# Taste Perceptions of Chlorinated Water

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## Introduction

Thousands of deaths worldwide are attributable to unsafe water practices, and in 2015, 700 million people still used unimproved water sources (WHO, 2016). Problems in drinking water also disproportionately impact rural areas.

Chlorine, a strong oxidizing agent, can be a cheap and effective water disinfectant (Deborde et al., 2008). However, its use can introduce objectionable new tastes and odors, presenting a barrier to community acceptance of water treatment systems (Firth et al., 2010).

The government of Ecuador has been working to install water treatment and piped delivery systems throughout the country, especially in rural communities. Consumer taste testing can help guide system implementation and management.

## Objectives

- Determine perceptions of chlorinous flavors, look for a potential window of compromised acceptance (above detection but below rejection), and find rejection rates of treated water.
- Perform a cross-national comparison to assess how country of residence and past chlorine exposure history might impact taste perceptions.
- Provide recommendations for management of new water treatment systems, especially in rural areas, to give the highest probability of effective disinfection and community acceptance.

## Methods

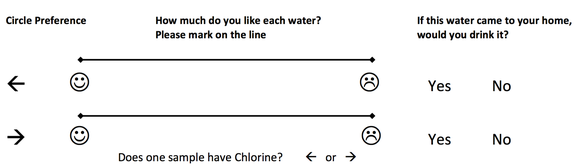
### Participants

Participants can be grouped by country. An Ecuadorian sample consisted of 123 volunteers (61 female, 62 male) aged 18-85 from 5 Quichua communities in rural Ecuador.

A U.S. sample included 54 volunteers from the Calvin College community (21 female, 33 male) aged 19-69.

### Materials

Data were collected using questionnaires to assess participants' liking for the water, acceptance of the water, and ability to detect chlorine. In Ecuador the questionnaires were presented orally to each participant, while in the US participants filled the questionnaires themselves.




### Procedure

Participants underwent 6 rounds of tasting water in sample pairs, according to a constant stimulus, paired comparison procedure. One of the samples was always chlorine free, while the other rose in chlorine concentration from 0 mg/L to 3 mg/L.

*This image illustrates the testing done in Ecuador. Participants came forward to taste sample pairs, then questions were presented verbally and responses recorded by the investigators.*

## Results

### Chi-Square Analysis:

Two way Chi-square analysis was used to assess participants' ability to correctly identify chlorinated water. Counts of participants able to correctly identify chlorinated samples were compared to counts of mistaken identifiers:

$X^2_{Ecuador}$ (4, 270) = 17.899, p=0.001

$X^2_{US}$ (4, 203) = 4.093, p=0.394

Follow-up pair-wise tests were performed on the Ecuador data at each chlorination level:

$X^2_{0.1}$ (1, 35) = 0.257, p=0.612, $X^2_{0.3}$ (1, 42) = 3.429, p=0.064, $X^2_{1.0}$ (1, 54) = 1.185, p=0.276, $X^2_{2.0}$ (1, 69) = 32.014, p<0.001, $X^2_{3.0}$ (1, 70) = 22.857, p<0.001

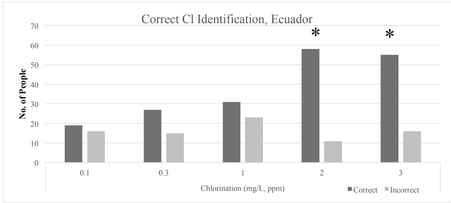
One way Chi-square was performed to test for a threshold of rejection of the chlorinated water, comparing counts of rejections at each chlorination level:

$X^2_{Ecuador}$ (4, 65) = 13.231, p=0.010

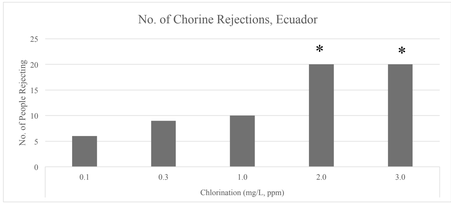
$X^2_{US}$ (4, 59) = 0.576, p=0.966

Again, follow up Chi-squares were performed on the Ecuador sample:

$X^2_{0\text{-}0.1}$ (1, 12) = 0.00, p=1.00, $X^2_{0\text{-}0.3}$ (1, 15) = 0.600, p=0.439, $X^2_{0\text{-}1.0}$ (1, 16) = 1.00, p=0.317, $X^2_{0\text{-}2.0}$ (1, 26) = 7.538, p=0.006, $X^2_{0\text{-}3.0}$ (1, 26) = 7.538, p=0.006

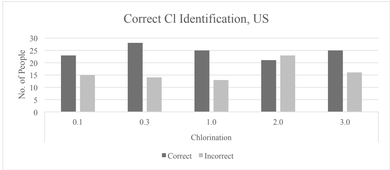



*This graph shows that a significant number of participants could identify chlorine when water was at or above 2.0 mg/L chlorine.*

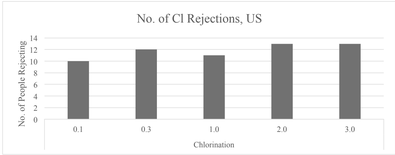



*This graph illustrates that significantly more people rejected the chlorinated water when chlorine was at or above 2.0 mg/L. However, at 2.0 mg/L, <20% of participants rejected the treated water.*

## Results, cont'd




*Among US participants, increasing chlorination had no effect on the subjects' ability to correctly identify chlorine.*




*Although more US participants rejected the chlorinated water, increasing chlorination had no effect on rejection rates.*

## Conclusions

- Consumers in rural Ecuador are more sensitive to the flavor of chlorine than consumers in the US. US consumers, while rejecting water samples more frequently (19% of all samples, while only 8% for Ecuadorians), showed no sensitivity to the level of chlorination.
- Habituation to the flavor of chlorine is a likely explanation for this result.
- Consumer reports may put a biased downward pressure on chlorine disinfection efforts.
- When water treatment is well managed (free chlorine ~0.5-1.0 ppm at the tap), there will likely be a low number of consumer complaints. Treatment practice should not be modified unless such complaints can be verified with minimally biased instruments.

## References

Deborde, M. & von Gunten, U. (2008). Reactions of chlorine with inorganic and organic compounds during water treatment- Kinetics and mechanisms: a critical review. *Water Research, 42*, 13-51.

Firth, J., Balraj, V., Muliyil, J., Roy, S., Rani, L. M., Chandresekhar, R., & Kang, G. (2010). Point-of-use interventions to decrease contamination of drinking water: A randomized, controlled pilot study on efficacy, effectiveness, and acceptability of closed containers, *Moringa oleifera*, and in-home chlorination in rural South India. *The American Journal of Tropical Medicine and Hygiene*, *82*(5), 759-765.

World Health Organization. (2016) *World Health Statistics 2016, Monitoring Health for the Sustainable Development Goals.* Retrieved from http://www.who.int/gho/publications/world_health_statistics/2016/en/