

STUDY OF THE INTESTINAL CONTENTS OF NEWLY BORN INFANTS *

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Reports of the *chemical composition* of meconium have been made by Müller¹ and by Zweifel² in the eighties of the last century. Since that time no analyses of the inorganic composition of meconium have been made or reported in the literature. The analyses of Müller and of Zweifel were carried out in conjunction with their studies of metabolism during starvation on the professional fasters, Cetti and Breithaupt. According to Zweifel the dry matter of meconium amounts to 20 per cent., whereas Davy³ in an earlier analysis reported that the dry matter was 27.3 per cent. of the meconium. The total ash was 5.1 per cent. of the dry matter in Zweifel's experiments, and 6.2 per cent. in Müller's. In horse meconium Müller found the ash to be 9.33 per cent. of the dry matter. The following table is taken from Müller's work. The results are expressed in percentage of the ash:

TABLE 1.—ANALYSES OF MECONIUM

	Müller		Zweifel			
	Horse	Human	I Human	II Human	III Human	IV Human
Fe ₂ O ₃	0.80	0.87	1.36	2.60	0.86	0.80
CaO.....	18.76	8.00	21.80	5.70	5.09	9.50
MgO.....	2.65	4.32	3.60	4.00	7.23	7.92
P ₂ O ₅	10.21	10.66	7.80	5.40	3.20	8.58
SO ₃	38.42	47.05	22.30	23.00	39.50	31.90
Alkalis.....	21.93	24.42	.....	30.20	.....	23.02
Cl.....	8.40	.....	3.78	2.53	8.68	3.90
Insoluble in HCl.....	0.30	0.67				

It will be seen from these analyses that the water soluble portion of the meconium ash is very much larger than the water soluble portion of the feces ash. The predominant feature is the large percentage of alkalis which in meconium is from 21.92 per cent.

* From the Department of Laboratories, Beth Israel Hospital.

1. Müller: Ztschr. f. Biol., 1884, p. 327.

2. Zweifel: Arch. f. Gynaek., 1875; 1886.

3. Davy: In Gorup-Besanez "Lehrb. d. physiol. Chem.," 1862, p. 501.

to 24.42 per cent. of the ash, whereas in dogs fed on meat, the ash of the feces contained 4.5 per cent. alkalis. The alkalis are in a large measure, as Zweifel has pointed out, in union with sulphuric acid and the observation of certain older authors that there is no sulphur in meconium is an error. The fact that there is such a large excess of water soluble substances in meconium shows that the absorption of the fetal alimentary canal is poor. The large amount of sulphur present (as compared with the feces of starving subjects) can be explained on the basis that the taurin excreted in the bile in the form of taurocholic acid is not liberated and reabsorbed during intrauterine life as it is in extrauterine life. On the contrary, the taurin is excreted in the meconium unchanged. A large portion of the sulphur is derived from shed epithelial cells of the intestinal mucosa (Müller).

TABLE 2.—CONSTITUENTS OF MECONIUM (AUTHOR'S ANALYSES)

	I	II	III	IV	V
Parts per Thousand—					
Water.....	732.3	801.7	784.5	697.7	718.6
Dry matter.....	267.7	198.3	215.5	302.3	281.4
Organic matter.....	245.2	180.1	197.7	280.5	257.9
Ash.....	22.5	18.2	17.8	21.8	23.5
Ash Percentage of—					
Total meconium.....	2.25	1.82	1.78	2.18	2.35
Dry matter.....	8.8	9.1	8.2	7.2	8.3
Analysis of Meconium Ash (per cent.)—					
Fe ₂ O ₃	3.17	1.17	2.24	0.92	1.44
CaO.....	18.24	.....	17.55	21.18	16.34
MgO.....	4.21	8.05	6.17	6.18	4.75
P ₂ O ₅	12.62	8.62	.....	.....	11.70
SO ₃	23.14	25.63	18.47	28.30	24.32
Cl.....	5.86	7.12	6.89	5.34	
K and Na.....	24.19	.....	33.72		

On comparison of the analyses of meconium by Müller and by Zweifel with their analyses of the hunger feces of the professional fasters, Cetti and Breithaupt, it will be seen that the meconium has lower proportions of calcium, iron and phosphorus, which has been explained by the greater need for these elements in the growing organism as compared with the adult (Cambridge⁴).

We have analyzed the meconium of five infants, voided during the first twenty-four hours of extrauterine life, with the results shown in Table 2.

4. Cambridge: Feces of Children and Adults, 1914.

On comparing our figures (Table 2) with those obtained by Zweifel and Müller on hunger feces (Table 3) we see that there is no great variation in the calcium and iron percentages. This is a distinct difference from the figures obtained by the German authors, and we cannot subscribe to the explanation that the need for lime in the fetus causes a lowering of the calcium content of the meconium. It seems that the need of lime by the growing organism can be compensated by an increased maternal supply. The phosphorus is, however, much lower in meconium, whereas the sulphur proportion is much higher.

Several of the *organic constituents* were also examined. The *total nitrogen* of meconium varies. In a number of specimens analyzed we found from 0.62 per cent. to 1.07 per cent. Traces of *ammonia* were found in all specimens of meconium.

TABLE 3.—ANALYSES OF HUNGER FECES (MÜLLER)

	Cetti, per Cent.	Breithaupt, per Cent.
Insoluble in HCl.....	1.213	1.780
Fe ₂ O ₃	1.530	3.03
CaO.....	14.516	12.53
MgO.....	1.200	4.12
P ₂ O ₅	43.132	55.75
SO ₃	6.341	3.71
K and Na.....	19.620	12.649
HCl.....	1.320	1.96

Weintraud,⁶ in 1895, made the observation that meconium yields 0.1 to 0.3 gm. of pure *uric acid* for every 100 gm. of dry weight. In adults, uric acid is nearly always absent, according to Weintraud, when calomel has been administered. In infants, however, he always found uric acid and the purin bases. He therefore concluded that when putrefaction and processes of reduction, which generally go together, predominate in the alimentary canal, the formation of uric acid is not possible; but when, as in the case of meconium, processes of oxidation are going on, not only is the conversion of bilirubin to biliverdin possible, but there is also a development of uric acid from the nuclein bases. Since meconium is sterile and consists mainly of the products of excretion from the body, these results of Weintraud would tend to support the view that the nucleins are partly of intestinal origin.

6. Weintraud: Die Heilkunde, 1898, p. 67.

Schittenhelm,⁷ who also found uric acid in meconium, concluded that it was derived from the swallowed amniotic fluid, and not from the intestinal changes.

So far as the uric acid is concerned, we have been unable to demonstrate its presence in twelve specimens of meconium, and we, therefore, cannot corroborate Weintraud's and Schittenhelm's results or their conclusions.

The *ferments* of the meconium were also studied. From the purely physiologic point of view, it is interesting to examine the enzymic contents of the intestine during intrauterine life. The entire subject of enzyme incidence is encrusted with teleologic conceptions which only time will root out. In intrauterine life, intestinal enzymes can have no function, since there is no food in the intestinal canal. The functions of the pancreas are quiescent, except, perhaps, the function of internal secretion.

Wegscheider⁸ demonstrated the presence of *amylase* in infant feces. It was shown by Pottevin⁹ that it is constantly present in meconium. This was confirmed by Hess. No quantitative studies of this enzyme in meconium was, however, ever made, and we determined to analyze fifteen specimens of meconium from fifteen infants quantitatively for pancreatic amylase by the method of Wohlgemuth¹⁰ as modified by Hawk.¹¹ We obtained the results given in Table 4.

It will be seen that while the starch splitting enzyme is, it seems, present in meconium, its quantity is very much reduced. We did not filter the meconium through a Berkefeld filter, and we cannot state whether the traces of amylase found were not in reality results of bacterial digestion, the bacteria having contaminated the meconium during the process of collection. In spite of the fact that it can have no function in the early months of extrauterine life, the amylase is present in increasing quantities in infants' feces.

Orban¹² found *lactase* in the intestinal mucosa, and it was later demonstrated in the feces of infants. Lactase is formed, according to some observers, by the epithelial cells of the alimentary mucous membrane, but Martinelli¹³ observed it also in the pancreatic tissue. We have been unable to find lactase in any of fifteen specimens of meconium.

7. Schittenhelm: Zentralbl. f. d. ges. Physiol. u. Pathol. d. Stoffwechs., 1909.

8. Wegscheider: Dissertation, 1875.

9. Pottevin: Compt. rend. Soc. d. biol., 1900, p. 589.

10. Wohlgemuth: Biochem. Ztschr. 9:1, 1904.

11. Hawk: Practical Physiological Chemistry, 1917.

12. Orban: Prag. med. Wchnschr., 1899, p. 427.

13. Martinelli: Zentralbl. f. d. ges. Physiol. u. Pathol. d. Stoffwechs., 1907, p. 481.

Trypsin is normally present in the feces of children and adults. It has been reported by some observers, Hess and others, that pancreatic protease is present in meconium. We have been unable to find trypsin in the freshly voided specimens of meconium during the first day of extrauterine life. Eight individual specimens were examined with constant negative results. We present these findings with reserve, for we are aware that we contradict the observations of a number of children specialists. We used the method of Gross¹⁴ for the trypsin analysis. We have also applied Spencer's technic in an endeavor to apply a very delicate test. As Schmidt and Strassburger¹⁵ suggest that the trypsin which is reported present may be, in a large percentage of cases, due to *erepsin*, we examined several specimens of meconium for erepsin, but we cannot report any success. The results were invariably negative.

TABLE 4.—AMYLASE IN MECONIUM

Specimen	Dm ^{38°} * 24h
1.....	12.1
2.....	11.7
3.....	10.9
4.....	0.0
5.....	11.1
6.....	0.0
7.....	12.4
8.....	10.7
9.....	10.8
10.....	10.4
11.....	0.0
12.....	?
13.....	?
14.....	12.2
15.....	10.3

* Dm ^{38°}_{24h} signifies the diastatic digestion of 1 c.c. of pure meconium at 38 C. incubated for twenty-four hours. The figures in the table represent the number of cubic centimeters of a 1 per cent. starch solution digested by 1 c.c. of meconium for twenty-four hours at 38 C.

Lipase was found by Hecht¹⁶ in sucklings' feces in the very earliest days of life. Schönberner¹⁷ found lipase in meconium (1909). This was Schönberner's research for his inaugural dissertation at Munich.

14. Gross: Deutsch. med. Wchnschr., 1909.

15. Schmidt and Strassburger: Die Feaces des Menschen, 1910.

16. Hecht: Wien. klin. Wchnschr., 1908.

17. Schönberner: Dissertation, Munich, 1909.

His experiments and conclusions are to be strictly scrutinized, for, no doubt, he has permitted a number of errors to enter his experiments. We have found no lipase in fresh meconium voided during the first twenty-four hours of life.¹⁸

CONCLUSIONS

1. The inorganic composition of the meconium is reported, five specimens having been analyzed. The iron and calcium contents are similar to those obtained in hunger feces. The phosphorus of meconium is less. The sulphur is much increased.

2. Traces of ammonia were found in meconium.

3. No uric acid was found in twelve specimens of meconium examined. This fails to corroborate Weintraud's analyses.

4. Amylase is found in the meconium in extremely faint traces.

5. Neither trypsin nor erepsin were found in eight specimens of fresh meconium.

6. No lactase was found in meconium.

7. No lipase was found in fresh meconium.

18. Consult also, Ury: *Arch. f. Verdauungskr.*, 1908, p. 411; *Biochem. Ztschr.* **23**:153, 1909.