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Causal relationship between the slightly acid pH of water used for mate and the fast washing of yerba mate

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Causal relationship between the slightly acid pH of water used for mate and the fast washing of yerba mate.

Relación causal entre el pH ligeramente ácido del agua utilizada para el mate y el rápido lavado de la yerba mate

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ABSTRACT

This research explains one of rason why yerba mate washes away quickly.

Yerba mate undergoes some physicochemical changes it tends to lose its "organoleptic" properties, that would trigger its washing, caused by the lixiviation of its components.

while we was making the research, 882 experiment were conducted and 9,702 mates were brewed.

A higher frequency of quickly washed mates was observed when using water with pH 6.5 and a lower frequency of quick washed mates when using water with pH 8.5.

Our results suggest that pH significantly influences fast washing of yerba mate; lower pH allowed of drinking water, the faster yerba mate is washed regardless of the temperature used.

Chi-squared test demostrarte the causal relationship between fast washing of yerba mate and drinking water pH. t-Student test showed that yerba is washed fast using water with a slightly acidic pH.

ABSTRACTO

Esta investigación explica una de las razones por las que la yerba mate desaparece rápidamente.

La yerba mate sufre algunos cambios fisicoquímicos, tiende a perder sus propiedades "organolépticas", que desencadenarían su lavado, provocado por la lixiviación de sus componentes.

Mientras realizábamos la investigación se realizaron 882 experimentos y se prepararon 9.702 parejas.

Se observó una mayor frecuencia de mates lavados rápidamente al usar agua con pH 6.5 y una menor frecuencia de mates lavados rápidamente al usar agua con pH 8.5.

Nuestros resultados sugieren que el pH influye significativamente en el lavado rápido de la yerba mate; Cuanto menor sea el pH del agua potable, más rápido se lava la yerba mate independientemente de la temperatura utilizada.

La prueba de chi-cuadrado demuestra la relación causal entre el lavado rápido de la yerba mate y el pH del agua potable. La prueba t-Student demostró que la yerba se lava rápidamente usando agua con un pH ligeramente ácido.

1. INTRODUCTION:

Mate is a traditional Latin American infusion rich in caffeine that gives it´s stimulating effect. It´s made by soaking dried and crushed leaves of yerba (Ilex paraguarensis) in a mate groud. This hot drink was consumed by the Guaraní and Tupi peoples, where Paraguay is today. Mate is the

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official drink of Argentina and Uruguay, although it´s also consumed in Paraguay, Brazil, part of Chile and Bolivia, and also in Syria and Lebanon.

One of the drawbacks of mate is that yerba is “washed” (la yerba se lava en español), that is, the yerba loses it´s flavor and is evident because it begins to sediment, yerba loses its organoleptic properties (Pagliosa et al. 2009). It´s impossible to prevent the yerba from being washed, since drinking mate involves leaching the compounds from yerba every time hot water is added *(Scherer et al. 2002)*.

Although yerba is washed at some point, there are situations in which yerba is washed much faster and according to empirical evidence - or popular myth - this may be due to the temperature of wáter used or the quality of yerba, among other little studied variables.

2. Objetives:

Determine if there is a causal relationship between water pH and fast washing of yerba mate.

Present to the community a study that explains one of the causes why mate washes off quickly.

Disseminate scientific research that sets a precedent for future research.

3. MATERIALS AND METHODOLOGY:

3.1 Materials.

The materials used for the experimentation were: 3 types of commercial yerba, plastic mate, baking soda, lemon juice, distilled water, mate straw, Stanley thermos, digital pHmeter and thermometer.

Variables used.

Water temperature, water pH, sugar, amount of water to brew in mate, thermal shock, soaking time of yerba (set of variables Annex 2).

3.2 Experimentation

The experiment consisted of brew mate until yerba was washed away. The precipitate and loss of flavor of yerba are taken as a parameter to consider a washed mate.

A quickly washed mate is taken to be the one that loses its organoleptic properties before brew the 9th mate, and washed mate is normally the one that loses its properties from brew the 9th mate onwards.

Work began using water with neutral pH and then to reach pH 6 and 6.5 water was acidified using lemon juice and to reach pH 7.5, 8 and 8.5 sodium bicarbonate was used to alkalinize water.

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Seven temperatures were used for the water (70°C, 75°C, 80°C, 85°C, 90°C, 95°C and 100°C), 21 sets of variables were analyzed. The research team carried out 882 separate experiments And they brew 9,702 mates in total.

4. RESULTS:

The results obtained from experimentation are shown in figures for better interpretation (experimental results-annex 1).

In figure 1 is observed number of mates brewed quickly according to the pH and temperature of water used. At 80°C mates brewed with of pH 8 or pH8.5 water did not wash quickly.

Figure 2 shows the number of quickly washed mates taking into account only the pH (at different temperatures). The lower pH, greater the frequency of quickly washed mates.

Figure 1: Number of mates washed faster by temperature at different pH.

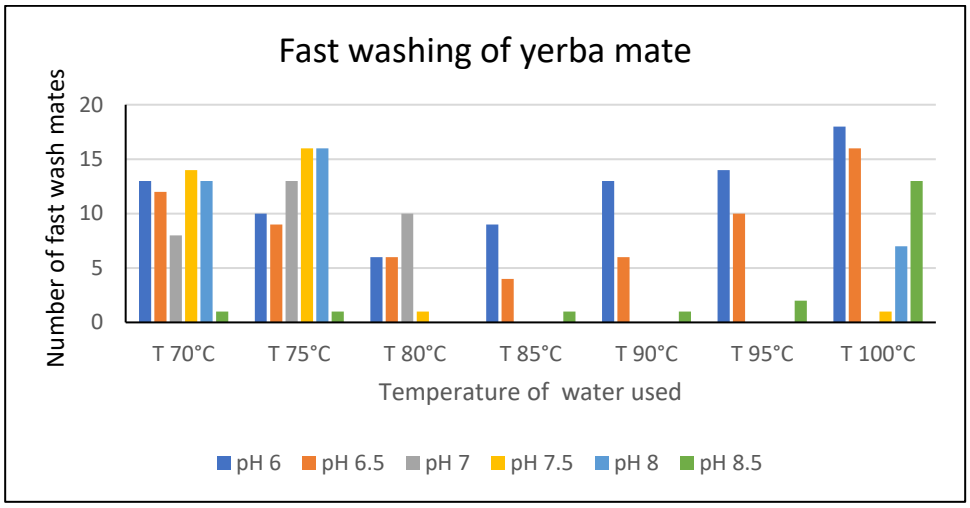

Figure 2: Number of washed mates by pH of the water, regardless of temperatura.

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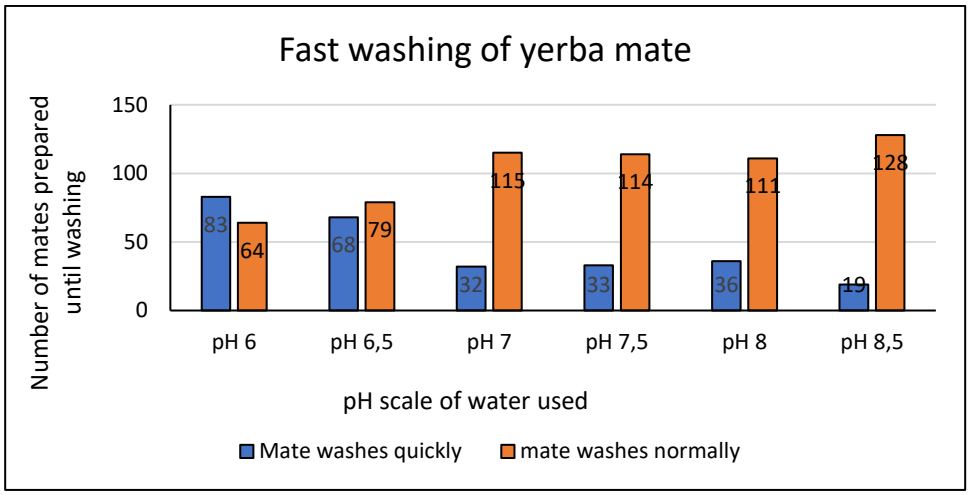

5. Results analysis

A Pearson Chi square test (χ^2) was performed to verify a possible association between the variables: fast washing of yerba and water pH.

Frequencies of the number of mates brewed before washing the yerba using water with different pH were observed (Table 1) and the Chi-square values were calculated by pH categories (Table 2).

Table 1: Contingency table.

	pH 6	pH 6,5	pH 7	pH 7,5	pH 8	pH 8,5	Total sum.
Faster washing of yerba.	83	68	32	33	36	19	271
Normal washing of yerba.	64	79	115	114	111	128	611
Total sum.	147	147	147	147	147	147	882

Hypothesis test:

H_0: fast washing of yerba does not depend on water pH used.

H_1: fast washing of yerba does depend on water pH used.

Table 2: Chi square values table.

	pH 6	pH 6,5	pH 7	pH 7,5	pH 8	pH 8,5	Total sum.
fast washing of yerba.	31,69	11,54	3,84	3,28	1,86	15,16	
Normal washing of yerba.	14,06	5,12	1,70	1,45	0,83	6,73	
Total sum.							97,26

$$X^2 = \Sigma \frac{(Oi-Ei)^2}{Ei} = 97,26$$

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Critical value

gl= (r-l).(c-i).

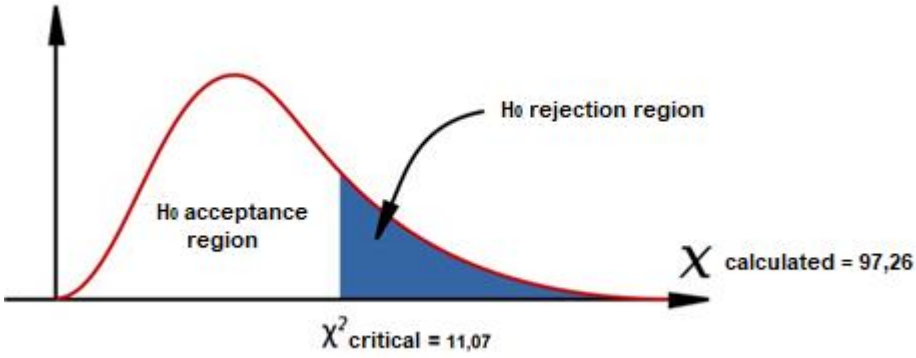
gl = (2-1).(6-1) = 5 (freedom degrees)

α = 0,05 (5%)

χ^2(1-α).(r-1).(c-1) = 11,07 calculated with INV.CHICUAD.CD(α.gl). en Excel.

The statistical value calculated (97.26) is greater than critical value (11.07). H_0 is not accepted, that is, fast washing of yerba will depend on water pH used (Figure 3).

Figure 3: chi-square test graph, for fast washing test of mate with different pH water.



t-Student analysis for two related samples (paired).

We want to demonstrate that amount of mates washed quickly using pH6 water is greater than the amount of mates washed quickly using pH8.5 water, for this we will work with the average of the differences (Table 3).

$H_0md \leq 0$ That is, yerba does not wash faster using pH 6 water.

$H_0md > 0$ That is, yerba is washed faster using pH 8.5 water.

Table 3: table of averages of difference for t-student analysis

fast wash	pH 6	pH 8.5	D(difference)
1	6	6	0
2	5	0	5
3	0	0	0
4	1	2	-1
5	3	1	2
6	4	1	3
7	7	1	6
8	6	1	5

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9	5	1	4
10	7	1	6
11	5	1	4
12	6	1	5
13	6	1	5
14	6	1	5
15	7	0	7
16	1	0	1
17	4	1	3
18	0	0	0
19	3	1	2
20	1	0	1
21	1	0	1

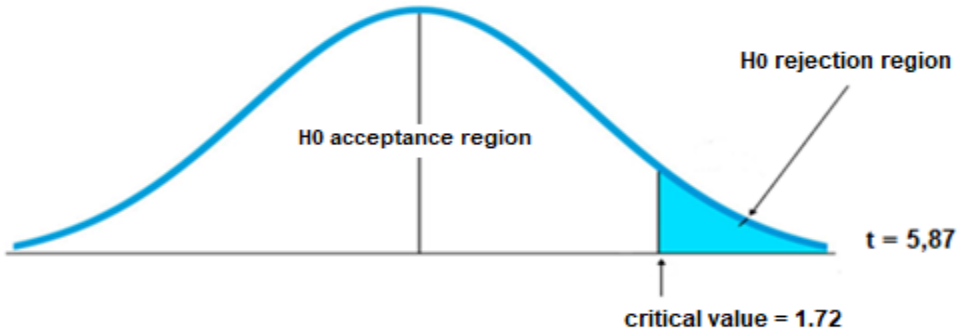
Table 3 showed amount mates that were washed quickly with pH 6 and pH8.5 at variable temperatures.

Table 4: Student's t-test for average of two paired samples

	pH 6	*pH 8.5*
Average	4	0,95238095
Variance	6	1,64761905
Observations	21	21
Pearson correlation coefficient	0,31805042	
Hypothetical media difference	0	
Degrees of freedom	20	
t-statistic	5,876755595	
P(T<=t) one tail	0,000004751	
Critical value of t (one-tailed)	1,724718243	
P(T<=t) two tails	9,50236E-06	
Critical value of t (two-tailed)	2,085963447	

Table of critical and probable values for student's t generated by Excel

Figure 4: t-student function graph for quick mate wash test using pH6 and pH7 water.



The average of the differences indicates that yerba mate is washed faster using pH 6 water than with pH 8.5 water (Table 4), The statistic test value calculated is greater than critical value, so H_0 is rejected (Figure 4).

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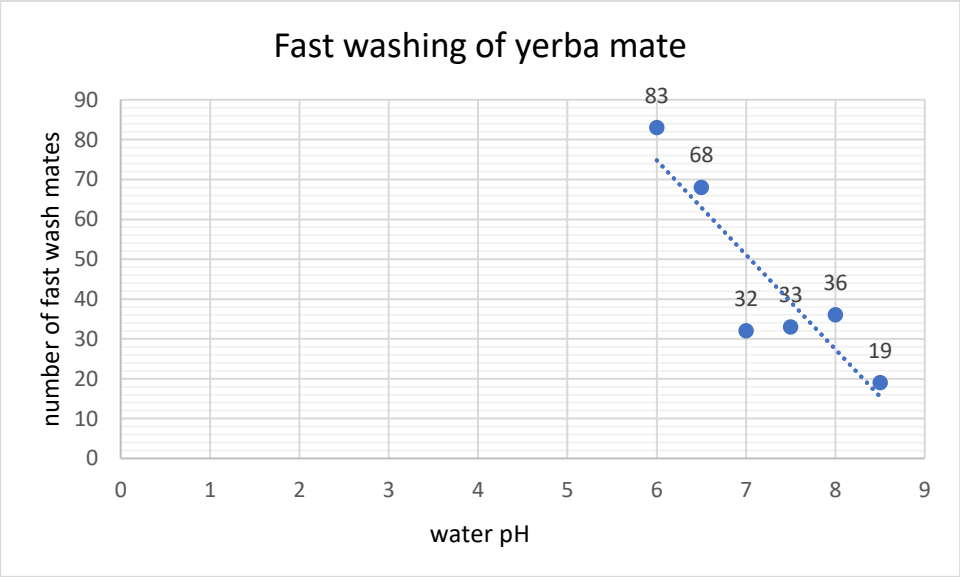
Figure 5 shows a strong and negative correlation, which indicates that the variables are associated in the opposite direction. The higher water used pH used, the lower the observed frequency of quick washing of yerba mate.

Figure 5: correlation graph between water PH and fast washing of yerba mate



6. DISCUSSION:

It´s currently recommended that the optimal and safe water temperature is between 70 and 80 °C. There are reasons to assume that the use water above 80°C can be a health risk (Casnati 2013) although water consumed in mate never exceeds 57°C even if the water temperature used is higher than 90°C (Thea 2017; Alegre 2017).

In our research we found evidence that allows us to assume that water temperature is a variable that significantly affects the fast washing yerba mate, since at variable pH washing of yerba was significantly lower at a 85°C temperature (Figure 1), although this temperature is not recommended for health. It can be seen that at temperatures of 75°C and 80°C mate is washed faster than at 85°C, this may be because at 80°C yerba mate has a high leaching rate as the number of mates brewed increases (Bernica 2019).

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We find that emperature does affect some of the organoleptic properties of yerba, with very hot temperatures above 80°C mate has a very bitter taste and below 70°C the flavor is very faint (Drunday 2019).

Although there is a lot of information about yerba mate, we did not find information on how water pH affects its organoleptic properties and if it´s related to washing yerba.

In our research we found that water pH is a variable that significantly affects fast washing of yerba, mates that were brew with pH6 water and pH 6.5 showed that yerba was washed faster regardless of temperature used (figure 2).

Assuming that the temperature is an intervening variable, it was observed that at higher temperature and lower pH yerba washes faster (table 1), and that at temperature of 85°C and pH 8.5 yerba lasts longer without wash.

Yerba mate has a pH of 7.5 – 7.1, the infusion has a pH of 5.7 (Larrusea 2013) and that at higher temperatures pH drops, it can be thought - a priori - that Lower pH the leaching percentage increases of the organic compounds in yerba (Linares 2010) and this probably makes yerba wash faster. We observed that mates brewed with water of pH 8.5 were the ones with the lowest frequency of fast washing.

Statistical analysis chi-square shows us that there is an association between pH and the fast washing of yerba, t-student test indicates that yerba is washed faster when using water pH 6.

7. CONCLUSIONS:

Upon analysis of the result and subsecuent discussion we concluded that:

- Water pH used for infusion of mate directly affects the fast washing of yerba mate.
- The lower pH of drinking water, faster yerba mate will be washed, pH6 water washed yerba faster.
- Water with ph8.5 is optimal for drinking mate, since the yerba is washed more slowly.
- Of the temperature range recommended for health, water at 80°C is the most suitable so that the yerba mate lasts longer without washing, preserving its flavor for longer.

We believe that this research is a precedent for future analytical research on how pH influences yerba mate leaching and washing at different temperatures.

Declaration of conflicting interests (conflicto de intereses):

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work presented in this article.

Disclosure statement

The data supporting this study's findings are available from the corresponding author upon reasonable request.

Dataset

Aquino B, Carcamo T, Cayun M, Choque siles A, Varas M. sept 2024. Datos experimentales del lavado de la yerba mate. Harvard dataverse. https://doi.org/10.7910/DVN/UNJ1DF

Co-authors contributions

Tiziana Carcamo: Develop the experimental design and carry out the experiments.

Maia Cayun: Develop the experimental design and carry out the experiments.

Antonela Choque Siles: Organized the experimental data and performed the statistical analyses.

Milagros Varas: Carry out the experiments.

special thanks

Fiorella Di Feo: Organized the experimental data and performed the statistical analyses.

Guillermo MacDonald: professor responsible for the Natural Sciences laboratory, was in charge of managing resources for development of work.

Kiara Llanquin: Carry out the experiments.

References

- Alegre, C. A; Schmalko, M.E; Lovera, N.N; Hedman, J.C. 2017. Estudio del perfil térmico del agua caliente durante el consumo de mate. VII Congresso Sulamericano da Erva-mate. Brasil 2017. Recuperado de https://www.conicet.gov.ar/new_scp/detalle.php?keywords=&id=24519&inst=yes&congresos=yes&detalles=yes&congr_id=7598258
- Carlos Larrucea V.; Erika Henríquez O.; Monserrat Inostroza T.; Laura Campos M.; Carolina Peña G.; Carlo Larrucea S.; Miguel Arenas S. & Karina Larrucea S. 2013. Efecto Inmediato de Infusiones de Consumo Habitual en las Propiedades Salivales. Int. J. Odontostomat. vol.7 no.3 Temuco. Recuperado de https://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0718-381X2013000300002#f3
- Casnati, B; Álvarez, R; Massa, F; Lorenzo, S; Angulo, M; Carzoglio, J. 2013. Prevalencia y factores de riesgo de las lesiones de la mucosa oral en la población urbana del Uruguay. Odontoestomatología vol.15 no.spe Montevideo jun. 2013. Recuperado de http://www.scielo.edu.uy/scielo.php?script=sci_arttext&pid=S1688-93392013000200007
- Drunday, F; Higa, F; García, V; Calviño, A. 2019. ATRIBUTOS SENSORIALES Y NO SENSORIALES ASOCIADOS A LOS CAMBIOS DE ACEPTABILIDAD DE YERBAS COMERCIALES ELABORADAS Y COMPUESTAS. Universidad de Buenos Aires,

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- Linares, A; Hase, L; Vergara, M. L; Resnick, S. 2010. Modelado de la cinética de extracción acuosa de yerba mate: Influencia de la temperatura. ELSEVIER. Volumen 97, número 4, abril 2010, Páginas 471-477. Recuperado de https://www.sciencedirect.com/science/article/abs/pii/S0260877409005603?via%3Dihub
- Pagliosa, C.M.; Pereira, S.M.; Vieira, M.A.; Costa, L.A.; Teixeira, E.; de MC Amboni R.D. & E.R. Amante. 2009. Bitterness in yerba mate (Ilex paraguariensis) leaves. Journal of Sensory Studies 24(3): 415-426. Recuperado de https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1745-459X.2009.00218.x
- Marx, F.; Janssens, M.J.J.; Urfer, P. & R. Scherer. 2003. Caffeine and theobromine composition of mate (Ilex paraguariensis) Leaves in five plantations of Misiones, Argentina. Plant Foods for Human Nutrition 58: 1-8. Recuperado de https://www.academia.edu/24374711/Inheritance_studies_of_caffeine_and_theobromine_content_of_Mate_Ilex_paraguariensis_in_Misiones_Argentina?uc-g-sw=19219330
- Thea, A.2020. Poner al mate en su lugar. Entrevista. Recuperado de https://www.conicet.gov.ar/poner-al-mate-en-su-lugar/
- Venica, D; Baldor, S; Bottero, M; Rodríguez livov, M; Boeris, V. 2019. Relación entre cualidades fisicoquímicas de la yerba mate y sus características de lixiviación. Congreso; XXI Congreso Latinoamericano y del Caribe de Ciencia y Tecnología de Alimentos & XVII Congreso Argentino de Ciencia y Tecnología de Alimentos; Buenos Aires. 2019. Recuperado de https://alimentos.org.ar/wp-content/uploads/2021/02/CYTAL2019-Libro-de-Resumenes.pdf

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