

tration and mucosal pathology following the burns may be attributable to the fact that those animals received a 40% 10-second burn, a less severe burn than the majority of the animals in this study received. Serial blood pressure determinations were made in 3 burned dogs, continuously anesthetized, which developed hemoconcentration, and no readings of shock level were observed. Animals were usually awake and moving about after 4 hours following the burn.

It is interesting to note that superficial necrosis of the gastric mucosa was present upon microscopic examination in 2 dogs, both sacrificed, one after marked hemodilution due to overtreatment, the other after marked hemoconcentration and congestion of the mucosa. Microscopically, the vascular spaces of the mucosa of the overtreated animal were conspicuously devoid of blood, while those of the untreated animal were markedly dilated and engorged with blood with extravasa-

tion and necrosis. Both conditions result in mucosal ischemia, susceptible to the erosive action of gastric acid-peptic secretions.

Conclusions. Evidence is presented to show that increased concentration of the blood following burns is an important factor in the occurrence of gastro-duodenal ulcer after experimental burns. (The occurrence of gastro-intestinal congestion, erosion and/or ulcer in burns is directly related to the occurrence of hemoconcentration).

Moreover, gastro-intestinal abnormality following burns, even when accompanied by histamine administration, may be prevented by avoidance of the hemoconcentration of burns by proper therapy.

The incidence of gastric and/or duodenal ulceration provoked by hemoconcentration in burns is markedly increased when histamine-beeswax administration accompanies the burn.

15706

Comparative Utilization of Raw and Autoclaved Soy Bean Protein by the Human.

JESSICA H. LEWIS AND F. H. L. TAYLOR.

(With the technical assistance of M. A. Adams and L. J. Harrison.)

From the Thorndike Memorial Laboratory, Second and Fourth Medical Services (Harvard), Boston City Hospital, and the Department of Medicine, Harvard Medical School, Boston.

Osborne and Mendel¹ in 1917 noted that rats fed raw soy bean flour grew more slowly than a control group which received the same flour after it had been autoclaved. Hayward, Steenbock and Bohstedt² confirmed these investigations and suggested that this effect was not due to a difference in palata-

bility but to a deficiency in the raw flour. Later investigations by Hayward and Hafner,³ Almquist, Mecchi, Kratzer and Grau⁴ and Johnson, Parsons, Steenbock⁵ suggested that this increase in biological activity produced by autoclaving raw soy bean flour was due to a rise in the level or increase in the availability of sulfur bearing amino acids.

That the autoclaved soy bean protein has a high biological value similar to egg white and liver protein has been shown by Cahill, Schroeder and Smith⁶ from a study of ni-

¹ Osborne, T. B., and Mendel, L. B., *J. Biol. Chem.*, 1917, **32**, 369.

² Hayward, J. W., Steenbock, H., and Bohstedt, G., *J. Nutrition*, 1936, **11**, 219.

³ Hayward, J. W., and Hafner, F. H., *Poultry Science*, 1941, **20**, 139.

⁴ Almquist, H. J., Mecchi, E., Kratzer, F. H., and Grau, C. R., *J. Nutrition*, 1936, **63**, 277.

⁵ Johnson, Y. M., Parsons, H. T., and Steenbock, H., *J. Nutrition*, 1939, **18**, 423.

⁶ Cahill, W. M., Schroeder, L. J., and Smith, A. H., *J. Nutrition*, 1944, **28**, 209.

⁷ McNaught, J. B., Scott, V. C., Woods, F. M., and Whipple, G. H., *J. Exp. Med.*, 1936, **63**, 277.

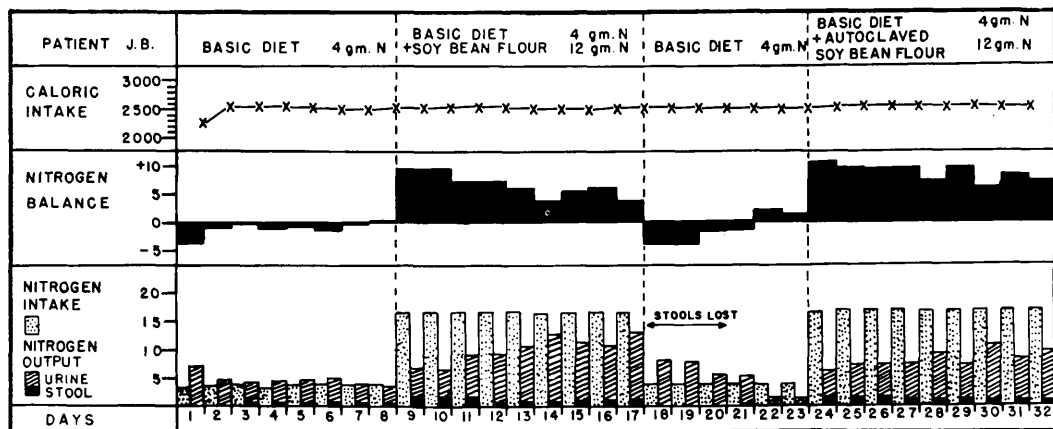


FIG. 1.
Nitrogen balance in Patient J. B.

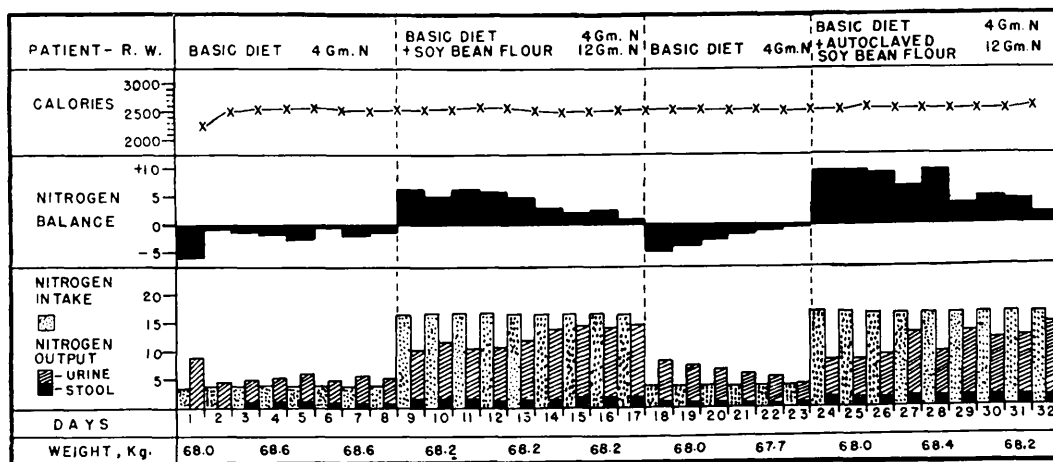


FIG. 2.
Nitrogen balance in Patient R. W.

trogen balance in humans and by McNaught, Scott, Woods and Whipple⁷ from a study of plasma protein regeneration in dogs.

Recently another explanation has been offered for the apparent lower biological activity of raw soy bean protein. Ham and Sandstedt⁸ isolated a trypsin-inhibiting substance from the unheated soy bean flour which they felt was identical with its growth-retarding action. In later studies, Ham, Sandstedt and Mussehl⁹ showed that this

trypsin-inhibiting substance isolated from soy bean flour had a retarding effect upon the normal growth of chicks; and, by *in vitro* test they showed that the proteolytic activity in the small intestine of the chick was greatly inhibited. Similar results were obtained by Klose, Hill and Fevold¹⁰ in growing rats.

Bowman¹¹ demonstrated the inhibition of the tryptic digestion of casein by a fraction

⁸ Ham, W. E., and Sandstedt, R. M., *J. Biol. Chem.*, 1944, **154**, 505.

⁹ Ham, W. E., Sandstedt, R. M., and Mussehl, F. E., *J. Biol. Chem.*, 1945, **161**, 635.

¹⁰ Klose, A. A., Hill, B., and Fevold, H. L., *Proc. Soc. Exp. Biol. and Med.*, 1946, **62**, 10.

¹¹ Bowman, D. E., *Proc. Soc. Exp. Biol. and Med.*, 1944, **57**, 139.

¹² Kunitz, M., *Science*, 1945, **101**, 668.

¹³ Kunitz, M., *J. Gen. Physiol.*, 1946, **29**, 149.

of an aqueous extract of raw soy bean. This was also shown by Kunitz¹² who later isolated this trypsin inhibitor in crystalline form.¹³

Tagnon and Soulier¹⁴ have shown that this trypsin inhibitor acts *in vitro* as an anti-coagulant of whole blood and plasma, suggesting that it may also inhibit the plasma enzyme associated with blood coagulation.

In view of the current widespread use of soy bean flour as a human food, and because of the observations made in animals, the investigations reported here were undertaken to compare the utilization of raw and autoclaved soy bean flour in humans.

Methods and Materials. Two cooperative, well nourished patients, one with a diagnosis of mild osteoarthritis; the other a hemophiliac without hemorrhagic manifestations, were chosen as subjects. Both patients were allowed unrestricted activity about the ward and their caloric requirements were estimated at 2500 calories. The basic diet was, therefore, planned to afford 2500 calories daily and provided a low protein intake of 25 g from mixed sources, about 75% of which was of vegetable origin. After an initial control period of 8 days, during which the subjects received only the basic diet, 188 g of raw soy bean flour containing 75 g of protein was substituted for an equal caloric value of carbohydrate in the basic diet. The soy bean flour was given as a liquid supplement dissolved in water to a volume of one liter. After this 9-day period on raw soy bean flour the subjects returned to the basic diet for 6 days. This was followed by another 9-day trial period during which the subjects received 188 g of soy bean flour previously autoclaved for one hour at 15 lb pressure.

Nitrogen balance and body weights were followed throughout the study period.

Urine nitrogen determinations were done by micro-Kjeldahl method on aliquot of 24-hour specimens, and stool nitrogens were de-

termined by macro-Kjeldahl method on 3-day pooled specimens.

Results. Fig. 1 and 2 show the caloric intake and nitrogen balances of these 2 patients. The average daily nitrogen retention of patient J.B. was 6.7 g on raw soy bean flour and 8.5 g on the autoclaved material. Patient R.W. showed similar results with an average daily nitrogen retention for the first period of 4.1 g and for the second period of 5.4 g. In each of these subjects the nitrogen retention is about 20% greater when the autoclaved material is used instead of the raw material. Increase in stool nitrogen does not account for this difference as subject J.B. showed an average daily stool nitrogen of 1.3 g during the first period and 1.1 g during the second period, while subject R.W. showed 1.6 g in the first period and 1.8 g in the second period. There was no significant change in body weight in either patient.

The soy bean supplements were not disagreeable in taste. Both patients complained of flatulence during both of the trial periods. There were no other gastro-intestinal symptoms.

Discussion. Both the raw and autoclaved soy bean protein support positive nitrogen balance in adult humans. Retention of nitrogen is about 20% greater during the administration of the autoclaved material than with the raw material. The cause of this greater biological activity is not clear from these investigations. There is no increase in excretion of nitrogen in the stool following intake of raw material, suggesting that intestinal protein digestion has progressed far enough to produce absorbable nitrogen products. Whether all these products absorbed from nonautoclaved soy bean flour are capable of entering the metabolic pool requires further study.

Conclusions. 1. Both raw and autoclaved soy bean protein support positive nitrogen balance in the adult human. 2. Nitrogen retention is about 20% greater with the autoclaved material than with the raw material.

¹⁴ Tagnon, H. J., and Soulier, J. P., *Proc. Soc. Exp. Biol. and Med.*, 1946, **61**, 440.