LXXII. THE OSMOTIC PRESSURE OF GUM ACACIA SOLUTIONS.

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(Received February 13th, 1934.)

THE great and increasing use of solutions of gum acacia, with or without the addition of sodium chloride, as an infusion in cases of shock and loss of blood [Bayliss, 1918], together with the mass of data now available relating to the osmotic pressure of the blood-colloids in health and disease, render an exact knowledge of the osmotic pressure of the colloids in gum acacia solutions of importance.

The osmotic pressure of the solution is likely to be modified by such factors as the concentration of salts present, the heat treatment to which the solution has been submitted for purposes of sterilisation and, perhaps, the dilution of the gum, a concentrated solution containing larger complexes than one more dilute.

It was, therefore, decided to study the effects of concentration, of the addition of salts and of the influence, if any, of different methods of sterilisation upon the osmotic pressure of the colloids in solutions of gum acacia.

METHODS.

Apparatus. For the majority of the experiments recorded below the Krogh [Krogh and Nakazawa, 1927] type of osmometer, made by the Zsigmondy Ultra-filter company, was used. In a few of them the osmometer used by Widdowson [1933] was employed. The osmometers were set up in all the three possible positions—dialysate above plate with bent capillary; dialysate below plate (Krogh); dialysate above plate with straight capillary—and, as concordant results were obtained with all of these, the pressures measured were obviously real. A loose-fitting cap containing damp cotton wool covered the open ends of the osmometers in cases one and three above, while the end dipped into water when in the “Krogh” position. Evaporation of the dialysate was thus prevented. Pressures were recorded in cm. of water.

Membranes. In the present series of experiments only cellophane (“No. 600”) as used by Widdowson and by Govaerts [1927] was employed.

Time and temperature. Between 22 and 24 hours was allowed for equilibrium to be attained. 17 hours was definitely too short a time and in several cases good readings were obtained after a lapse of 46 hours. One of the osmometers was accommodated in a vacuum flask, but this did not seem to add much to the consistency of the readings. All pressures were reduced to 0°.

Material. Finest commercial “Gum acacia parv” was used for making the test solutions. Solutions were never more than 3 days old for “fresh” gum.

When sterilised material was employed it was sterilised in small bottles and a fresh one used if the previous one had been open for more than 3 days. Some fresh

gum solutions were preserved by the addition of sufficient thymol to saturate the mixture.

The standard infusion solution used clinically contains 6 % of gum acacia. This strength was made a standard and all results referred to it.

Effect of concentration on osmotic pressure.

Solutions of varying strength were examined. It was not possible, with the apparatus in use, to measure pressures much higher than were given by a solution of 6 % concentration.

Table I.

Strength of solution %	Osmotic pressure observed cm. water at 0°	Osmotic pressure for 6 %
2	28.1	84.3
2	23.9	71.7
3	37.4	74.8
3	40.4	80.8
3	40.0	80.0
3	38.8	77.2
6	80.8	80.8
6	77.7	77.7

Mean value (for 6 % gum) 78.4 cm. p_H 4.4-4.5.

The results in Table I show that the osmotic pressure is not affected within the limits of experimental error by alteration in the strength of the solution between the limits 2-6 %. For solutions saturated with thymol the results are given in Table II.

Table II.

Strength of solution %	Osmotic pressure observed cm. water	Osmotic pressure for 6 % at 0°
2	23.82	71.46
2	25.55	76.65
3	40.1	80.2
3	36.5	73.0
4	48.9	73.3
6	73.4	73.4

Mean value (for 6 % gum) 74.7 cm.

Again it is obvious that dilution has not affected the observed osmotic pressure. The presence of thymol causes a diminution of 4.9 % in the osmotic pressure.

Effect of the addition of sodium chloride (Table III).

Solutions containing 6 % of gum and 0.9 % salt (corresponding to the clinical solution of 6 % gum in normal saline) were examined.

Mean osmotic pressure observed 11.93 cm.; p_H 4.2.

Table III. *Effect of different concentrations of sodium chloride.*

Gum 6 % containing salt (%)	Mean osmotic pressure	p_H
2.0	11.0	—
0.9	11.93	4.2
0.46	15.8	4.3
0.31	18.0	—
0.276	18.26	4.4
0.2	21.6	—
0.1	32.6	—
0.05	49.5	—
Nil	78.4	4.5

The addition of salt has therefore a profound depressing action on the osmotic pressure of the colloids in gum solutions.

6 % gum in 0.9 % saline saturated with thymol, 11.32 cm.

Saturating the solution with thymol depresses the osmotic pressure by the same proportion (4.9 %) as was found for pure gum solutions.

The figures obtained all lie on a smooth curve of hyperbolic type, and no discontinuity is observed. (See Fig. 1.)

Fig. 1. Osmotic pressure of 6 % gum acacia solution with varying amounts of NaCl.

The p_H of the solution falls proportionately as the salt content rises. This is due to a change in the gum, not to the salt itself, since 3 % gum in normal saline has a p_H of 4.3 as against the value of 4.2 for 6 % gum containing the same amount of salt.

Effect of dialysis (Table IV).

In view of this series of results it was decided to measure the osmotic pressure of gum solutions purified from salts, naturally present in the solution, by dialysis.

Pure gum solutions were dialysed in a pair of Asheshov's tubes, fitted with a cellophane membrane, against distilled water. The gum was preserved by the addition of thymol as above and the distilled water was also saturated with this preservative. The osmotic pressures were corrected for the depressing action of thymol by the amount found to be correct from earlier work. The water was changed daily.

Table IV. *Effect of dialysis.*

	Osmotic pressure cm.
Gum solution 1 month old dialysed for 5 days gave	83.6 for 6 %
Gum dissolved in apparatus and dialysed 7 days gave	115 for 6 %
Gum freshly dissolved	78.4

The difference between the two results above may be ascribed to one of three causes or to a combination of them.

1. Thymol does not protect the gum completely against bacterial action.
2. The osmotic pressure of a gum solution may alter naturally with time.
3. The second solution was dialysed for a longer time.

It is considered that the first cause cited above is the most likely.

As expected, purification of the gum solution by dialysis caused a rise in the observed osmotic pressure.

Sterilisation.

The effect of different types of heat treatment on the osmotic pressure was investigated on four solutions containing 6 % of gum. The treatments to which these were subjected were as follows (Table V).

Table V. *Effect of heat treatment.*

Solution A, steamed for 20 minutes on 3 successive days; B, autoclaved to 30 lbs. pressure; C, autoclaved to 30 lbs. pressure and then to 7 lbs. for 10 mins.; D autoclaved to 30 lbs. pressure, and then steamed on 3 successive days.

The osmotic pressures are those for 6 % concentration.

Solution	Mean osmotic pressure observed cm. water	p_H
A	80.9	4.55
B	77.3	4.65
C	98.2	4.55
D	101.6	4.60
Fresh gum	78.4	4.4-4.5

For gum solutions containing 0.9 % of sodium chloride the values in Table VI were obtained (the letters refer to the same heat treatment as in the pure gum series).

Table VI.

Solution	Mean osmotic pressure	p_H
A	12.87	4.4
B	12.59	—
C	15.91	4.3-4.2
D	17.04	4.3
Fresh gum saline	11.93	4.2

The conclusions to be drawn from these two sets of results are that, while sterilising by any method does break up the gum molecule, such damage is not so profound as to render the resulting particles dialysable to any marked extent. If this had occurred a diminution in the value of the osmotic pressure would have been found instead of the increase actually met with.

The second sterilisation (after filling into the final container) does more damage than the first and steaming on 3 successive days is more active as a disruptive agent than is the autoclave treatment.

The same order of increase in osmotic pressure is noted in both sets of solutions, but the proportionate increase is greater when salt is present (Table VII).

Table VII

Solution	Saline osmotic pressure	Pure (calc. from saline figures) osmotic pressure	Pure (observed) osmotic pressure
Fresh	11.98	(78.4)	(78.4)
A	12.87	85.3	80.9
B	12.59	83.5	77.3
C	15.91	105.5	89.2
D	17.04	112	101.6

The p_H of gum solutions is not markedly affected by sterilisation.

DISCUSSION AND SUMMARY.

The results detailed above show that while the colloid osmotic pressure of gum acacia is independent of the concentration over the range 2–6 %, it is greatly reduced by the presence of salt. The actual osmotic pressure of 6 % gum in normal saline is only little more than one-third of that of the blood-colloids, and, while sterilisation causes a considerable increase in the osmotic pressure, the latter is even then less than one-half that of the colloids in normal blood. It would seem that the addition of salt to gum solutions is, partially at least, defeating the clinical object of the administration of such treatment.

The sterilised gum solutions used in the work were supplied by The Crookes Laboratories.

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