective diets that they could eat. Their weights were taken weekly, pictures were taken at regular intervals, and all changes in appearance were carefully noted.

The rats were all subjected to the same environment and placed in individual and sanitary cages. The amount of food given was determined by the amount eaten the previous day, care being taken to give each rat all it could eat.

Rat No. I, which had been fed on fresh milk, bore eleven young, which when separated were fed on the following diets:

Rat I, No. I A	- - fresh milk and bread
Rat I, No. I a	- - fresh milk and bread
Rat I, No. I B	- - dry milk and bread
Rat I, No. I b	- - dry milk and bread
Rat I, No. I C	- - condensed milk and bread
Rat I, No. I c	- - condensed milk and bread
Rat I, No. I D	- - Mellins food, bread, and water
Rat I, No. I E	- - Mellins food, bread, water, and orange juice
Rat I, No. I F	- - fresh milk, bread, and orange juice.

Rat No. II, which had been fed on dry milk, bore six young which were fed as follows:

Rat II, No. II a - - bread and fresh milk
Rat II, No. II b - - bread and dry milk
Rat II, No. II c - - dry milk paste.

Rat No. III, fed on condensed milk, bore nine young which were separated and fed the following:

Rat III, No. III A - - fresh milk and bread
Rat III, No. III b - - dry milk and bread
Rat III, No. III C - - condensed milk and bread
Rat III, No. III c - - condensed milk and bread
Rat III, No. III D - - condensed milk, bread and orange juice
Rat III, No. III d - - condensed milk, bread and orange juice
Rat III, No. III E - - Mellins food, bread, and water
Rat III, No. III e - - Mellins food, bread, and water
Rat III, No. III f - - Mellins food, bread, water and orange juice.

The liter obtained from Rat I, two of which died before the twenty-fifth day, appeared scrubby; those from Rat II, three of which died before the date of separation, were large; while those from Rat III were small and nervous; no death occurred, however.

The weights of all rats fed on the same diet will be given on the same page, comparison being made by means of charts and pictures showing the best rat obtained from each diet.

Fresh Milk.

	Rat II, No. IIa.	Rat I, No. IA.	Rat I, No. Ia.	Rat III, No. IIIA
	Male	Female	Female	Male
Aug. 1	54.6	32.4	32.0	23.5
" 8	74.7	40.4	42.4	34.0
" 15	85.0	50.0	53.5	46.0
" 22	101.7	62.2	65.5	55.1
" 29	115.1	72.1	73.4	64.8
Sept. 5	129.7	76.6	83.1	74.2
" 12	132.8	85.0	95.0	88.9
" 19	134.9	97.7	108.6	100.0
" 26	144.5	103.6	114.7	110.2
Oct. 3	144.7	110.0	113.2	116.5
" 10	144.9	112.9	115.7	122.0
" 17	148.5	114.0	122.4	133.1
" 24	155.5	125.0	126.9	154.8
" 31	163.1	126.7	134.3	170.0
Nov. 7	163.4	130.9	142.5	184.8
" 14	162.4	135.0	146.7	196.3
" 21	165.7	138.3	150.0	202.9
" 28	168.8	143.3	148.5	206.6
Dec. 5	172.7	149.3	160.0	219.2
" 12	175.3	152.4	161.9	217.8
" 19	178.0	156.5	165.2	220.0
" 26	180.8	157.5	165.2 (1)	234.3
Jan. 2	186.9	164.5	*	250.0
" 9	185.0	165.0		252.1
" 16	180.7	163.3		262.3
" 23	180.7	163.9		262.0
" 30	186.5	167.4		262.2
Feb. 6	191.8	167.0		246.4
" 13	195.5	174.0		267.0
" 20	192.3	169.0		270.0

(1) Bred with Rat I for two weeks.

* Weights absent due to breeding, January 22, nine young.

Bread and Dry Milk

Dry Milk
Paste

	Rat II, No. IIb. Male	Rat I, No. Ib. Male	Rat I, No. IB. Male	Rat III, No. IIb Female
Aug. 1	43.8	32.5	30.2	27.0
" 8	58.9	39.7	39.0	37.7
" 15	74.0	47.6	42.1	44.6
" 22	78.3	51.0	50.2	48.3
" 29	84.5	52.9	55.0	50.0
Sept. 5	92.1	60.0	64.7	54.8
" 12	101.3	70.3	74.2	63.2
" 19	112.7	86.5	91.6	70.3
" 26	125.7 (1)	95.0	96.4	78.9
Oct. 3	131.5	108.3	110.6	84.2
" 10	130.0	116.0	120.1	100.0
" 17	151.7	136.4	134.4	105.3
" 24	166.4	162.0	156.9	113.4
" 31	175.1	171.4	160.0	120.3
Nov. 7	(2)	169.7	160.0	123.5
" 14	173.9	171.1	165.0	120.0
" 21	178.2	183.5 (5)	179.4	124.2 (6)
" 28	177.6	182.0	184.8	125.7
Dec. 5	184.0	181.1	188.1 (3)	127.4 (7)
" 12	185.7	176.7	193.6	132.4
" 19	181.2	169.4	186.0	(8)
" 26	185.3	172.2	184.2 (4)	119.3
Jan. 2	210.0	193.9	210.5	136.3
" 9	210.0	203.0	205.8	145.0
" 16	203.4	205.8	203.4	148.6
" 23	198.8	207.4	203.6	*
" 30	199.0	213.4	208.4	
Feb. 6	201.8	193.0	193.6	
" 13	208.8	205.0	206.5	
" 20	210.0	209.0	210.5	

- (1) Bred with Rat II, No. II c during day, separated at night.
 (2) Bred with Rat II, No. II c all day for two weeks.
 (3) Bred with Rat III, No. III b all day for one week.
 (4) Bred with Rat III, No. III b all day for two weeks.
 (5) Bred with Rat III, No. III b all day for two weeks.
 (6) Bred with Rat I, No. I B all day for one week.
 (7) Bred with Rat I, No. I B all day for two weeks.
 (8) Bred with Rat I, No. I B all day for two weeks.
 (9) Bred with Rat II for two weeks.

* January 30, six young.

Bread and Condensed Milk

	Rat I, No. IC. Male	Rat I, No. Ic. Female	Rat III, No. IIIC. Female	Rat III, No. IIIc. Male
Aug. 1	33.8	32.3	25.2	26.0
" 8	42.3	42.8	36.7	36.5
" 15	43.1	57.6	56.7	47.5
" 22	54.6	63.2	66.1	59.4
" 29	62.3	74.9	70.8	70.9
Sept. 5	79.4	83.5	82.7	80.0
" 12	91.7	94.0	89.1	83.8
" 19	102.0	103.4	97.5	91.7
" 26	102.3	118.1	106.7	106.1
Oct. 3	95.0	124.4	109.4	114.4
" 10	Dead	129.7	115.8	123.4
" 17		130.9	112.9	121.2
" 24		138.9	122.3	134.0
" 31		148.1	123.1	146.6
Nov. 7		157.5	125.0	150.0
" 14		160.4	125.6	150.2
" 21		162.1	128.5	169.5
" 28		161.7	128.1	168.7
Dec. 5		164.1	129.6 (1)	173.0 (4)
" 12		168.6	129.4	175.3
" 19		169.1	(2)	174.7
" 26		169.7	131.6	182.9 (5)
Jan. 2		177.5	132.1	187.6
" 9		183.8	134.0	195.2
" 16		180.6	127.6 (3)	181.0
" 23		176.6	122.0	166.7
" 30		177.2	119.6	161.7
Feb. 6		168.3	109.6	161.1
" 13		173.5	96.5	163.0
" 20		173.2	Dead	161.8

- (1) Bred with Rat III, No. III c one week.
- (2) Bred with Rat III, No. III c two weeks.
- (3) Bred with Rat III two weeks.
- (4) Bred with Rat III, No. III C one week.
- (5) Bred with Rat III, No. III c two weeks.

Bread, Condensed Milk, and
Orange Juice.

Bread, Fresh Milk, and
Orange Juice.

Rat III, No. IIID. Rat III, No. IIId
Male Male

Rat I, No. If
Female

Aug. 1	26.3	25.4	28.9
" 8	32.5	34.8	38.5
" 15	47.7	45.6	49.1
" 22	60.0	58.9	70.5
" 29	68.8	69.4	80.2
Sept. 5	69.1	79.2	91.7
" 12	80.3	89.2	93.4
" 19	86.1	94.2	107.7
" 26	94.8	101.0	110.7
Oct. 3	99.3	110.9	113.2
" 10	103.4	111.2	121.5
" 17	106.8	97.8	126.6
" 24	114.3	96.0	134.0
" 31	124.2	89.5	141.1
Nov. 7	132.7	80.7	151.5
" 14	140.0	Dead	146.7
" 21	148.7		152.3
" 28	153.5		155.0
Dec. 5	160.2		164.3
" 12	163.9		170.0
" 19	165.0		172.2
" 26	170.0		176.9
Jan. 2	163.8		179.7
" 9	169.1		181.5
" 16	160.2		179.6
" 23	159.5		183.6
" 30	163.2		190.0
Feb. 6	158.6		181.7
" 13	157.0		194.5
" 20	155.0		191.5

Mellins Food, Bread, and Water

	Rat I, No. ID Male	Rat III, No. IIIE Male	Rat III, No. IIIe Male
Aug. 1	25.9	27.2	32.3
" 8	25.3	24.5	32.6
" 15	26.7	26.0	37.8
" 22	30.0	24.1	35.9
" 29	30.7	26.6	38.0
Sept. 5	31.1	36.0 (1)	33.3
" 12	34.4	66.8	39.6
" 19	35.8	83.0	39.3
" 26	37.7	92.6	40.2
Oct. 3	36.4	111.3	38.4 (2)
" 10	39.3	130.8	70.0
" 17	35.7		86.4
" 24	46.4	165.2	107.3
" 31	48.1	186.7	130.7
Nov. 7	45.5	192.4	149.3
" 14	42.4 (3)	206.3	166.2
" 21	65.0	225.4	186.7
" 28	63.0	241.6	197.2
Dec. 5	65.5	255.0	211.6
" 12	70.7 (4)	265.0	221.7
" 19	94.0	256.5	237.3
" 26	74.0	255.5	237.7
Jan. 2	75.7	271.8	244.5
" 9	82.9 (5)	273.0	245.7
" 16	80.8	278.4	251.9
" 23	77.4	284.4	251.7
" 30	75.8	295.0	266.1
Feb. 6	82.1	280.5	247.2
" 13	82.2 (6)	306.7	283.0
" 20	86.0	308.7	287.2

(1) Diet changed to Mellins Food, Bread, and Milk.

(2) Diet changed to Mellins Food, Bread, and Milk.

(3) Diet changed to Mellins Food, Bread, and Milk for three days, then back to Water.

(4) Diet changed as in (3).

(5) Diet changed as in (3).

(6) Diet changed as in (3).

Mellins Food, Bread, Water, and Orange Juice.

Rat I, No. I E.	Rat III, No. III f.
Male	Male

Aug. 1	27.2	24.8
" 8	28.0	22.4
" 15	28.3	25.7
" 22	Dead	26.5
" 29		29.7
Sept. 5		28.7
" 12		34.5
" 19		35.5
" 26		32.0
Oct. 2		34.9
" 9		Dead

NORMAL RAT
AGE
FIVE WEEKS

"NORMAL RAT
AGE
FIVE WEEKS

DEBILITATED DIET
AGE
THIRTYFIVE WEEKS

NORMAL DIET
AGE
THIRTYFIVE WEEKS

grams

100

80

60

40

Nettins food, bread + water Rat I #10

2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 WEEKS

grams

200

180

160

140

120

100

80

60

40

Fresh mushrooms & Dried mushrooms
Evaporation 10%
Net I 100
Net II 100
Net III 100

Weeks

gms

Evaporated milk + bread
Fresh
Dry

Rat I #I c
Rat I #I A
Rat III #III b

WEEKS

CONCLUSION.

Conclusion.

The results as shown in the charts demonstrate quite plainly the relative nutritional value of the respective diets; it can be stated in addition, however, that the rats fed on dried milk were more susceptible to cold than those fed on fresh milk, and the fecundity of the former is lower than that of the latter.

The rats maintained on evaporated milk grew more slowly, and in only one case was greater weight attained. These rats were most susceptible to disease, and greater mortality resulted.

The curves resulting from plotting a diet containing vitamins in what might be termed excess or at least in abundance show a steadier rise to normal adult weight than in any other case, thus proving the benefit derived from the vitamin content in the diet.

The result obtained from experimenting with a diet consisting of Mellins food, bread and water gives the result one would expect of a diet that contains little tissue replacing elements. The rapid growth evidenced when the diet was

changed to include fresh milk confirms the belief that normal weight and health are maintained only by a well balanced diet rich in vitamins.