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Texture Profile for Molded Poultices[1]

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An investigation was carried out on poultices molded on cloth to ascertain whether y_j can be related to x_i, where x_i is the value of the i'th physical property of a molded poultice, obtained by using instrumental techniques, and y_j is the preference value of a subject treated with the poultice for the j'th textural characteristic, obtained by sensory evaluation. Four formulations of molded poultices were prepared and used. Sensory tests of these poultices were performed with 23 volunteers. The relations between y_j and x_i were obtained for six characteristics as linear regression equations with good correlation coefficients. It should be possible to apply these equations to screen the quality of a new molded poultice by means of objective and reproducible measurements using instrumental techniques instead of extensive field tests.

Keywords——molded poultice; textural characteristic; instrumental technique; sensory test; regression equation

Poultices represent one of the most ancient classes of pharmaceutical preparations,[2] and are usually intended to be made extemporaneously for application to the skin with the object of reducing inflammation and allaying pain.[3]

Currently, poultices are thick paste preparations preserved in air-tight containers such as glass bottles or metal cans, and are applied hot on a cloth base.[2,4] Molded poultices are sheets consisting of thick paste covered with a liner, and backed with cloth. They are preserved in a laminated bag of aluminium foil and polyethylene sheeting. This type of poultice can be used more easily than those kept in air-tight containers.

A molded poultice is composed of three parts: 1) a soft, moist mass containing essential oils, 2) a liner sheet covering the paste, and 3) a backing cloth of flannelette or nonwoven fabric. The paste is usually prepared by mixing glycerin, water, and other suitable liquid materials with finely powdered drugs, and then adding essential oils such as methyl salicylate, menthol, and camphor.[5] It is desirable for molded poultices to have the following properties: it is easy to manually peel off the liner covering the paste; the poultice is adhesive enough to the skin to avoid inadvertent removal; and it is thereafter peelable from the skin without any paste remaining on the applied area.

The absorption, distribution, and excretion of ^{14}C-methyl salicylate applied dermally in molded poultices were investigated in rabbits by Kitakawa.[6] The absorption was rapid and radioactivity was detected in the blood at 15 min after the administration. The peak blood concentration was observed at 2 h.[6] Suzuki[7] reported that the combination of methyl salicylate, menthol, and camphor resulted in additive anti-inflammatory and analgesic effects on the application of molded poultices on the hind foot of rats. Molded poultices seem to have the following effects when applied to the skin[8]: 1) the water contained in the paste cools the inflammed area of skin where it is applied; 2) the drugs in the paste are rapidly absorbed through the skin according to an effect of occlusive dressing treatments.

Relatively few biopharmaceutical or physicochemical investigations on molded poultices

TABLE I. Abbreviations

a_k:	Quantity of ingredient k in a molded poultice		
a_1,	gelatin	a_2,	propylene glycol
a_3,	sorbitol (70% aq. soln.)	a_4,	polyvinyl alcohol
a_5,	sodium polyacrylate	a_6,	magnesium dichloride
a_7,	alum	a_8,	polybutene
a_9,	kaolin	a_{10},	minor constituents
a_{11},	essential oil	a_{12},	water
x_i:	The values of the substitute properties for textural characteristics and rheological properties		
x_1,	"peeling" (g)	x_2,	"tackiness" (g)
x_3,	"stickiness" (g)	x_4,	"Dare" (cm)
x_5,	yield value ($\times 10^4$ dyn/cm^2 at 37 °C)		
x_6,	average viscosity (poise at 37 °C)		
x_7,	hysteresis loop area ($\times 10^7$ dyn/cm^2 s at 37 °C)		
y_j:	Average preference value by sensory assessments		
y_1,	peeling	y_2,	tackiness
y_3,	stickiness		
y_4,	peeling at 3 h after application		
y_5,	stickiness at 3 h after application		
y_6,	tackiness at 3 h after application		
y_7,	Dare		
Y:	Overall preference value on sensory assessments		

have been reported. The reasons for this are thought to be as follows: 1) molded poultices have been in common use for only two decades in Japan[9]; 2) the formulation of poultices is too complicated for their physicochemical properties to be easily studied quantitatively; 3) the properties of molded poultices can be evaluated qualitatively by sensory assessment.

The purpose of the present work was to contribute to the design of molded poultices in the light of textural and physicochemical studies. The following parameters are defined: x_i is the value of i'th physical property of a molded poultice, obtained by using instrumental techniques, y_j is the preference value of a subject treated with the poultice for the j'th textural characteristic, obtained by sensory tests, Y is the degree of overall preference and acceptability for the molded poultice, obtained by sensory tests, and a_k is the quantity of ingredient k in a preparation. Now if y_j is related to x_i (this is called relation (1)), and Y is related to y_j (this is called relation (2)), then Y can be obtained from x_i by using relations (1) and (2). If this approach is valid, it will be possible to screen the preference for and acceptability of a new molded poultice by means of objective and reproducible measurements using instrumental techniques instead of sensory assessments. If x_i is related to a_k, the overall preference, Y, can be expressed as a relation between Y and a_k. Optimum formulations of molded poultices could then be readily obtained by calculation without any experimental tests. This investigation was designed to ascertain the relations (1) and (2) by means of a textural study. The terms used in this work are summarized in Table I.

Sherman[10] reported a texture study based on the following procedure. 1) In order to simplify the discussion, the vocabularies used in the sensory test are defined. 2) The degree of preference for each textural characteristic is obtained by sensory assessments. 3) Physicochemical properties are measured by instrumental techniques. 4) Relationships between the degree of preference and properties are evaluated. Steps (1) and (2) are usually performed, for evaluation of molded poultices, whereas steps (3) and (4) are rarely carried out. The rheological evaluation of pharmaceutical semisolids is a useful technique for texture study. To support sensory assessments of consistency,[11] spreadability,[12] and stickiness[13] of

TABLE II. Consistency Profile for Molded Poultice

Initial assessment prior to usage	(stage 0)
Ease of removal from container	
Visual appearance	
Ease of removal of liner from paste (y_1)	
Initial impression on contact with treatment area	(stage 1)
Adhesion to treatment area (y_2)	
Stickiness (y_3)	
Elasticity, viscosity	
Coolness at treatment area	
Application to treatment area	(stage 2)
Ease of removal of poultice from treatment area (y_4)	
Stickiness after application (y_5)	
Adhesion to treatment area (y_6)	
Softness when applied	
Consistency (*e.g.* paste runs out)	
Dare (slippage from treatment area) (y_7)	
Presence or absence of irritation, coolness	
Impression of residue	(stage 3)
Oily, greasy, or sticky residue on treatment area	
Ease of removal of residue	
Appearance of treated area (*e.g.* dull, slippery, matt)	
Presence or absence of irritation	

ointments and creams, viscoelastic measurements with a penetrometer,[14] and cone-plate viscometer,[12] and creep testing,[15] and oscillatory testing,[16] are useful in evaluating the physical properties of ointments and creams. However, few reports on rheological or textural studies of poultices are to be found, although there is one on an adhesivenss test of cataplasms by means of a rheometer.[17] A consistency profile for molded poultices, according Sherman,[10] is shown in Table II. One can regard sensory assessment of molded poultices as a four-stage process, which may be summarized as follows.

Stage 0: This stage covers initial assessment of molded poultices prior to use. Ease of removal of the poultice from laminated bags of aluminium foil, visual appearance of the poultice, and ease of removal of the liner from the paste are observed.

Stage 1: This stage covers initial contact of molded poultices with the treatment area. Adhesion of the poultice to the skin, and the stickiness and viscosity of the paste are observed.

Stage 2: This stage covers the period of application of molded poultices to the treatment area. Stickiness of the poultice after application, adhesion to the skin, and ease of removal of the poultice from the applied area are observed.

Stage 3: This stage covers residual impression. Oily, greasy, or sticky residue of the paste on the treatment area, ease of removal of the residue, appearance of the treated area of skin, and presence or absence of irritation are considered.

In the present investigation, six sensory characteristics (y_1—y_6 in Table II) were defined in order to simplify the discussion of sensory evaluations.

Sensory tests with four formulations of molded poultices were performed by 23 volunteers of both sexes, who were familiar with the definitions of the six characteristics. The average preference value (y_j) for a characteristic was assessed by the paired comparison method. The values, x_i, of rheological properties and properties selected as objective representative sensory characteristics were measured with appropriate instruments. The 23 subjects were asked to give an overall evaluation of the molded poultice and to note their degree of satisfaction with it. Overall preference (Y) was assessed from these scores by a paired comparison method.

TABLE III. Formulations of Molded Poultices

Components	Samples			
	A	B	C	D
a_1, gelatin	5	—	1.43	—
a_2, propylene glycol	8.5	8.34	8.34	8.34
a_3, sorbitol (70% aq. soln.)	12.5	11.92	11.92	11.92
a_4, polyvinyl alcohol	0.6	2.37	1	3
a_5, sodium polyacrylate	—	—	—	1
a_6, magnesium dichloride	7	3.5	3.5	—
a_7, alum	0.21	—	—	—
a_8, polybutene	4	9	9	9
a_9, kaolin	45.8	42.09	42.09	42.09
a_{10},minor constituents	1.27	0.2	0.2	0.2
a_{11},essential oil[a)]	3.8	3.8	3.8	3.8
a_{12},water added to	100 g	100 g	100 g	100 g

a) The essential oil contained *dl*-camphor (21% (w/v)), l-menthol (24%), methyl salicylate (24%), and peppermint oil (31%).

Experimental

Materials——The materials used to prepare the molded poultices are listed in Table III. Sodium polyacrylate, magnesium dichloride, and polybutene satisfied the requirements of the Japanese Standards of Food Additives. The sodium polyacrylate, obtained from Nippon Junyaku Co., Ltd., was of commercial grade (degree of polymerization, 30000—40000); and the polybutene (average molecular weight, 2350) was obtained from Furukawa Kogyo Co., Ltd. Polyvinyl alcohol of commercial grade (degree of substitution, 87—89%), with a Brookfield viscosity of 4% (w/v) in aqueous solution, 44—50 cP at 25 °C, and complying with the Japanese Standards of Cosmetic Ingredients, was obtained from Denki Kagaku Kogyo Co., Ltd. The other materials were of Japanese Pharmacopoeia quality. These materials, which are shown in Table III, were used without further treatment.

Preparation of Molded Poultices——Four formulations of molded poultices with the compositions shown in Table III were prepared by the following procedures. Gelatin suspended in propylene glycol and polyvinyl alcohol suspended in a 70% aqueous solution of sorbitol were added to hot water (60 °C) with stirring. The mixing was continued until the materials were fully dissolved, and then kaolin, the minor constituents, and polybutene were added. The mixture was allowed to cool to below 50 °C. After the essential oil was added, mixing was continued for a further 60 min. The resultant paste (100 g) was molded onto a backing cloth with a surface area of 700 cm^2 and the molded poultice was covered with a liner of polyethylene sheeting. These poultices were cut into pieces of 14 × 10 cm, and five pieces were packed in a laminated bag.

Sensory Evaluation——(1) Subjects and Definitions: Sensory tests were performed by 23 members of our laboratory staff of both sexes ranging in age from 25 to 45. The following six characteristics were assessed by a paired comparison method: 1. Peeling (y_1 at stage 0 in Table II)—degree of ease of removal of the liner from the paste. 2. Tackiness (y_2 at stage 1)—degree of adhesion to treatment area. 3. Stickiness (y_3 at stage 1)—amount of paste residue on the area where applied. 4. Peeling off 3 h after application (y_4 at stage 2)—degree of ease of removal of the molded poultice from the treatment area. 5. Stickiness at 3 h after application (y_5 at stage 2). 6. Tackiness at 3 h after application (y_6 at stage 2).

(2) Sensory Test I: The samples were paired in six pairs, *viz.* A–B, A–C, A–D, B–C, B–D, and C–D. A pair was presented at one time to the test subjects of the panelists, who were asked to evaluate the above characteristics individually after application to the skin of both forearms in a normal manner, and to note their degree of satisfaction with each characteristic in each pair according to the following scale, taking the A–B pair as an example:

Formulation A is far more satisfactory than B	+2
Formulation A is more satisfactory than B	+1
Formulations A and B are approximately equally satisfactory	0
Formulation A is less satisfactory than B	−1
Formulation A is far less satisfactory than B	−2

The pairs were then tested in reverse order (B–A, C–A, D–A, C–B, D–B, and D–C), keeping the identities of the samples unknown to the subjects. Each of the 23 subjects was tested 12 times. The scores thus obtained were analysed by the paired comparison method of Scheffé.[18]

(3) Sensory Test II: To obtain the degree, Y, of overall preference, overall sensory assessments were made as follows. Subjects were asked to give overall evaluations of the poultices and to note the degree of preference and pleasantness of each on a scale from 0 to 100 on the same paper which was employed for sensory test I. Scores for the comparative degree of pleasantness of the samples were obtained on the following scale, and the scores obtained from the 23 subjects were analyzed by Scheffé's method. Taking the A–B pair as an example,

where formulation A's evaluation was at least 20 more than formulation B's	+2
where formulation A's evaluation was from 5 to 19 more than formulation B's	+1
where the difference between formulation A's evaluation and formulation B's evaluations was 4 or less	0
where formulation A's evaluation was from 5 to 19 less than formulation B's	−1
where formulation A's evaluation was at least 20 less than formulation B's	−2

Measurement of Properties Representative of Textural Characteristics——In order to allow objective observations to be made in a reproducible manner using measuring instruments, instead of a sensory test, certain properties of molded poultices were selected as substitutes for textural characteristics, as follows: 1) Peeling (x_1 as a substitute for y_1 in Table II) was evaluated in terms of the weight of paste residue remaining on the plastic liner after the removal of this liner from the paste as slowly as possible by hand. 2) Tackiness (x_2 as a substitute for y_2 in Table II) was evaluated in terms of the force applied in the following peeling test. A sample of molded poultice was cut to 9 × 2 cm, and a 5 × 2 cm sample of it was placed on a glass plate previously coated with gelatin, and pressed three times with a roller weighing 2 kg (JIS Z-0237, 1980). This glass plate was placed on a copper plate at 37 °C for 3 min, then the poultice on the glass plate was peeled from the plate with a spring balance according to the 180° peeling test of JIS Z-0237, illustrated in Fig. 1. 3) Stickiness (x_3 as a substitute for y_3 in Table II) was evaluated in terms of the weight of the paste remaining on the glass plate after the peeling test. 4) "Dare" (x_4) is the length observed in the following "Dare" test. A sample poultice was cut to 2 × 5 cm and placed on a cellophane sheet, and then pressed three times with the 2 kg roller and made to adhere. This sheet of cellophane was placed on a wet piece of cotton gauze, as shown in Fig. 2. The distance that the sample poultice slipped down on the cellophane sheet in 5 min was measured. This test was designed to provide an index of the slippage of a poultice on a treatment area after weakening of the gel network-structure of the paste by the absorption of sweat from the skin.

Measurement of Rheological Properties[19]——The rheological properties of a paste were observed by using a

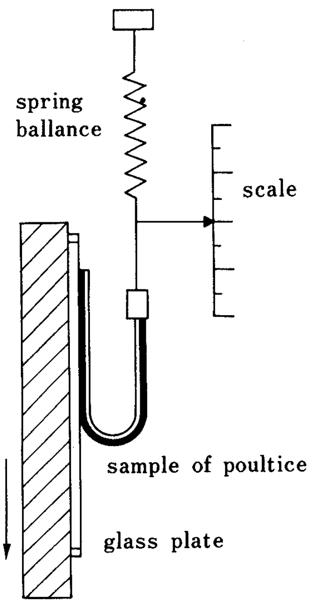

Fig. 1. Schematic Drawing of the Peeling Test Apparatus

A, sample poultice; B, spring balance; C, scale; D, glass plate.

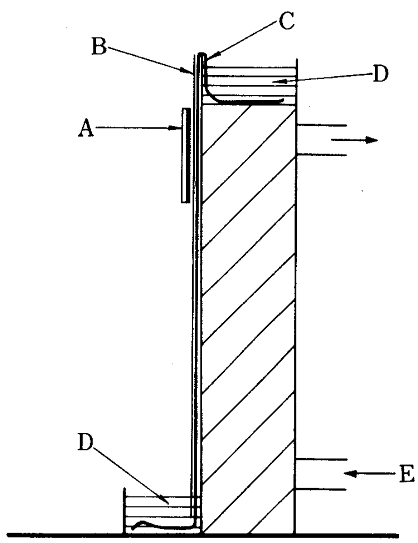

Fig. 2. Schematic Drawing of the "Dare" Test Apparatus

A, sample poultice; B, cellophane paper; C, cotton gauze; D, water; E, hot water at 37 °C.

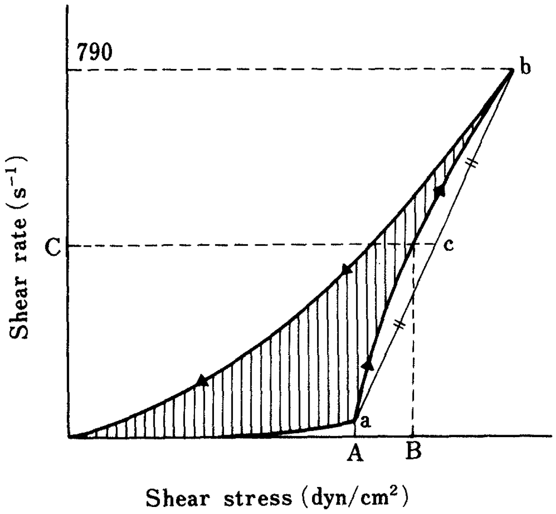

Fig. 3. Schematic Drawing of a Rheogram Obtained with a Cone-Plate Viscometer

$\overline{ac} = \overline{bc}$; A = yield value; B/C = average viscosity.

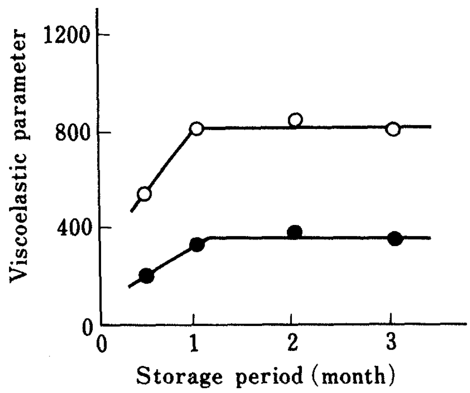

Fig. 4. The Effect of Storage Period on the Rheological Properties of Molded Poultice A

—○—, average viscosity (poise); —●—, yield value (× 10^3 dyn/cm^2).

TABLE IV. Values of Physical Properties for the Four Formulations of Molded Poultices

Properties	Formulation			
	A	B	C	D
x_1	0.0	0.26	0.36	0.15
x_2	59	75	78	46
x_3	0.01	0.21	0.36	0.02
x_4	14	12	60	60
x_5	39.6	112	24.6	97.8
x_6	822	1590	647	1520
x_7	12.3	33	11	24.3

Ferranti–Shirle cone-plate viscometer with an automatic flow curve recorder unit. A 1.00 cm cone with cone angle of 0.00647 rad was used. The calibration of the viscometer was checked using standard viscometer oils showing Newtonian flow. A schematic drawing of this rheogram is shown in Fig. 3. The yield value (x_5 in Table I) was the shear stress A at the point a in the up curve of the rheogram of Fig. 3. Average viscosity (x_6 in Table I) was obtained in the up curve with the shear stress B at the shear rate C, which is the average of the shear rates at the yield point a and the maximum point b in Fig. 3. The hysteresis loop area (x_7 in Table I), corresponding to the shaded area of the rheogram in Fig. 3, was obtained with a planimeter.

Results and Discussion

Effect of Storage Period on the Properties of Molded Poultices

When five molded poultices were packed in a bag of laminated aluminium foil, their paste stiffened with time for the following reasons: (1) the paste is thixotropic; (2) in a closed bag, the water and oils in the paste gradually seep into the backing cloth and the plastic liner. A certain storage time, called the aging time, is necessary for a molded poultice to reach equilibrium. The rheological properties of sample A in Table III were determined and are plotted in Fig. 4 against the storage period at room temperature (about 23 °C). The slopes of average viscosity and of yield value *versus* storage time are very steep over the first month, but thereafter scarcely change. The samples used in this study were stored for two months at room temperature.

Properties of Molded Poultices

The rheological and substitute properties of the four formulations of molded poultices are presented in Table IV. As regards the rheological properties, formulations A and C, which contained gelatin, had relatively low values of yield value, average viscosity, and hysteresis loop area, measured at 37 °C. The consistency of these pastes prepared with gelatin was soft at this temperature. Formulation A contains 4% and formulation D contains 9% polybutene, which was used to provide tackiness. Nevertheless, formulation A showed a higher x_2 value than formulation D. It is not always the case that formulas containing large amounts of tacky agent show higher x_2 values. The value of x_2 of formulation A may depend not only on the quantity of polybutene but also on the quantities of the other ingredients in the formula. Hence a property of a molded poultice may not always be attributable to the properties of one of its constituents.

Results of Sensory Evaluations

The subjective data on the six textural characteristics, obtained through sensory assessments repeated 12 times by each of the 23 subjects according to the paired comparison method of Scheffé, are shown in Tables V (for peeling, y_1), VI (for tackiness, y_2), and VII (for overall preference, Y).

The average preferences calculated from these data for the four formulations are given in Table VIII, at a level of significance of $p<0.05$ as determined by variance analysis.

Higher positive values of y_j indicate greater preferences for the poultices, but none of the tested poultices gave a high preference for all characteristics. Thus, formulation A, which shows the highest value, 0.912, for overall preference, Y, nevertheless has a lower value of y_2, -0.250, than formulations B and C.

Texture Profiling

(1) Correlation between Textural Characteristics and Physical Properties——If the relation between the preference value for the j'th textural characteristic, y_j, and the value of the i'th mechanical property, x_i, could be ascertained, it would be easy to design and to

Table V. Sensory Assessment Data Obtained by the Paired Comparison Method of Scheffé for Peeling, y_1

Sample	Scale −2	−1	0	+1	+2	Total score
A–B				8	15	38
B–A	17	6				−40
A–C			1	4	18	40
C–A	19	4				−42
A–D			4	6	13	32
D–A	7	9	7			−23
B–C			12	9	2	13
C–B	2	5	16			−9
B–D	20	3				−43
D–B				4	19	42
C–D	14	4	5			−32
D–C			4	9	10	29
Total score	79	31	42	40	77	5

Table VI. Sensory Assessment Data Obtained by the Paired Comparison Method of Scheffé for Tackiness, y_2

Sample	Scale −2	−1	0	+1	+2	Total score
A–B	3	9	11			−15
B–A			11	10	2	14
A–C	4	10	9			−18
C–A			9	13	2	17
A–D			14	9		9
D–A	1	7	16			−9
B–C		6	17			−6
C–B			19	4		4
B–D			3	15	5	25
D–B	4	13	6			−21
C–D			4	13	6	25
D–C	7	12	4			−26
Total score	19	57	123	64	15	−1

TABLE VII. Sensory Assessment Data Obtained by the Paired Comparison Method of Scheffé for Overall Preference Y

Sample	Scale −2	−1	0	+1	+2	Total score
A–B			4	12	7	26
B–A	7	15	1			−29
A–C				15	8	31
C–A	9	12	2			−30
A–D			4	13	6	25
D–A	9	9	5			−27
B–C			19	3	1	5
C–B		4	19			−4
B–D		3	20			−3
D–B		1	22			−1
C–D	1	5	17			−7
D–C			15	7	1	9
Total score	26	49	128	50	23	−5

TABLE VIII. Average Preference Values for the Four Formulations on Sensory Assessment by Scheffé's Method

Sensory characteristic	Formulation A	B	C	D
y_1	1.1685	−0.7663	−0.8967	0.4946
y_2	−0.2500	0.3533	0.5217	−0.6250
y_3	0.5924	−0.4185	−0.3261	0.1522
y_4	0.4946	−0.7554	−0.2554	0.5136
y_5	0.4565	−0.6141	−0.2228	0.3804
y_6	0.3043	0.6739	−0.5054	−0.4728
Y	0.9120	−0.2600	−0.4670	−0.1850

TABLE IX. Correlations between the Preference Values (y_j) and Physical Properties (x_i) of Molded Poultices

Regression equation	Proportion r^2	F value (V_e)
$y_1^*=-0.967x_1^*$	0.935	28.8 (0.10)
$y_2^*=0.996x_2^*$	0.993	2706.0 (0.001)
$y_3^*=-0.836x_3^*$	0.698	4.6 (0.45)
$y_4^*=-0.757x_3^*$	0.573	2.7 (0.64)
$y_5^*=-0.769x_3^*$	0.591	2.9 (0.61)
$y_6^*=-0.973x_4^*$	0.947	35.7 (0.08)

r is the regression coefficient and V_e is the unbiased variance of the residual. $n=4$, $F_2^1(0.05)=18.5$ and $F_2^1(0.01)=98.5$.

develop molded poultices by purely technical means, without the need for subjective evaluation. The following procedures[20] were used to obtain these relations: a) The average preferences shown in Table VIII were used as y_j, and the values of the properties given in Table IV were used as x_i. b) These values of y_j and x_i were standardized using the following equation:

$$y_j^*=(y_j-\bar{y}_j)/\sigma_y \quad (1)$$

$$x_i^*=(x_i-\bar{x}_i)/\sigma_x \quad (2)$$

where $\bar{y}_j$ and $\bar{x}_i$ are the mean values of y_j and x_i; σ_y and σ_x are the standard deviations of y_j and x_i; y_j^* and x_i^* are the standard variables,[20] of which the mean values are zero and standard deviations are 1. c) The relations between y_j^* and x_i^* were obtained as linear regression equations with a calculator. The results are shown in Table IX. The equations for y_1^*, y_3^*, y_4^*, y_5^*, and y_6^* show negative regression coefficients; high positive values of these y_j correspond to low values of x_i. The regression equations of y_3^*, y_4^*, and y_5^* showed lower values of F ratio in variance analysis than the other equations. These low values were probably the result of the high values of unbiased variance, V_e, of the residual in Table IX.

Proportion, r^2, is a ratio of the variation of the value, y, predicted from x to the total variation of the objective value.[20] For example, $r^2=0.935$ in the regression equation of y_1^* in Table IX is 93.5% of the total variation. Oishi *et al.*[14] obtained $r^2=0.599$ and 0.602 between the results of sensory tests and those of physical consistency measurements by means of a curd meter and a spread meter on seven admixtures of petrolatum and liquid paraffin. Anzaldua-Morales and Brennan[21] studied the relationship between the physical properties of dried beans and their textural characteristics after processing and reported that the maximum force for 50% compression of uncooked beans (X_f) was related to the sensory firmness (Y_f) of baked beans by the equation, $Y_f=4.9-0.0014\ X_f$ ($r^2=0.436$, $n=6$). X_f was related sensory chewiness (Y_c) according to the equation, $Y_c=3.1-0.000117\ X_f$ ($r^2=0.533$, $n=6$). In comparison with these results, the regression equations in Table IX can be said to show quite good correlations between y_j and x_i. The subjects sweated comparatively little, so that "Dare," y_7 could not be evaluated. However, this relation had already been tested and Eq. 3 obtained by means of sensory tests in a sauna bath.

$$y_7^*=-0.743x_5^*-0.392x_4^*-0.041 \qquad (3)$$

$$(r^2=0.593)$$

The proportion, r^2, of the Eq. 3 was greater than that of the regression equation between y_7^* and x_4^* (data not shown).

(2) Overall Sensory Evaluation——It is desirable for a liner film to be easy to peel from the paste of a poultice and for the poultice itself not to become detached from the treatment area. There should thus be a balance among the textural characteristics of a molded poultice. This balance was assessed as the overall evaluation (Table VIII). Formulation A gave the highest value for Y and formulation C the lowest. The relation (2) between Y^* and y_j^* can be written as follows:

$$Y^*=A_0+A_1y_1^*+\cdots+A_jy_j^*+\cdots+A_6y_6^* \qquad (4)$$

where A_j is a coefficient value. Observed values of Y number only four in Table VIII for molded poultices A, B, C, and D, so that Eq. 4 can not be solved for six independent variables. Combinations of three independent variables were tested. Taking y_1^*, y_2^*, and y_3^* as an example,

$$Y^*=-0.32+4.82y_1^*+1.55y_2^*-2.46y_3^* \qquad (5)$$

This equation yields the following balance among y_1, y_2, and y_3:

$$y_1:y_2:y_3=4.82:1.55:-2.46 \qquad (6)$$

Equation 6 indicates that peeling, y_1, is one of the most important characteristics, and that stickiness, y_3, decreases with increase in overall preference, Y. The regression equation of y_3 with x_3 in Table IX indicates that an increase of x_3 corresponds to a decrease of y_3. The subjects preferred stickier and tackier poultices than those used in this test, because the areas treated on the arms are more mobile and less liable to sweat than areas on the shoulders and back. The optimum balance of y_j may thus depend on the area of skin treated and the season. Therefore, the relation between overall preference Y and y_j will be dependent on the intended usage of the poultice.

Conclusion

Four formulations of molded poultices were prepared. Their physical properties, x_i, were measured and sensory tests were performed by 23 subjects to obtain preference values for textural characteristics, y_j, according to the paired comparison method of Scheffé. The relation between y_j and x_i was obtained (Table IX) by linear regression analysis, and the proportion, r^2, was calculated for each characteristic. Values of 0.573—0.993 were obtained.

Overall preference, Y, was assessed using the same sensory test. The relation between Y and y_j appeared to vary depending on the treated area of skin and the season. It might be practical to set up this relationship in advance according to the intended purpose of the molded poultice.

Optimum formulations of molded poultices obtained with the aid of these relationships will be discussed in the next paper.

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