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Quantification of Water used to Defrost Food in Los Angeles area Commercial Kitchens

Final Report

Prepared for: CNSRV LTD.

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1 Introduction

Multiple considerations framed this applied research project. They include:

(1) Food industry sustainability has primarily focused on the agricultural sector (Edwards, Lal, Madden, Miller, & House, 1990).

(2) Promoting economic growth in a sustainable way is vital to protect Earth's finite resources (Sachs, 2015).

(3) Sustainability is not a recent concept (Barbier, 1987). Yet, in many sectors, it is a struggle to bring it into common use.

(4) Potable water is an essential resource. Implementing sustainable conservation practices is crucial to the optimal use of this life-supporting resource.

(5) Facilitating economic and practical means to conserve water in commercial kitchens is both necessary and desirable.

The management of water resources includes, and is not limited to:

(i) minimize water pollution,

(ii) reduce water waste,

(iii) maintain high water quality standards, and

(iv) promote/incentivize/mandate proven conservation practices.

Water treatment is energy intensive, costly, and not always sustainable. Further - all individuals, businesses, and public entities feel the rising costs of water treatment. Public entities must emphasize to their communities the value of water is a way in which the control and sustainability of water usage can be effectively promoted (UN Water, 2021). Minimizing water waste is in everyone's interest – and more so in drought conditions. In that spirit – it is a worthy endeavor to seek, create and implement sustainable solutions to minimizes water consumption. A sector where water conservation can e further incentivized is commercial kitchens. One aspect of commercial kitchens water usage that merits scrutiny is the most common method to defrost food (e.g., The Cold-Water Method) – which was conceived and approved when water was more plentiful and cheaper - and when environmental concerns where less acute. As part of the Metropolitan Water District of Southern California's (District) on-going efforts to seek and implement sustainable water use practices – a grant was awarded to conduct a best effort survey to quantify water used to defrost food in Southern California commercial kitchens. This survey was prompted by the introduction of commercial kitchen appliances that save water and time while safely defrosting food. Its findings are intended to serve as a base for the District to justify financial incentives to commercial kitchens for such water saving devices.

2 Background

This applied research project is targeted to facilitate sustainability in commercial kitchens, and specifically to conserve water.

The last U.S. Geological Survey Circular to estimate water commercial end uses was conducted in 1995. This 27 yrs. old survey reports that 17% of all water from public US sources was used in the commercial sector. And that 15% of the water consumed by the commercial sector was used in hospitality and food services (Solley, Pierce, & Perlman, 1998).

A powerful reason for a commercial kitchen to save water is to lower its water & sewage bills – particularly as water rates will only rise. It also helps counter the global water crisis as well as local draught conditions. It is also good PR as a restaurant's efforts to be sustainable can influence a patron's choices. According to the National Restaurant Association, up to half of consumers surveyed say that a restaurant's sustainability efforts factor in where they choose to dine (National Restaurant Assosiation, 2018). An associated suggestion is for restaurants to put a sign stating they are committed to conserve water (Alliance for Water Efficiency, 2017). Conserving water also lowers energy consumption. Implementing practices to lower water use by as little as 15% in this sector drops operating costs by 11%, and energy use by 10% (SmartMarket, 2009).

There are "low hanging fruit" conservation opportunities for commercial kitchens – like finding and stopping leaks, not running a partially full dishwasher, investing in more water efficient equipment, and installing flow restrictors or aerators (Alliance for Water Efficiency, 2017). There is also mention of saving water by defrosting food in the fridge, and that this only requires foresight. But this valid suggestion fails when time is at a premium, or there's not enough fridge space, or frozen food demand peaks.

There were other efforts to quantify water usage in commercial kitchens. In 2012 – the EPA found that 52 % of the water consumed in restaurants is used in the kitchen/dishwashing processes (WaterSense, 2012). Although valuable in traditional restaurant environments – this data point is of little value for supermarket food preparation kitchens or where food is consumed on paper plates, or is taken away.

As part of the preparation for this applied research project – significant effort went into finding prior non-anecdotal sources and/or science-based attempts to quantify the water used to defrost food using the Cold-Water Method. The need for this project is further supported by the fact that no such sources/studies were found.

The US Food and Drug Administration (FDA) publishes a food code that all restaurants and commercial kitchens must observe. This code includes a section on thawing (3-501.13). In it, four approved ways to thaw foods are listed:

(1) in the refrigerator,

(2) under cold, running water (a.k.a. The Cold-Water Method),

(3) direct to cooking equipment, and

(4) in the microwave, followed immediately by cooking (FDA, 2017).

The research team – through extended in-field observations – found that the second FDA approved thawing method – is most frequently used in Southern California commercial kitchens. Accordingly, this survey focuses solely on method (2).

FDA also states that food should be fully submerged under running water and that:

(1) water temperature of 21°C (70 °F) or below must be maintained.

(2) there must be sufficient water velocity to agitate and float off loose particles.

(3) procedure lasts for a period that doesn't allow thawed portions of ready-to-eat food to rise > 5 °C (41 °F) OR raw animal food to rise > 5 °C (41 °F) for more than 4 hours - including thawing and preparation/cooking time (US FDA, 2017).

The same regulation limits the thawing process to four (4) fours. Thus - a tap running at 20 Liters/min can use up to 4,800 Liters (1,268 Gallons) in one thawing session.

Within the field of culinary science, some limited research has been conducted on thawing processes. For instance – it has been reported that in a self-serve restaurant 76.2 L/kg of beef was used to thaw beef (Martinelli, Cavalli, Pires, Proenca, & Proenca, 2012). Also - in Chinese restaurants, around 30% of all the water went to defrost foods (Lo, Chan, & Wong, 2011). These statistics point to a rich vein to mine for significant water savings via more water efficient thawing appliances/methods.

Since flash-frozen foods were invented (Karwatka, 2016), its popularity has grown and with it a surge in frozen food storage. At commercial facilities, frozen food improves labor conditions, helps manage inventory, and allows more leeway for shipping times and longer shelf lives (Jaekel, 2021). The frozen food industry may even help relieve food shortages – as seen during the COVID-19 pandemic (Simplot Foods, 2020). A rise in frozen food purchases during a crisis (e.g., the COVID pandemic) was also seen in domestic kitchens (USC Consulting Group, 2020). The frozen food supply chain is also more sustainable vs. fresh foods – with short shelf lives and even shorter lead times – (Zanoni & Zavanella, 2012).

As thawing food is now practically a daily occurrence for single restaurants as well as for the largest of chains, it is imperative to mitigate the amount of potable water used as well as the wastewater generated.

Other thawing techniques are divided into thermal and non-thermal processes. Thermal processes include microwave, dielectric, or resistive mechanisms. The non-thermal processes use high pressure, ultrasound, and vacuum mechanisms. The thermal processes face challenges like heat dissipation, uneven heating, and high energy consumption. More recent non-thermal processes were found to yield uneven thawing and even localized heating (Cai, Cao, Regenstein, & Cao., 2019). These challenges have prevented the implementation of such technologies in commercial kitchens.

Research was also been conducted on post thawing food quality. As food-poisoning pathogenic microorganisms can multiply within the 0-50 °C temperature range (Genigeorgis, 1981) - the thawing process can affect meat quality. It was found that less exudate occurred with faster thawing, keeping moisture levels as-fresh. Also - during slow thawing it has been hypothesized that fibers are released in the fluid that cannot be reabsorbed. This can negatively affect the texture of the meat (Akhtar, Khan, & Faiz, 2013). A literature source also states that *"there is a great deal of evidence that suggests that food thawed in cold water, fast, results in the best and most quality foods after the completion of the thawing process*" (Bazilchuk, 2016).

3 Participating Commercial Kitchens

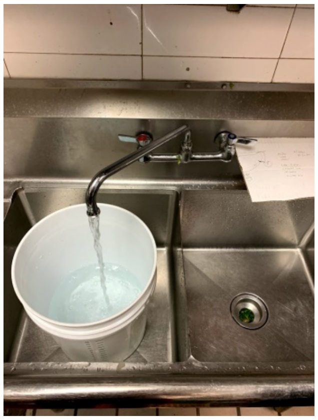
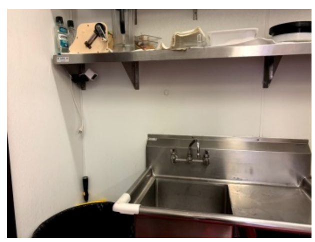
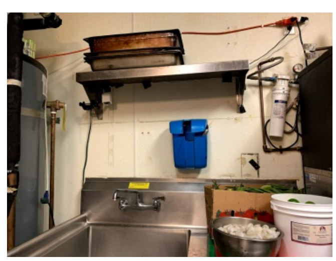
12 commercial kitchens participated in this research (see below table) All participated given that their collaboration remains **anonymous –** thus, the kitchens are numbered rather than named..

No.	Location	Start Date
1	Kitchen 1	June 16, 2021
2	Kitchen 2	June 29, 2021
3	Kitchen 3	June 29, 2021
4	Kitchen 4	June 29, 2021
5	Kitchen 5	July 02, 2021
6	Kitchen 6	July 14, 2021
7	Kitchen 7	July 29, 2021
8	Kitchen 8	August 03, 2021
9	Kitchen 9	August 18, 2021
10	Kitchen 10	August 25, 2021
11	Kitchen 11	December 10, 2021
12	Kitchen 12	June 2, 2022

Photos of water flow rate measurements and camera installations are shown below:

Table 1: Pictures of experimental procedure at participating kitchens.

Location No.	Flow rate measurement	Camera Installation	Camera View
1			

2			
3		N/A	
4			
5			

6	N/A		
7	N/A	N/A	N/A
8			
9			
10			
11	N/A		

12			N/A

4 Timeline


June 16, 2021
Kitchen 1
Flow measurements (ultrasonic + graduated bucket). Identification of usable security camera footage for study.
Kitchen 2 Attempt 1
Consolidation of experimental process. Flow measurements (ultrasonic + graduated bucket).
June 16, 2021
June 16, 2021
Kitchen 3
Flow measurements (ultrasonic + graduated bucket).
Kitchen 2 Attempt 1
Camera installation.
June 29, 2021
June 29, 2021
Kitchen 4
Flow measurements (graduated bucket). Camera installation.
Kitchen 3
Camera installation.
June 29, 2021
July 2, 2021
Kitchen 5
Flow measurements (graduated bucket). Camera installation.
Kitchen 2 Attempt 2
Camera installation.
July 13, 2021
July 14, 2021
Kitchen 6
Flow measurements (graduated bucket). Camera installation.
Kitchen 7
Flow measurements & thawing cycle duration obtained from management
July 29, 2021
August 3, 2021
Kitchen 8
Flow measurements (graduated bucket). Camera installation.
Kitchen 9
Flow measurements (graduated bucket). Camera installation
August 18, 2021
August 25, 2021
Kitchen 10
Flow measurements (graduated bucket). Camera installation
Kitchen 11
Flow measurements (graduated bucket).
December 10, 2021
March 1, 2022
Kitchen 11
Camera installation.
Kitchen 12
Flow measurements (graduated bucket). Camera installation
June 2, 2022

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5 Method

This section describes the measurement and camera installation process for a particular restaurant. All the commercial kitchen visits followed closely this same method.

Once the team arrived at a restaurant, a manager directed them to the sink where food is defrosted. A manager or kitchen worker then shared the kitchen's general defrosting practices and the types of food defrosted.

Then, flow measurements were made per EPA's "WaterSense at Work" report, page 1-13[1] using a graduated 5 Gallon bucket (graded in one-liter increments). The measurements consisted of recording how much water collected in the bucket after a specific period elapsed (e.g., 45 seconds). The tap flow time was selected as to avoid overfilling beyond the highest one-liter mark. Flow measurements were taken at the fully open tap setting. This setup is shown in

Figure 1.

[1] WaterSense at Work – Best Management Practices for Commercial and Institutional Facilities. (2008). Retrieved from https://www.epa.gov/sites/production/files/2017-02/documents/watersense-at-work_final_508c3.pdf

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Figure 1: Left image: the experimental setup for the 5 Gallon bucket method. Right image: Engineer monitoring tap flow

This procedure was repeated up to five times. Uncertainties were calculated with +/-0.5 sec timer uncertainty and +/-0.25 L for the volume uncertainty. Processes to calculate uncertainty and standard deviation, are shown in Appendix A and B, respectively.

Next, the team set up the Wyze camera (fitted with a 128 GB micro-SD card.) Compatibility with the micro-SD card was tested prior to the site visit. This camera can record data continuously for >16 days. The camera software was also set up in advance. The camera – as set up – once it's powered uo it immediately starts recording. Mounting the camera and connecting it to power were the only steps required on site. However, sometimes kitchen managers kindly provided access to their Wi-Fi. In that case, the team would restarted the Wyze camera and set it to the restaurant's Wi-Fi – starting a live feed. But tis footage is saved onto the micro-SD card regardless of Wi-Fi connectivity status, for review later.

The camera was firmly clamped onto a structure above the sink – as shown in Figure 2. It is out of the way and hidden from sight.

Figure 2: Camera mounted onto the corner strut.

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Either a 6 ft or 20 ft power cord was used to connect to a power outlet. The cord was wrapped up and tucked into a notch in the camera mount. This bundle was then taped so no loose cables were visible. The rest of the cord was fed around and over the shelf, taped to the wall and plugged in. The USB plug was also taped to the outlet. This process is shown in Figure 3.

Figure 3: Left: Power cord is taped into the camera mount. Right: note the tape holding the cord on the wall behind the kitchen apparatus. The plug can be seen behind the apparatus. The apparatus is sitting on the shelf under which the camera is attached.

Once secured, a team member opened the Wyze app to check the camera view. Figure 4 shows the placement of the camera, and the view from the camera.

Figure 4: Left: camera placement (see red circle). Right: the image as viewed by the camera.

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The team showed the camera and the live feed view to the kitchen staff, who typically agreed to keep the camera in place for ~10 business days. After ~10 business days the camera was collected and the footage from the micro-SD card was reviewed.

6 Results and Discussion

Table 2 shows the measured flow rates at the data collection sites.

Data was collected from camera footage.. as shown in Appendices A and B, respectively.

Table 2: Tap flows in sinks used to thaw out frozen food in the participating kitchens.

Location	Number of sinks	Flow Rate (L/min)											
		Sink 1			Sink 2			Sink 3			Sink 4		
1	1	20.30	+/-	0.47									
2	4	18.08	+/-	0.14	5.83	+/-	0.12	16.17	+/-	0.17	6.83	+/-	0.12
3	1	16.22	+/-	0.31									
4	1	16.17	+/-	0.17									
5	1	21.60	+/-	1.19									
6	1	25.25	+/-	0.49									
7	1	20.00	+/-	0.54									
8	1	14.00	+/-	0.17									
9	1	19.00	+/-	0.27									
10	2	24.38	+/-	1.43	17.88	+/-	0.39						
11	1	14.00	+/-	0.13									
12	1	18.00	+/-	0.20									

An unanticipated challenge arose: no commercial kitchen surveyed fully observed the FDA food defrosting codes. At some point or another during the food defrosting process all these kitchens would do so in stagnant water (some more than others.)

To get a better idea of how much water would be wasted if all these commercial kitchens complied with FDA standards – a rules/regs compliant scenario was calculated.

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For this rule compliant hypothetical, the known tap flow rates were multiplied by the total time food was defrosted, whether in stagnant or flowing water.

These total times are reported in the "Total Hours Assuming FDA Compliance" column in Table 3 below. This is the amount of water that would be used if all the thawing were conducted with flowing water (as per FDA code). The rise in time required for the FDA compliant scenario is shown as a percentage vs. observed use flow times.

Table 3: The collected defrosting process data.

Location	Length of Study (days)	Number of Cycles	Total Hours Thawing With Flowing Water (Hrs)	Total Hours Assuming FDA Compliance (Hrs)	% Increase
1	11	14	9.02	29.07	222.28
2	10	30	50.68	54.82	8.17
3	10	3	0.90	7.78	764.44
4	10	4	2.22	3.87	74.19
5	10	5	5.17	7.93	53.38
6	13	20	1.62	8.63	433.70
7[2]	10	25	80.00	90.00	12.50
8	11	5	0.65	11.95	1738.46
9	10	7	4.72	9.20	94.92
10	10	28	19.48	95.40	389.73
11	10	2	0.57	1.30	128.07
12[3]	10	25	20.00	90.00	350.00

From Tables 2 and 3, it is possible to calculate an overall average tap flow rate, and an average thawing cycle duration. Results are highlighted below:

Average tap flow rate: 17.1 L/min

Average thawing cycle duration with flowing water: 69.7 min

Average thawing cycle duration (ideal FDA compliant case): 146.4 min

[2] Water usage provided by restaurant management.
[3] Projected water usage. Data still to be analyzed.

Thus - an average commercial kitchen in the LA area can use up to **1,192** Liters in a single thawing cycle.

In most kitchens surveyed more than one cycle is required in each business day.

And if the kitchen adheres to FDA guidelines, usage rises to **2,503** Liters/thawing cycle.

Given that the latest CNSRV WTR appliance uses ~150 L/cycle (depending onf the volume of the food being thawed), **2,353 L** per thawing cycle can be saved. This is a 94.0% drop in water usage per thawing cycle - if the FDA guidelines were observed.

Under observed conditions, ~ **1,042 L** per thawing cycle are saved – which turns out to be a 87.4% saving for a single cycle – and much more for multiple cycles/day

Aside from this applied research project – the team reviewed recently deployed pre-commercial prototypes of the updated CNSRV WTR appliance under test at one restaurant and two market chains' kitchens. From these field visits it was learned that the end-users were highly satisfied with these appliances. In fact – they grouched when the units were temporarily retracted for updates and/or repairs. All three expressed a high level of satisfaction with the updated version vs. the older units (now discontinued) as well as vs. the Cold Water Method. The three field tests were conducted at Whole Foods in Sherman Oaks, CA (since April 19. 2022) , at Whole Foods in El Segundo CA (since May 17, 2022) and Santa Monica Seafood (since June 6, 2022). They all confirmed significant water and time savings as well as ease of operation. All three decided to purchase these test units.

Some commercial kitchens run more than one thawing cycle/day – and some run less than one/day . On average – at the tested sites – there were 1.34 thawing cycles/day.

All the visited commercial kitchens did not follow FDA code. It is equally alarming how much water would be wasted if FDA codes were strictly followed. This suggests that a broad adoption of the CNSRV WTR appliance successfully tackles the general lack of FDA compliance along with freeing up valuable sink space, saving time, lowering water and sewage bills - and most importantly – conserving a significant amount of potable water. Better yet – there would be less food poisoning.

Kitchen 12

CNSRV USER 1005

Kitchen 7

CNSRV USER 1009

Figure 5: CNSRV WTR pre-commercial prototypes in use.

7 Conclusions

Several conclusions can be drawn:

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A. On average - **the use of one CNSRV WTR appliance in one commercial kitchen** that defrosts food leads to 1,396 Liters (369 Gallons) saved per business day – or about 114,390 Gallons/year (assuming most restaurants are open 310 days per year) - or **0.351 acre feet/kitchen each year.**

B. In Los Angeles County alone – County published statistics indicate there are "*over 26,000 restaurants, 12,000 markets and 1,200 food warehouses*".
Conservatively estimating that 60% of the restaurants and 75% of the markets in LA County defrost food — in Los Angeles County alone – yields 16,500 facilities that can benefit from the subject water conservation appliance.
Given that:
(i) LA County has a population of approx. 10 million people, and
(ii) the District serves about 19 million people.
…….it is conservatively projected that there are ~30,000 commercial kitchens in the District that defrost food
…….which yields an estimate of **10,530 acre-ft saved per year in the District**.

C. The introduction of CNSRV WTR appliance in commercial kitchens will lower the risk of food poisoning caused by inappropriate food defrosting practices.

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Appendix A - Uncertainty

This process outlines the manner in which uncertainty was calculated for the 5 Gallon bucket flow measurements. First, let Q_i be the volumetric flow rate of trail *i*. In the experiment, a volume V_i (L) and a time taken t_i (s) were found. The subscript *i* refers to the i^{th} trail of *n* total tails. The relationship between these two quantities is given by:

$$\boldsymbol{Q_i} = {}^{\boldsymbol{V_i}}\!/_{\boldsymbol{t_i}} \tag{1}$$

During the experimental procedures, there was an uncertainty in the volume and time measurements, δV and δt respectively. Thus, the error δQ_i in the total value Q_i (flow rate measured in trail *i*) is given by:

$$\frac{\delta Q}{|Q|} = \sqrt{\left(\frac{\delta V}{V}\right)^2 + \left(\frac{\delta t}{t}\right)^2} \tag{2}$$

In the experiment, multiple readings are calculated and then averaged. *Q* is the flow rate average value. To find the uncertainty δQ in the total value *Q* for *n* measurements, the below relationship was used:

$$\delta Q = \frac{1}{n}\sqrt{{Q_1}^2 + {Q_2}^2 + \cdots + {Q_i}^2 + \cdots + {Q_n}^2} \tag{3}$$

Appendix B – Standard Deviation

This is to describe how the standard deviation was calculated for the 5 Gallon bucket flow measurements. The function "*STDEV.P*" was used in Excel. This built-in function uses the following equation[4]:

$$\sigma = \sqrt{\frac{\sum(Q_i - \bar{Q})}{n}} \tag{4}$$

Here, σ corresponds to the standard deviation; Q_i refers to the flow rate measured in the i^{th} trail; $\bar{Q}$ refers to the sample mean average; and *n* is the number of trails.

[4] STDEV.P function. Retrieved at: https://support.microsoft.com/en-us/office/stdev-p-function-6e917c05-31a0-496f-ade7-4f4e7462f285