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RESEARCH PAPER

# A Quantified Study on Toothpaste Abrasiveness*

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## ABSTRACT

*The authors quantified the abrasiveness of toothpastes found on the market by using a profilometric technique. This technique is based on the study of the surface state of polymethacrylate plates submitted to a brushing simulation. The study of the profiles obtained experimentaly allowed determination of two values: one (A) that gives the total quantity eroded and one (a) that gives the quality, which means the regularity of this abrasion. Depending on the values of A and a obtained, it is possible to classify the toothpastes as: very slightly abrasive, slightly abrasive, abrasive, and very abrasive.*

## INTRODUCTION

Toothpastes, according to French and European legislation, are cosmetics meant to clean, polish, protect, and sometimes treat teeth and gums.

Their abrasive power is the result of the addition in the formula of substances with abrasive properties of mineral (calcium carbonate, silica), animal (cuttlebone), or plant (cork powder) origin in the proportion of 20% to 50%. These abrasive powders are associated with binding agents, humectants, foaming substances, sweeteners, preservatives, and active principles (antitartar or antidecay) (1). The intrinsic hardness of an abrasive powder can be classified following the Moh scale, graduated from 1 (for talc) to 10 (for diamond).

Abrasive agents also have a cleaning power (2,3) and a polishing power (4,5) as well as their own abrasive power (6–10).

Different techniques were studied in order to quantify toothpaste abrasiveness (10–21): gravimetry (22,23), radioactivity (24,25), reflectometry (26), or techniques of profilometry (27,28). During our work, we estimated the abrasiveness of commercialized toothpastes and we perfected a system of values for easy comparison.

## METHODS

### Choice of the Substrate

We chose rectangular methylpolymethacrylate plates (2 cm × 7 cm) with a hardness, measured by micro-

*With the technical help of M. J. Leray and A. Tacquet.

billage, between 62 and 64 RC. This type of substrate was preferred (29–33) because its hardness is similar to that of human enamel (34).

### Substrate Abrading Technique

Brushing was realized using heads of toothbrushes available on the market, with a flat surface, following a regular alternative movement, 103 times per minute, given by a camshaft. A charge of about 200 g is applied on each brush head in order to simulate the manual application force in actual toothbrushing.

A ribbon of the toothpaste to be tested, weighing about 2 g, is applied on each plate. A clock times the work, continuous brushing for 12 successive cycles of 30 min each. Between each brushing cycle, brushes and plates are rinsed with tap water and a new ribbon of toothpaste is applied on the plates. At the end of the experiment, the plates are washed, dried, and then submitted to a profilometric study of their surface state.

### Profilometric Study

Reading of the abraded plates is done with an apparatus equiped with a needle sensor. This is connected to an amplifier, then to a voltmeter and to a recorder. Each plate is read by the sensor perpendicularly to the erosion trace.

## RESULTS AND DISCUSSION

By looking at the erosion curves, we tried to estimate the intensity and the quality of the abrasion.

Considering the abraded area, between I and J (Fig. 1), we estimate, using a manual planimeter, the surface $S_1$ (surface defined by the minimum envelope of the picks) and the surface $S_2$ (surface defined by the maximum envelope of the picks). This method is now transposed on a computer. We define the value $A$ as the addition of the surfaces $S_1$ and $S_2$, divided by 2:

$$A = (S_1 + S_2)/2$$

$A$ gives the quantity of abraded plate, as such representing the total abrasion.

We also define the value $a$:

$$a = (S_2 - S_1)/2$$

$a$ gives the surface state of the abraded plate and represents the quality of the abrasion. If the value $a$ is high, this means that the toothpaste erodes the abraded surface irregularly. On the other hand, if $a$ is low, the toothpaste polishes while it is eroding.

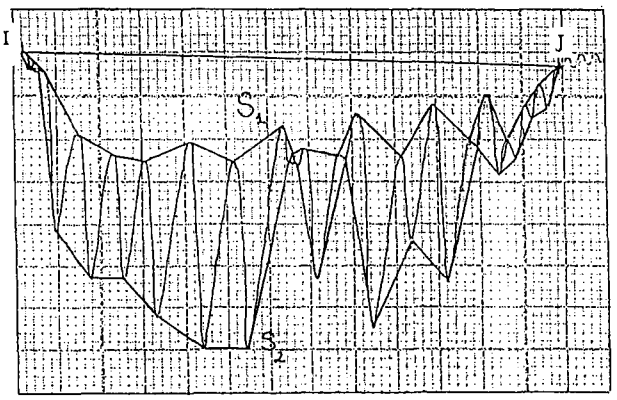


**Figure 1.** Profilometric graph.

According to our trials, on more than 100 toothpastes of the French market, we were able to classify them into four classes depending on the value of $A$ (Table 1). It is also possible to define, depending on the value of $a$, three classes of eroding quality (Table 2).

Starting with Fig. 1, we obtain Fig. 2, which includes four choices available to the consumer, depending on preference for a gentle toothpaste or a very abrasive one, if he or she is subject to stained teeth. A

***Table 1***

*Determination Scale for Abrasive Power*

| Zone | Value of $A$ | Conclusion |
|---|---|---|
| Zone 1 | $0 < A < 200$ | Very slightly abrasive |
| Zone 2 | $200 < A < 350$ | Slightly abrasive |
| Zone 3 | $350 < A < 500$ | Moderately abrasive |
| Zone 4 | $500 < A$ | Very abrasive |

***Table 2***

*Determination Scale for Abrasion Quality*

| Zone | Value of $a$ | Conclusion |
|---|---|---|
| Zone 1 | $0 < a < 100$ | Smooth surface |
| Zone 2 | $100 < a < 200$ | Regularly eroded surface |
| Zone 3 | $200 < a$ | Rough surface, not recommended |

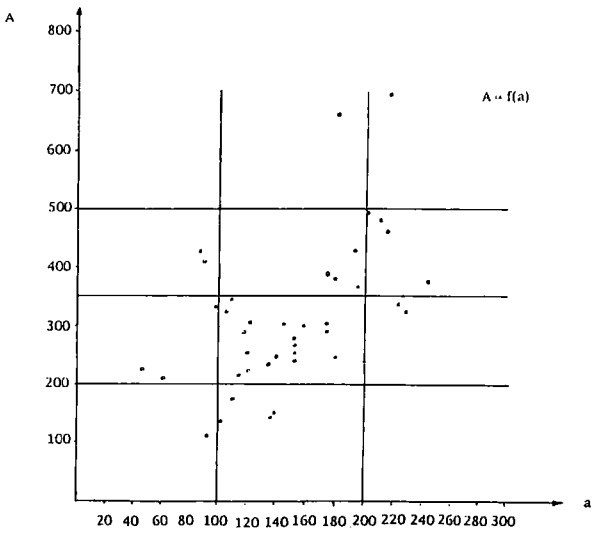


**Figure 2.** Some toothpastes available on the French market: data on the characteristics of their abrasiveness.

toothpaste from class IV will go to class III if $a$ is low; and a toothpaste from class II with a value of $a > 200$ will go to class IV.

It could then be recommended which formulations out of these extreme classes—$A$ and $a$ high and $A$ and $a$ low—should be either penalized or improved. The customer would only read on the tube:

- Class I: very slightly abrasive
- Class II: slightly abrasive
- Class III: abrasive
- Class IV: very abrasive

and could choose according to the quality of his or her teeth and food and smoking habits.

As a conclusion, we think that the profilometric methods are superior to the gravimetric ones, which only estimate the quantity of sample eroded rather than both the quantity eroded and the quality of the erosion. Similarly, isotopic methods selected by the ADA and the BSI only estimate the quantity of sample abraded, but not the quality of the erosion.

## ACKNOWLEDGMENTS

We wish that this method, standardized by the commission after more than 10 years of work, could be proposed to the ISO group which is already aware of its principle thanks to our friend Doctor Davis, who was a representative in Oslo, Hong Kong, Buenos Aires, and Washington.

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