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A METHOD FOR EVALUATION OF ACID POTENTIALITIES OF FOODS

by
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INTRODUCTION

Various laboratory and clinical tests as well as animal test systems have been developed for evaluation of the cariogenic properties of foods and beverages. These include tests based on acid production in suspensions of oral microorganisms or in food-saliva mixtures as well as animal experiments preferably on rats and hamsters. Small scale experiments have also been perfomed which intend to elucidate the cariogenic properties of foods by measuring the pH-changes developing in the dental plaques after ingestion of foods.

The present communication deals with a method for determinations of the acidogenic properties of foods in large scale experiments on the pH-changes occurring in dental plaques after intake of various kinds of foods.

The pH-changes occurring in the dental plaques of a group of persons after intake of a certain foodstuff or beverage were thus compared to those occurring after a sucrose rinse or after intake of some other type of food or beverage by the same persons.

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MATERIAL AND METHODS

Persons preferably between 20 and 50 years of age having active caries and a moderate to high tendency of accumulating dental plaque material were chosen. Before an experiment the subject had to refrain from toothbrushing for two days and appear in the laboratory in the morning of the third day without having brushed his teeth or having eaten or drunk anything except tap water. The subject was asked to rinse his mouth with tap water to remove loose debris on the teeth. Dental plaque material was collected with a blunt instrument from about 20 different spots on and between the teeth. The material was pooled in one drop of distilled water on a Beckman one-drop electrode connected to a Beckman Zeromatic or Expandomatic pH-meter, and the pH was determined.

The person was then asked to eat a certain amount (usually 2—5 grams) of the food to be tested or drink a certain amount (usually 10 ml) of a liquid to be tested. After 2, 5, 10, 20 and 30 minutes, the pH of the pooled plaque material from about 20 spots close to those tested at the first experiment was determined as previously described. Each sampling took about 10—15 seconds. The subject was asked to remain in the chair in a relaxed position, during the whole experiment. The experiments were usually performed with 18 different persons.

A second experiment with the same material was performed a few days later in exactly the same way.

During every experiment the pH-meter (which was calibrated against a standard buffer pH 6.00) was tested against standard buffers, pH 6.00 and 5.00.

Two tables containing the results of the experiments with the patient group were arranged (Tables II and III). In the tables the differences between initial pH and the pH at a certain time point were also given.

The table may also contain the consumption times in minutes if this information was considered to be of importance.

Determination of the error of the method. Ten identical experiments were performed with one person during five weeks. For each experiment the subject rinsed his mouth with a 50 per cent sucrose solution for 30 seconds.

The results are given in Table I and Fig. 1. The standard deviations of the pH-values and the pH-changes at the different time intervals were calculated. The standard error of the mean is also given for each time interval.

Statistical evaluation of the results. The pH-values read on the meter were used directly for the determination of mean pH-values. The reason for this is that it has been found that the pH-values were more evenly dis-

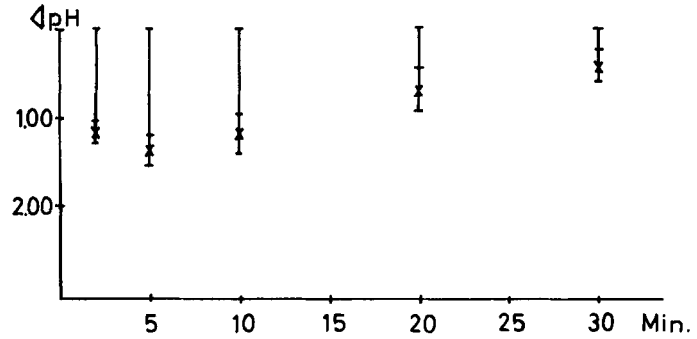

Fig. 1. Standard deviations at the different time intervals determined by 10 identical experiments.

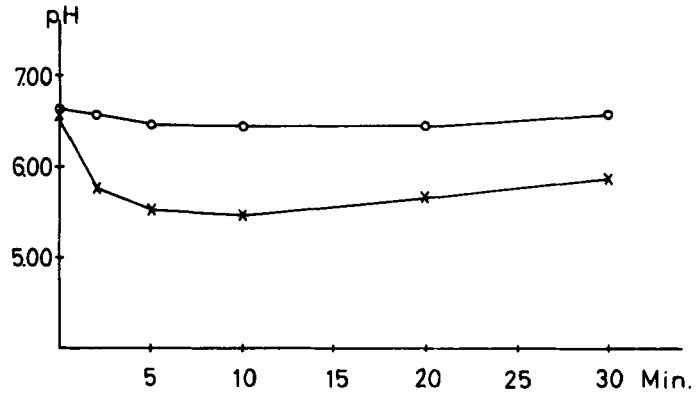

Fig. 2. Changes in pH of the dental plaques after a mouth rinse for 30 seconds with a 50 per cent sucrose solution (×—×) or a 50 per cent raw starch solution (0—0). Mean of 18 subjects.

tributed around the mean pH than were the actual H^+-concentration values around the arithmetic mean of these values.

Since the object of the investigation was to determine the influence of various factors on plaque pH and since the standard deviations of the pH-decreases as expected were smaller than those of the pH-values (Table I), the calculations were performed on the pH-decreases and not on the actual pH-values. Thus the results will give the pH-decreases and the differences between the pH-decreases (on comparison, for example, between the values given in Table II and III) which can be expected if the experiments are carried through with large series of persons.

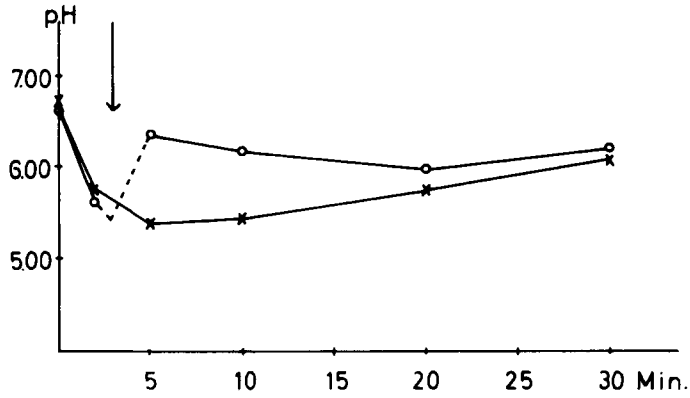

Fig. 3. Changes in pH of the dental plaques after a mouth rinse for 30 seconds with a 25 per cent sucrose solution (×—×) and a sucrose rinse followed after 3 minutes by a second rinse with a 0.5 per cent carbamide solution (0—0).

For the calculations Students't-test was applied. In order to reduce operational work an Olivetti Programma computer was used, which was found to be a great help.

FINDINGS

Comparison between a 50 per cent sucrose solution and a 50 per cent starch solution. Mercks'soluble starch (50 g in 100 ml) without any additions was dissolved or suspended in water. The solution was not heated. For comparison experiments with a 50 per cent sucrose solution were performed.

The results are given in Tables II, III and IV, and in Fig. 2.

The starch solution caused only slight pH-changes in the plaques, whereas the sucrose solution caused considerable pH-decreases. The difference was highly significant at all time intervals.

Effects of a mouth rinse with carbamide on the pH-changes in the dental plaques after intake of sugar. In the first experiment every person rinsed his mouth with a 25 per cent sucrose solution (10 ml for 30 seconds). In the second experiment the person first rinsed his mouth for 30 seconds with 10 ml of a 25 per cent sucrose solution. After 3 minutes he rinsed again for 30 seconds with a 0.5 per cent carbamide ($NH_2 \cdot NH_2 \cdot CO$) solution. Experiments were performed with 18 persons.

The results are given in Fig. 3 and Tables IV, V and VI.

The carbamide solution significantly reduced the pH-decrease after 5, 10 and 20 minutes but not after 30 minutes.

Table I.

pH-values and pH-differences of superficial dental plaques after a mouth rinse with 10 ml of a 50 per cent sucrose solution for 30 seconds.

Ten identical experiments

Pat.		0 pH	2 pH	2 diff	5 pH	5 diff	10 pH	10 diff	20 pH	20 diff	30 min. pH	30 min. diff
O.E.		7,35	6,30	1,05	5,95	1,40	6,10	1,25	6,40	0,95	6,80	0,55
O.E.		7,05	6,15	0,90	5,70	1,35	5,05	1,10	6,80	0,25	7,00	0,05
O.E.		7,40	6,20	1,20	5,85	1,55	5,70	1,70	6,40	1,00	6,80	0,60
O.E.		7,00	6,00	1,00	5,65	1,35	5,75	1,25	6,10	0,90	6,60	0,40
O.E.		7,35	6,30	1,05	5,75	1,60	6,15	1,20	6,65	0,70	6,80	0,55
O.E.		7,20	6,00	1,20	6,10	1,10	6,20	1,00	6,70	0,50	6,80	0,40
O.E.		7,15	5,80	1,35	5,70	1,45	5,80	1,35	6,40	0,75	6,50	0,65
O.E.		7,30	6,30	1,00	5,95	1,35	6,00	1,30	6,70	0,60	6.95	0,35
O.E.		7,35	6,35	1,00	6,15	1,20	6,50	0,85	7,00	0,35	7,00	0,35
O.E.		7,00	5,95	1,05	5,70	1,30	5,90	1,10	6,15	0,85	6,80	0,20
M:		7,22	6,14	1,08	5,85	1,37	6,01	1,21	6,53	0,69	6,81	0,41
Figures	$\bar{x}$	7,2150	6,1350	1,0800	5,8500	1,3650	6,0050	1,2100	6,5300	0,6850	6,8050	0,4100
given by	SD	0,1562	0,1870	0,1315	0,1794	0,1489	0,2418	0,2282	0,2877	0,2559	0,1606	0,1865
the computer	SE	0,0493	0,0591	0,0415	0,0567	0,0470	0,0764	0,0721	0,0909	0,0809	0,0507	0,0589
	t	146,3488	103,8071	26,0240	103,1746	29,0425	78,5994	16,7822	71,8371	8,4672	134,2209	6,9609
	c	0,0216	0	0,1217	0,0306	0,1090	0,0402	0,1885	0,0440	0,3735	0,0236	0,4548

$\bar{x}$ = difference from zero = arithmetic means
SD = standard deviation
SE = standard error
t = t-value
c = variation coefficient

Table II.

Changes in pH of the dental plaques after a mouth rinse with a 50 per cent sucrose solution for 30 seconds

	0	2		5		10		20		30 min	
Pat.	pH	pH	diff	pH	diff	pH	diff	pH	diff	pH	diff
♀ B.S.	6.71	6.23	0.48	5.71	1.00	5.62	1.09	5.69	1.02	6.21	0.50
♀ G.R.	6.73	6.09	0.64	5.81	0.92	5.42	1.31	5.83	0.90	6.13	0.60
♀ K.S.	6.53	5.82	0.71	5.67	0.86	5.63	0.90	5.98	0.55	6.23	0.30
♂ D.C.	6.41	5.53	0.88	5.38	1.03	5.32	1.09	5.78	0.63	5.90	0.51
♀ A-K.S.	6.36	5.92	0.44	5.83	0.53	5.61	0.75	5.81	0.55	6.08	0.28
♀ A-K.E.	6.42	6.01	0.41	5.69	0.73	5.58	0.84	6.03	0.39	6.28	0.14
♀ R.L.	6.31	5.63	0.68	5.51	0.80	5.47	0.84	5.78	0.53	5.95	0.36
♂ L.E.	6.77	5.58	1.19	5.40	1.37	5.00	1.77	5.10	1.67	5.55	1.22
♂ P-E.S.	6.53	5.43	1.10	5.02	1.51	5.23	1.30	5.42	1.11	5.91	0.62
♂ S.K.	6.67	5.82	0.85	5.53	1.14	5.49	1.18	5.63	1.04	5.73	0.94
♂ O.E.	6.90	5.70	1.20	5.69	1.21	6.15	0.75	6.19	0.71	6.30	0.60
♀ S.S.	6.81	5.93	0.88	5.52	1.29	5.40	1.41	5.71	1.10	5.72	1.09
♀ E.E.	6.45	5.40	1.05	5.05	1.40	5.33	1.12	5.42	1.03	5.71	0.74
♂ B.K.	6.80	5.98	0.82	5.73	1.07	5.70	1.10	5.85	0.95	6.00	0.80
♂ R.E.	6.41	5.82	0.59	5.48	0.93	5.30	1.11	5.50	0.91	5.68	0.73
♀ M.T.	6.10	5.88	0.22	5.30	0.80	5.75	0.35	5.25	0.85	5.10	1.00
♀ B.L.	7.10	5.80	1.30	5.80	1.30	5.42	1.68	5.98	1.12	6.40	0.70
♀ G.K.	6.00	5.30	0.70	5.42	0.58	4.80	1.20	5.22	0.78	5.20	0.80
M:	6.56	5.77	0.79	5.53	1.03	5.46	1.10	5.68	0.88	5.89	0.67

DISCUSSION

This method will give information on pH-changes caused in superficial dental plaques by contact with different types of foods and beverages and other substances. The results would probably be different if interdental plaque pH was measured. The investigations are continued in order to compare the results of this method with those obtained with measurements on interdental plaques, which cannot as easily be carried through on a large scale.

The results indicate that a difference in mean pH exceeding 0.3 pH-units was usually statistically significant at a 1 per cent level provided that experiments were performed with 18 persons. A mean difference exceeding 0.5 pH-units was usually significant at a 0.1 per cent level.

Table III.

Changes in pH of the dental plaques after a mouth rinse with a 50 per cent starch solution for 30 seconds

Pat.	0 pH	2 pH	2 diff	5 pH	5 diff	10 pH	10 diff	20 pH	20 diff	30 min. pH	30 min. diff
♀ B.S.	6.40	6.50	+0.10	6.30	0.10	6.35	0.05	6.45	+0.05	6.60	+0.20
♀ G.R.	6.20	6.25	+0.05	5.90	0.30	6.05	0.15	6.15	0.05	6.20	0
♀ K.S.	6.75	6.60	0.15	6.50	0.25	6.65	0.10	6.70	0.05	6.90	+0.15
♂ D.C.	6.60	6.70	+0.10	6.80	+0.20	6.60	0	6.80	+0.20	6.90	+0.30
♀ A-K.S.	7.40	7.50	+0.10	6.90	0.50	7.80	+0.40	6.90	0.50	6.90	0.50
♀ A-K.E.	6.80	6.50	0.30	6.80	0	6.80	0	6.80	0	6.70	0.10
♀ R.L.	6.30	5.85	0.45	5.95	0.35	5.70	0.60	5.70	0.60	6.10	0.20
♂ L.E.	6.40	6.50	+0.10	6.30	0.10	6.00	0.40	6.10	0.30	6.20	0.20
♂ P-E.S.	6.70	6.50	0.20	6.60	0.10	6.40	0.30	6.70	0	6.75	+0.05
♂ S.K.	6.80	6.15	0.65	6.40	0.40	6.60	0.20	6.40	0.40	6.65	0.15
♂ O.E.	6.80	6.70	0.10	6.65	0.15	6.75	0.05	6.80	0	6.90	+0.10
♀ S.S.	6.70	6.85	+0.15	6.70	0	6.70	0	6.60	0.10	6.90	+0.20
♀ E.E.	6.50	6.10	0.40	6.20	0.30	5.80	0.70	6.10	0.40	6.35	0.15
♂ B.K.	6.70	6.75	+0.05	6.50	0.20	6.50	0.20	6.55	0.15	6.65	0.05
♂ R.E.	6.30	6.50	+0.20	6.30	0	5.90	0.40	6.00	0.30	6.10	0.20
♀ M.T.	6.20	6.40	+0.20	6.10	0.10	6.00	0.20	6.10	0.10	6.10	0.10
♀ B.L.	6.60	6.75	+0.15	6.40	0.20	6.70	+0.10	6.60	0	6.80	+0.20
♀ G.K.	7.10	7.10	0	6.90	0.20	6.75	0.35	6.90	0.20	7.00	0.10
M:	6.63	6.57	0.06	6.46	0.17	6.45	0.18	6.46	0.17	6.59	0.04

Table IV.

a) Comparison between sucrose (25 per cent) and sucrose followed by carbamide rinse (0.5 per cent) at 3 minutes

	2	5	10	20	30 min.
Sucrose	0.99	1.35	1.29	0.97	0.64
Sucrose + carbamide rinse	1.00	0.26	0.46	0.65	0.41
Difference	0.01	1.09	0.83	0.32	0.23
t-value	0.07	9.45	5.83	1.94	1.50
Level of significance	—	***	***	*	—

b) Comparison between a sucrose rinse (50 per cent) and a starch rinse (50 per cent.)

	2	5	10	20	30 min.
Sucrose	0.79	1.03	1.10	0.88	0.67
Starch	0.06	0.17	0.18	0.17	0.04
Difference	0.73	0.86	0.92	0.71	0.63
t-value	8.44	10.07	9.69	8.40	7.54
Level of significance	***	***	***	***	***

Table V.

pH-changes in the dental plaques after a mouth rinse with a 25 per cent sucrose solution for 30 seconds

Pat.	0 pH	2 pH	2 diff	5 pH	5 diff	10 pH	10 diff	20 pH	20 diff	30 min. pH	30 min. diff
♀ B.S.	6.90	5.60	1.30	5.58	1.32	5.31	1.59	5.95	0.95	6.40	0.50
♀ G.R.	6.50	5.90	0.60	5.40	1.10	5.39	1.11	5.78	0.72	6.00	0.50
♀ K.S.	7.20	5.68	1.52	5.90	1.30	6.15	1.05	6.68	0.52	6.79	0.41
♀ A-K.S.	6.80	5.70	1.10	5.71	1.09	6.05	0.75	6.00	0.80	6.45	0.35
♀ A-K.E.	6.82	5.75	1.07	5.30	1.52	5.68	1.14	6.50	0.32	6.65	0.17
♀ R.L.	6.60	5.68	0.92	5.10	1.50	5.15	1.45	5.30	1.30	5.90	0.70
♂ L.E.	6.60	5.90	0.70	5.45	1.15	5.30	1.30	5.20	1.40	5.60	1.00
♂ P-E.S.	7.19	6.30	0.89	5.40	1.79	6.05	1.14	6.00	1.19	6.85	0.34
♂ O.E.	6.90	5.35	1.55	5.20	1.70	5.10	1.80	5.95	0.95	6.40	0.50
♀ S.S.	6.45	5.95	0.50	5.40	1.05	5.91	0.54	6.40	0.05	6.50	+0.05
♀ E.E.	6.57	5.10	1.47	4.80	1.77	4.82	1.75	5.60	0.97	5.98	0.59
♂ B.K.	6.72	5.79	0.93	4.90	1.82	5.11	1.61	5.30	1.42	5.60	1.12
♂ R.E.	6.91	6.42	0.49	5.75	1.16	5.30	1.61	5.49	1.42	5.91	1.00
♂ J.O.	6.81	6.20	0.61	6.20	0.61	5.50	1.31	5.52	1.29	5.85	0.96
♀ M.T.	6.61	5.90	0.71	6.15	0.46	6.21	0.40	5.79	0.82	5.25	1.36
♀ Ch.S.	6.63	5.89	0.74	5.30	1.33	5.10	1.53	6.09	0.54	6.11	0.52
♂ R.F.	6.65	6.10	0.55	5.11	1.54	5.40	1.25	5.80	0.85	6.80	+0.15
♀ B.L.	6.48	4.30	2.18	4.48	2.00	4.60	1.88	4.50	1.98	4.82	1.66
M:	6.74	5.75	0.99	5.40	1.35	5.45	1.29	5.77	0.97	6.10	0.64

The contact time between plaque and substrate has been kept constant in most experiments. However, in many cases it may be more practical to study the changes in pH after natural consumption of the food. Such experiments have also been carried through (*Frostell*, 1965, 1969).

The results obtained with starch confirm the opinion that starch has usually little influence on dental plaque pH.

The method presented probably gives information on the primary acid attack caused by different foods on accessible tooth surfaces. It does not, however, give complete information on the cariogenicity of a certain foodstuff, since cariogenicity is determined by other factors also except the primary acid attack demonstrated, for example, implantation and stimulation of growth of caries-inducing micro-organisms, content of substrate for polysaccharide production and content of factors influencing mineralized tooth substance solubility.

Table VI.

pH-changes in the dental plaques in 18 subjects after a mouth rinse with sucrose (25 per cent) for 30 seconds followed after 3 minutes by a second rinse with 0.5 per cent carbamide

	0	2		5		10		20		30 min.	
Pat.	pH	pH	diff	pH	diff	pH	diff	pH	diff	pH	diff
♀ B.S.	6.90	5.75	1.15	7.10	+0.20	6.58	0.32	6.80	0.10	6.50	0.40
♀ G.R.	6.59	5.80	0.79	6.20	0.39	6.28	0.31	5.50	1.09	6.09	0.50
♀ K.S.	5.56	5.05	0.51	6.22	+0.66	4.48	1.08	4.51	1.05	4.82	0.74
♀ A-K.S.	6.60	5.58	1.02	6.01	0.59	5.80	0.80	5.85	0.75	6.30	0.30
♀ A-K.E.	7.10	5.60	1.50	6.58	0.52	6.80	0.30	6.70	0.40	6.65	0.45
♀ R.L.	6.70	5.68	1.02	6.10	0.60	6.15	0.55	6.35	0.35	6.70	0
♂ L.E.	6.51	5.72	0.79	6.50	0.01	6.09	0.42	5.91	0.60	6.15	0.36
♂ P-E.S.	7.22	6.00	1.22	6.70	0.52	6.41	0.81	6.25	0.97	6.42	0.80
♂ O.E.	6.81	5.02	1.79	5.90	0.91	5.98	0.83	6.02	0.79	6.18	0.63
♀ S.S.	6.28	4.87	1.41	5.50	0.78	5.99	0.29	5.10	1.18	5.40	0 88
♀ E.E.	6.18	5.55	0.63	5.82	0.36	6.80	+0.62	6.41	+0.23	6.60	+0.42
♂ B.K.	7.08	5.82	1.26	6.51	0.57	6.11	0.97	5.63	1.45	5.68	1.40
♂ R.E.	6.40	5.30	1.10	6.55	+0.15	6.10	0.30	5.85	0.55	6.40	0
♂ J.O.	6.80	5.55	1.25	6.58	0.22	5.68	1.12	5.70	1.10	6.10	0.70
♀ M.T.	6.00	5.72	0.28	6.15	+0.15	6.10	+0.10	4.85	1.15	5.81	0.19
♀ Ch.S.	6.88	6.61	0.27	7.50	+0.62	6.91	+0.03	7.30	+0.42	7.15	+0.27
♂ R.F.	7.21	6.32	0.89	6.75	0.46	6.91	0.30	6.68	0.53	6.97	0.24
♀ B.L.	6.58	5.46	1.12	6.01	0.57	6.00	0.58	6.38	0.20	6.02	0.56
M:	6.63	5.63	1.00	6.37	0.26	6.18	0.46	5.99	0.65	6.22	0.41

SUMMARY

A method is described for the evaluation of the influence of foods and beverages on the dental plaque pH in the post-consumption period. Double experiments were performed, usually with 18 persons, with the two substances which are to be compared. Dental plaque pH was determined after 2, 5, 10, 20 and 30 minutes and the values obtained were compared statistically. The accuracy of the method was determined and its limitations were discussed.

RÉSUMÉ

MÉTHODE POUR L'ÉVALUATION DE L'ACIDITÉ POTENTIELLE DES ALIMENTS

L'auteur décrit une méthode destinée à évaluer l'influence de certains aliments et de certaines boissons sur le pH de la plaque microbienne dentaire pendant la période suivant la consommation. Des expériences doubles ont

été effectuées, en général sur 18 personnes, avec les deux substances devant être comparées. Le pH de la plaque microbienne dentaire a été déterminé au bout de 2, 5, 10, 20 et 30 minutes, et les valeurs obtenues ont été comparées par méthode statistique. La précision de cette méthode a été déterminée et ses limites ont fait l'objet d'une discussion.

ZUSAMMENFASSUNG

EINE METHODE FÜR BESTIMMUNG DER SÄUREPOTENTIALE VON LEBENSMITTELN

Eine Methode für die Beurteilung von der Wirkung von Nahrungsmitteln und Getränken an der Plaque-pH während der Postkonsumtionsperiode wurde beschrieben. Doppelexperimente, gewöhnlich mit 18 Patienten, wurden mit zwei Substanzen, die verglichen werden sollen, gemacht. Das dentale Plaque-pH wurde nach 2, 5, 10, 20 und 30 Minuten bestimmt, und die so bekommenen Werte wurden statistisch verglichen. Die Genauigkeit der Methode und Ihre Einschränkungen wurden diskutiert.

REFERENCES

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