Comparison between mechanical properties of five brands of male condoms

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Resumo: O objetivo do presente trabalho consistiu na comparação entre preservativos masculinos disponíveis no mercado nacional. Para isto, inicialmente desenvolveu-se uma metodologia para ensaios mecânicos de tração em preservativos masculinos de látex. Os resultados obtidos demonstraram, pela diferença nas médias e incertezas de reprodutibilidade, variabilidade nas propriedades mecânicas em função da marca ensaiada.

Palavras-chave: preservativos, ensaios de tração, propriedades mecânicas, incerteza de reprodutibilidade.

Abstract: The aim of the present study was to compare male condoms available in the domestic market. For this, a methodology was initially developed for mechanical tensile tests on male latex condoms. Due to the difference in the means and reproducibility uncertainties, the results showed some variability in the mechanical properties as a function of the brand tested.

Keywords: Condoms, tensile tests, mechanical properties, reproducibility uncertainty.

1. INTRODUCTION

The quality of natural rubber condoms has been widely discussed in Brazil since 1987, when they were included in the category of pharmaceuticals products under the jurisdiction of the Brazillian Health Regulatory Agency (Anvisa). Anvisa and the National Institute of Metrology, Quality and Technology (Inmetro) adopted compulsory certification of condoms in 1995 through the technical regulation of quality RTQ 09 [1] and in 2001 the Mercosul countries started to follow the resolution 75/00 [2].

RDC Regulation 62/2008 [3] and the ABNT NBR ISO standard 4074:2013 [4] are currently used for the registration of male condoms in Brazil. Despite the many factors required for the manufacture and marketing of condoms, they do not stipulate acceptable minimum values of mechanical properties, such as maximum strength and deformation until rupture. A comparison between the different brands of condoms present in the national market becomes relevant, allowing the identification of possible differences in condom properties.

Thus, this work made a comparison in 3 steps between trademarks of male condoms: definition of type of test piece, selection of speed for the test and finally, a comparison of 5 brands of condoms. All tests were performed on an Instron universal test machine model 3365 with both a 100 N load cell and strain gauge.

2. MATERIALS AND METHODS

The general procedures for preparation and conditioning of the samples, among which laboratory identification, temperature and humidity, storage, cut-off of the specimens, followed ISO standard 23529 [5]. The types of samples to be adopted, their dimensions and their mechanical properties were based on ISO standard 37 [6].

The samples for the trials were taken from dry, lubricant-free and flavoring condoms. The environmental conditions, temperature and relative humidity of all the tests were those of the laboratory itself. The temperature varied between 21°C and 23 °C and relative humidity between 55% and 65%.

Only the samples that broke within the useful length were considered in the results analysis. Considering that the mechanical properties results of each condom have a normal distribution by using a Shapiro-Wilk’s test, the Chauvenet’s criterion was adopted at all stages, allowing the rejection of outliers data.

For the accomplishment of the tests there were the adoption of rectangular sections test pieces (dumb-bell geometry). ISO standard 37 establishes 5 possible dimensions for this type of test piece (type 1, type 1A, type 2, type 3, and type 4). The specimens of types 3 and 4 were used because they have the smallest dimensions, allowing the production of more samples in each condom, and even the same useful length (10 mm), allowing the comparison. Two condoms from one brand and two from another were used for this purpose.

After determining the type of specimen, the choice of the best test speed was selected from the values of 100, 150, 200, 250, 300 and 400 mm/min.

The last step was the comparison of 5 brands of condoms. Packages with 3 condoms were purchased (without flavoring and with a width of 52 mm) each. Each of these was tested with the load cell in the initial position, another with the load cell in the 180º position and the third in the 360º position.

3. RESULTS AND DISCUSSION

3.1. Definition of type of test piece

In both brands the deviations for the type 3 specimen were lower for the ultimate strength and Young's modulus, and larger for the maximum strain. In addition, it was also taken into account that the type 3 stamp facilitated the cutting of the samples and the separation after cutting as well as the handling of the samples.

3.2. Selection of test speed

The speed of 200 mm/min resulted in the lowest standard deviation for both the ultimate strength and maximum strain, whereas for the Young's modulus the smallest deviation was obtained with the speed of 250 mm/min (the speed of 200 mm/min resulted in the second smallest deviation). Although resulted in the smallest standard deviation for the Young's modulus, the velocity of 250 mm/min was the greatest deviation of the maximum strain. In this way, it was verified that the speed of 200 mm/min is in fact the most appropriate for this type of test piece.

3.3. Comparison between brands

The comparison between 5 different trademarks was then performed using the type 3 test specimen and a displacement speed of 200 mm/min at the three positions of the load cell (0, 180 and 360°). Tables 1, 2 and 3 illustrate the means, reproducibility errors and reproducibility uncertainties, respectively. The brands were listed with no identification of their respective names.

Table 1– Means of mechanical properties of the five brands tested

Brand	Mean		
	Ultimate strength (N)	Maximum strain (%)	Young's modulus (MPa)
1	5.667805	996.557960	1.906777
2	5.435296	866.263812	2.112222
3	6.049306	884.879606	3.383323
4	5.489232	756.133448	3.740721
5	6.713181	1192.955751	2.343855

Table 2– Reproducibility error of the mechanical properties of the five brands tested

Brand	Reproducibility error		
	Ultimate strength	Maximum strain	Young's modulus
1	0.601123	0.116611	0.911178
2	0.289018	0.218297	0.398343
3	0.463288	0.074871	0.523907
4	0.423901	0.123381	0.596878
5	0.309679	0.272632	0.118467

Table3– Reproducibility uncertainty of the mechanical properties of the five brands tested

Brand	Reproducibility uncertainty		
	Ultimate strength (N)	Maximum strain (%)	Young's modulus (MPa)
1	1.01	38.58	0.50
2	0.45	54.64	0.27
3	0.83	21.55	0.52
4	0.68	28.60	0.66
5	0.66	95.45	0.09

3.3.1 Ultimate strength

Figure 1 shows the values of the ultimate strength, in the three positions, for the 5 brands tested.

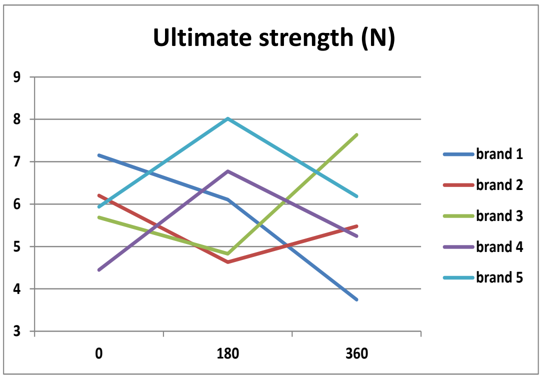

Figure 1 - Ultimate strength as a function of load cell position

The highest ultimate strength, of 8.02 N, was of brand 5 (at 180º position) while the smallest, of 3.74 N, was of brand 1 (at 360º position). Regarding the means of the three positions showed in Table 1, the average of the brand 5 resulted in the highest value (6.71 N) and the lowest mean value was the brand 2 (5.44 N). The greater dispersion of the values of the brand 1, resulted in higher error value (Table 2) and reproducibility uncertainty (Table 3).

3.3.2 Maximum strain

Figure 2 shows the values of the maximum strain, in the three positions, for the 5 brands tested.

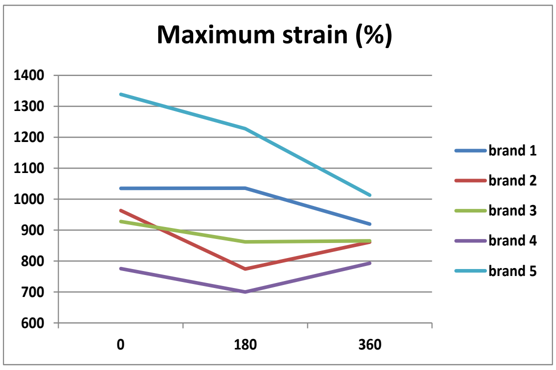

Figure 2 - Maximum strain as a function of load cell position

The highest ultimate strain, of 1338%, was of brand 5 (at 0º position) and the lowest ultimate strain, of 700%, was of brand 4 (at 180º position). For the average of the three positions (Table 1), the highest value was also of brand 5 (1193%) and the lowest was brand 4 (756%). Despite having the highest value, brand 5 was the one that resulted in the largest error (Table 2) and reproducibility uncertainty (Table 3) because the greatest dispersion between 0º, 180º and 360º positions.

3.3.3 Young's modulus

Figure 3 illustrates the Young's modulus values for the 5 brands tested, in the three positions.

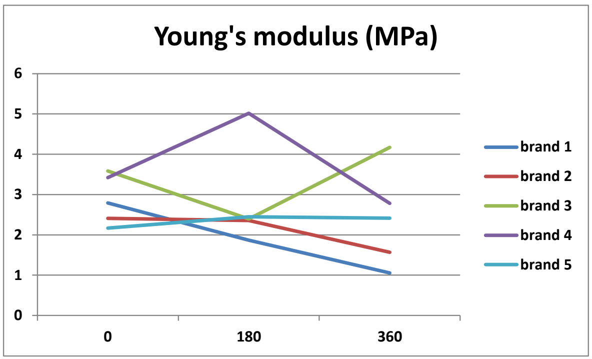

Figure 3 - Young's modulus in the three positions of the load cell

About the Young's modulus, the highest value (5.02 MPa) was obtained by brand 4 at position 180° while the smallest value (1.02 MPa) was of brand 1 at position 360°. Regarding the averages of the three positions, the brand 4 showed the largest Young's modulus (3.74 MPa), as well as the brand 1 had the lowest (1.91 MPa). Moreover, brand 1 was the one that resulted in the highest reproducibility error value (0.91), while the highest reproducibility uncertainty was of the brand 4 (0.66 MPa).

This work may assist in a future discussion about a revision of the current standard in the country (ABNT NBR ISO 4074: 2013 [4]), since minimum allowed values of mechanical properties are not addressed at all.

4. CONCLUSIONS

Due to the difference in averages and uncertainties of reproducibility, the comparison of trademarks showed, variability in the mechanical properties as a function of the brand tested.

Brand 5 has the highest ultimate strength, withstands higher tensile loads, while brand 2 tolerate lower loads. Given its high difference between the values of the ultimate strength, as a function of the position of the load cell, brand 1 resulted in larger error and uncertainty of reproducibility.

Due to its greatest deformation (1193%), brand 5 has a plastic deformation capability 58% bigger than brand 4 (ultimate strain of 756%). However, due to the greater dispersion between the values, for each position of the load cell, the largest error and measurement uncertainty are of the brand 5.

Brand 4 has the largest modulus of elasticity (3.74 MPa) being almost twice brand 1 (1.91 MPa). In addition, once again brand 1 has the greatest error and uncertainty of reproducibility.

Based on the results of this work, brand 5 has the higher plastic deformation capability (higher ultimate strength and maximum strain), while brand 4 has the highest elastic deformation capability (highest Young's modulus).

5. REFERENCES

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[3] RDC nº 062/2008 - Resolução da Diretoria Colegiada da ANVISA de 03 de setembro de 2008.

[4] Norma ABNT NBR ISO 4074:2013 "Preservativo de látex de borracha natural — Requisitos e métodos de ensaio".

[5] ISO Standard 23529:2010 "Rubber – General procedure for preparing and conditioning test pieces for physical test methods".

[6] ISO Standard 37:2011 "Rubber, vulcanized or thermoplastic – Determination of tensile stress-strain properties".