Determining the Capacities of the Hin, Omer, and Ephah

William P. Houser and Rochelle A. Houser

September 6, 2015

Showing 3.4 C in a quart jar for the omer, 10 of those in large bowl for an ephah, and 1 pint for the hin of oil. Also showing the proportions of the recipe for the bread and the drink offering in Exodus 29:40, and the resulting bread one batch made. Showing another 3.4 C flour with oil poured over, to show all the ways a grain offering could be brought except a roasted sheaf, according to Leviticus 2:1-7

Abstract:

We are illustrating the book of Exodus, for ease in understanding and memorizing it. There was too much variation in the published literature for the modern equivalents of the Biblical measures of hin, omer, and ephah to portray confidently their volumes. Also, the ratios between the hin and the omer

were such that a viable bread could not be made from the recipe in Exodus 29:40 that could be baked in two different thicknesses, and prepared two ways in a pan with oil, as described in Leviticus 2, and Exodus 29:2. We are proposing that these preparation methods were shallow-oil pan frying, and deep-fat-frying.

Therefore, we set out to determine the values for the hin, omer, and ephah that would comply with the various constraints set in the Bible. We determined by experimental evidence the maximum amount of olive oil that could be absorbed by modern wheat, with a minimum of water to make a viable bread prepared as described. **It was 5 parts oil to 16 parts flour, to 4 parts water.** We then evaluated the remaining constraints we could find in the Bible for these units, and used the experimentally determined ratio to set upper and lower bounds on the other units. Our calculations and analysis show:

The range for the omer is 3.2C – 2.8 C, using the highest low value and the lowest high value. **The average is 3.4 C for the average mid range.**

Using the Biblical equivalent of 10 omer = 1 ephah, then

The range for the ephah is 2.0 US gallons - 1.75 US Gallons, with an average of the mid range of 2.1 US gallons. (or a modern peck. Tanja Pommerening calculates the New Kingcom and Middle Kingdom hekat to be 1.26 gallons, in source 31. Another source lists a modern peck of 2.0 gallons as one of the Egyptian units, in source 11.)

The range for the hin is 4.0 C or less – 3.5 C or less, using the lowest low value and the lowest high value. The average is 4.0 C or less for the average mid range.

Since they have the same ranges and basically the same average, there is a possibility that they are the same value, of **approximately 3.5 C.** However, bread can be made without any oil at all, the values in our chart are maximums at each level. So, we could show the Egyptian value of a hin at 2.0 C, which corresponds to our modern US pint, and the omer at somewhere between 3-4 C, which corresponds to our modern quart, and the ephah as a large bowl with a capacity of close to 2 gallons, or our modern peck. This will satisfy all the Biblical constraints, and would provide a reasonable amount of Kcal as a daily ration for the omer, and also would produce loaves of bread that would fit on the showbread table.

Introduction:

In the process of illustrating the book of Exodus, we were faced with the question of how to show the amounts of an omer, ephah, and hin. (Exodus 16, Exodus 29:40). For the grain offerings we also wanted to show the different forms that could be brought and the approximate amounts specified. A literature search of Christian Bible-study aides, Jewish sources of the Talmud, and secular unit conversion sites showed such a wide variety of values for the hin and omer and ephah (from 12 C to 40 C for the hin, and from 3/5 bushel to over a bushel for the ephah), as to render them useless in trying to show the sizes, or to try to make the bread. Even if they would make bread, we thought the sheer size of most reported omers would be too much for a person to eat in one day. After also reading that the Hebrews didn't maintain a standardized measuring system throughout history (https://www.biblegateway.com/resources/encyclopedia-of-the-bible/Weights-Measures), and even used the same name for different amounts of a quantity, (http://www.jewishvirtuallibrary.org/jsource/judaica/ejud_0002_0020_0_20697.html), we decided to see what the ancient Egyptian measuring system was, to see if that would give more clarity to the amounts shown in Exodus, since it is likely that Moses would have been thinking in Egyptian units.

At one time, the Egyptian hin seems to be pretty standardized at 2.02 C or 0.477 L, but the hekat and

corresponding Oipe (which could correspond to the Ephah) had some changes from the Old Kingdom to the New Kingdom, and there was too much ambiguity in the descriptions on how they changed to be definitive. The hekat used to be 10 per Khar, but later 16. (Did the khar increase, or the hekat decrease?) The corresponding Oipe, and therefore omer, would be either 8 C or 5 C, and the hin would be either 2 C, or 1.26 C), depending on which way the system changed. There was also another decree changing the i'pt (oipe) to 50 hin. It was not reported when this change occurred, to see if it would be before or after Moses was likely to be in Egypt. Even if we used a somewhat standard value of 8 C for the omer and 2 C for the hin, when we made up a batch of bread as described in Exodus 29:40, it seemed like an excessive amount of food for an adult to reasonably eat in one day.

Therefore, we set out to determine what ranges these measures would have to be, in order to comply with the known constraints that are listed in the Bible. We have primarily used the Bible sources, and what Josephus says about the size of the showbread, and what we can find about grain and human physiology on the internet.

We have done an experiment with modern wheat and olive oil to establish the maximum ratio of oil that can be absorbed into flour, with a minimum of water needed to make a viable bread which can be baked as thick cakes, baked as thin wafers, and prepared two different ways in a pan/griddle with oil, as described in Leviticus 2 and Exodus 29:2, for ways to bring a grain offering in general, and for Aaron's and his sons' consecration service. **The ratio was determined to be 5 parts oil to 16 parts flour to 4 parts water.** This then, was applied to data that was known or calculated about either the hin or the omer from a particular Biblical constraint, and the minimum and maximum values were recorded for each situation.

Based on the data collected and calculated, the hin and the omer had similar minimum to maximum ranges, and could possibly be the same size.

The range for the omer is 3.2C – 2.8 C, using the highest low value and the lowest high value. The average is 3.4 C for the average mid range.

The range for the hin is 4.0 C or less – 3.5 C or less, using the highest low value and the lowest high value. The average is 4.0 C or less for the average mid range.

This table summarizes the details in the rest of this article.

Constraint	Omer Low	Omer Mid	Omer High	Hin Low	Hin Mid	Hin High
Ratio of oil:flour to make bread	4 omer: 1 hin 1 omer>=4/5 hin	4 omer: 1 hin		No min. can be calculated from this ratio	No mid can be calculated from this ratio	1 hin <= 5/4 omer
Omer's caloric value as daily ration	2 C	3.58 C	7 C	2.5 C or lessFrom ratio of flour to oil	4.5 C or lessFrom ratio of flour to oil	8.8 C or lessFrom ratio of flour to oil
Hin's minimum daily water ration	2.52 C Calculated from ratio and the Hin Mid value.		11.2 C or more Calculated from ratio and the Hin		3.15 C	14 C

Constraint	Omer Low	Omer Mid	Omer High	Hin Low	Hin Mid	Hin High
			Max value			
Bath's size based on Solomon's Laver	No minimum can be calculated	0.3331 US gallons= 5.3 US C. (if hemisphere)	0.495 US gallons = 7.92 US C (if cylinder)		6.6 C or less Calculated from ratio of oil to flour and the omer mid value	9.9 C or less Calculated from ratio of oil to flour and the omer high value
Showbread table size	No minimum can be calculated	3.2 C	13.5 C ridiculously tall 9" assumption		4.0 C or less Calculated from the ratio of oil to flour and the omer mid value	16.9 C or less Calculated from the ratio of oil to flour and the omer high value
Mishna's Showbread size, and our estimate of an etzba using modern barley grain sizing.	2.16 C (barley)		2.82 C (barley)	2.7 C or less Calulated from ratio of oil to flour from the omer low value		3.5 C or less (barley) (Calculated from ratio of oil to flour from omer high value)
Mishna's Showbread size, and our estimate of etzba using finger-width, and yeast bread conversion factor:	2.22 C	2.87 C	3.65 C	2.8 C or less (Calculated from ratio of oil to flour from omer low value)	3.6C or less (Calculated from ratio of oil to flour from omer mid value)	4.6C or less (finger-width) (Calculated from ratio of oil to flour from the omer high value)
Mishna's Showbread size, and our estimate of etzba using finger-width, and unleavened bread conversion factor.	3.2 C	3.8 C	4.6 C	4.0 C or less (Calculated from ratio of oil to flour from omer low value)	4.8 C or less (Calculated from ratio of oil to flour from omer mid value)	5.8 C or less (Calculated from ratio of oil to flour from omer high value)

Constraint	Omer Low	Omer Mid	Omer High	Hin Low	Hin Mid	Hin High
Sheaf size: (Lev. 23:10-15; Ruth 2)	No minimum can be established	1.4 C	15 C		1.75 C or less Calculated from the ratio of oil to flour from the omer mid value	18.8 C or less Calculated from the ratio of oil to flour from the omer high value
Conclusion:	**3.2 C** (highest of low range) 2.4 C avg.	**3.4 C (Avg)**	**2.8 C** (lowest) 8.2 C avg	**4.0 C or less** (highest of low range) (3.0 C or less avg)	**4.0 C or less** (avg of mid)	**3.5 C or less** (lowest of high range) 10.3C or less (avg)

Biblical Conversion Factors:

The Bible provides the following conversion factors:
10 omer = 1 ephah = 1 sheaf (See Ex 16: 36, Leviticus 23:10-12)
1 etzba = 1 finger-width (Jeremiah 52:21)
1 bath = 1 ephah = 10 omers (Ezekiel 45:11, Exodus 16:36)

Observations and Conclusion:

1. The ranges for omer and hin are basically the same; so, it is possible that they are the same size. This would eliminate a need to carry two different measuring systems with them. This is similar to our modern Liter, which is the same size for both liquid and dry.
2. Solomon's Laver was probably shaped more like a cone or a trumpet flower than a hemisphere or cylinder.
3. The caloric intake establishes the range for the omer which assumes that the calories in our estimated recipe is similar to manna.
4. The Standard published values for the hin, omer, and ephah generally are too large to fit with the constraints of the caloric intake per day, and shewbread table size.
5. Since our table values establish the maximum the hin could be at the different levels of high, medium, and low, and the Egyptian h**in** is pretty well established at 2.02 C or 0.477 L, as is the neo-Babylonian m**in**a, I am inclined to use this as the hin value, especially since our word for 2.0 C is p**in**t.
6. Bread for the grain offerings will be based on the ratios of oil and flour for the morning and evening sacrifices, as listed in Exodus 29:40.
7. Having an omer be 3-4 C would fit very nicely in one of our quart jars. When I am canning items using a quart jar, I usually only fill it to be between 3.0 and 3.8 C, so that there is headroom at the top of the jar. To get 4.0 C into a quart canning jar, one must fill it to the absolute top rim, which is unusual in normal usage. Therefore, I am inclined to show the omer in a **qua**rt jar, especially since the neo-Babylonian value for 1.006 L is a **qa** This makes the resulting ephah to be 1.26 gallons, which is a value matching an Egyptian hekat,according Tanja Pommerening in 2002 reported in source 31.

Further work needed:

- To refine our estimate of the etzba, we need to grow barley and sort and measure it directly, because we are using published screen sizing that may screen out the largest grains.
- We need to grow barley to test the sheaf size and yield.
- We need to try to eat simulated manna for a week, to determine how much each adult eats per day.
- We noticed so many similarities in names and amounts of the different Mid-Eastern measuring systems to the Old English/US system, that it begs for further study to standardize the systems, and see the word origins.

The Constraints:

1. Oil to Flour Ratio to Make Bread:

Our experimental values for making the bread showed that for modern wheat flour, the maximum amount of oil to flour ratio to make bread at a ratio of 1 omer to ¼ hin, was 5 part olive oil to 16 parts flour to 4 parts water.
Therefore, the minimum omer has to be: 1 omer >= 4/5 hin. Conversely, 1 hin <= 5/4 omer.

Discussion:
There are several recipes for bread for the grain offerings which use ratios of the ephah and hin. These recipes must be able to make a viable dough that can be baked, and prepared two different ways in a pan with oil, according to Leviticus 2, and Exodus 29:2, as the three different types of bread to be brought for Aaron's and his sons' consecration service. We are proposing these two different ways were deep-fat frying, and shallow-oil pan frying.

Meat offerings

Flour	Oil	Ratio of oil/flour or hin/ephah	Drink	Flesh	Event or Reason	Reference
0.1 deal	0.25 hin	2.5/1	0.25 hin	Daily Lamb	Daily burnt offering	Ex 29:40
0.2 deal	Not specified		0.25 hin	1 year old male lamb	Burnt offering to go with the wave sheaf.	Lev 23:13
0.1 deal	0.25 hin	2.5/1	0.25 hin	1 lamb (kid Num 15:11)	Burnt offering, or sacrifice to pay a vow, or freewill offering, or for	Num 15:4

					the solemn feasts (Numbers 15:3)	
0.2 deal	0.33 hin	1.1/1	0.33 hin	Ram	Same as for Numbers 15:4	Num 15:6
0.3 deal	0.5 hin	1.666\1	0.5 hin	Bullock	Same as for Numbers 15:4, and also as a congregational sin of ignorance offering.	Num 15:9
0.1 ephah	0.25 hin	2.5\1	0.25 hin	Daily lamb	Daily burnt offering. Should be brought as bread. Numbers 28:2	Num 28:5
0.3 deal	Not specified		0.5 hin	Bullock	New Moon offerings. Should be brought as bread. Numbers 28:2	Num 28:12-14
0.2 deals	Not specified		0.33 hin	Ram	New Moon offerings. Should be brought as bread. Numbers 28:2	Num 28:12-14
Several/10 deal	Not specified		0.25 in	Lamb	Should be brought as bread. Numbers 28:2	Num 28:12-14
1 ephah	1 hin	1/1	Not specified	Bullock	Passover grain offering.	Ezekiel 45:24
1 ephah	1 hin	1/1	Not specified	Ram	Passover grain offering.	Ezekiel 45:24
1 ephah	1 hin	1/1	Not specified	Ram	Sabbath and New Moon offerings.	Ezekiel 46:5
1 ephah	1 hin	1/1	Not specified	Bullock	Sabbath and New Moon offerings.	Ezekiel 46:7
1 ephah	1 hin	1/1	Not	Ram	New Moon	Ezekiel 46:7

			specified		offering.	
1 ephah	1 hin	1/1	Not specified	Bullock	Feasts and appointed festivals.	Ezekiel 46:11
1 ephah	1 hin	1/1	Not specified	Ram	Feasts and appointed festivals.	Ezekiel 46:11
0.166 ephah	0.33 hin	2/1	Not specified	Daily lamb	Morning offering.	Ezekiel 46:14

Conclusions from above table of bread ratios:

1. A "deal" = an "ephah".

   Where the word "deal" is, it should be understood as ephah, based on Numbers 28:5 and Exodus 29:40. These two texts describe the grain offering for the morning and evening sacrifices, and use the same ratios of flour to oil. In Exodus 29:40, the unit is left out, and the translators supplied the word "deal". However, in Numbers 28:5, the word epah (Strong's 374) is used. The same event would need to be the same amounts. Ezekiel 46:14 also describes the morning offering, but uses a different ratio of 2:1, instead of 2.5:1, but it also uses the Strong's 374, epah, in the verse. Since these are similar amounts, we are going to make the conclusion that the unit implied for the flour, when giving bread recipes is the ephah.

2. The largest ratio of oil to flour is in the morning/evening sacrifices listed in Exodus 29:40, at 2.5:1. Therefore, the hin and the ephah need to be related to each other so as to make viable bread in this ratio of oil and flour.

The experiment:

How Much Oil Can Be Absorbed by Wheat Flour And Still Make Bread That Can Be Baked, Pan-fried, and Deep-fat-fried? (Leviticus 2, Exodus 29:2)

Purpose: To determine the ratio of the Biblical hin to the Biblical omer, as given in Exodus 29:40

Starting Materials:
1 small mixing bowl
1 1-tsp syringe
1/3 C freshly milled wheat flour, unsifted
¼ teaspoon salt
150 mL olive oil to be titrated with the flour
150 mL water to be titrated with the saturated oil/flour mixture

Method:
1/3 C freshly milled wheat flour was put into a bowl, and ¼ teaspoon of salt was added and mixed. Next, 1-mL aliquots of olive oil were added, and stirred into the flour. Observations were made, and the experiment was ended when the flour was completely saturated, and formed a thixiotropic paste which had oil leaking out the sides of the paste. The paste was then subjected to baking, pan-frying, and deep-fat frying.

Results: It took 7 teaspoons of olive oil to completely saturate the 1/3 C flour and form a thixiotropic paste. This mixture did not hold together as bread when pan-frying and deep-fat frying, and when baking as shallow wafers. There was marginal success in the baked thick cake, but it was very crumbly, and would not hold together enough to be able to be held and passed from one person to another, as would need to be in Exodus 29:2 for Aaron's and his sons' dedication.

The experiment was repeated and 7 teaspoons saturated the 1/3 C flour. This time, 1-mL aliquots of water were added and stirred into the paste. Observations were made, and the experiment was ended when I thought there was enough gluten development to make a viable dough that could be baked, pan fried, and deep-fat-fried.
Results: It took 4 teaspoons of water and approximately 30 minutes of kneading to get a dough that had thin strings of gluten, which I determined would be suitable for trying to cook in the various methods. During this process, I was surprised that the flour absorbed the water at the expense of 2 teaspoons of oil. The resulting maximum oil to flour ratio was then adjusted down to 5 teaspoons of oil per 1/3 C of flour to account for this loss of oil.

Another batch was scaled up using 4 C flour, 1.25 C olive oil, and 1 C water. The oil/water/salt was added first and mixed into a thick emulsion, and then the flour added to that. It became a viable dough after only about 5 minutes of kneading, and there was no observable excess of oil squeezed out of the resulting dough. It was very oily, and appeared to be at the maximum level of oil the flour/water would hold. It made viable dough for the three cooking methods, and 4 forms of bread.

Conclusion:
The final ratio to make a viable bread is 5 parts oil to 16 parts flour to 4 parts water.
Since the recipe in Exodus 29:40 relates the two as 1 omer (1/10 ephah = 1 omer) to ¼ hin, the extrapolation of the maximum of the hin to the omer would be:

1 hin <= (5 parts oil x 4 /16 parts flour omer) or **1 hin <= 5/4 omer.** Conversely, **1 omer >= 4/5 hin.**

2. Omer's caloric value as daily ration

Exodus 16:16-21

16 This is the thing which the LORD has commanded: ‘Let every man gather it according to each one’s need, one omer for each person, *according to the* number of persons; let every man take for *those* who *are* in his tent.’”

17 Then the children of Israel did so and gathered, some more, some less. 18 So when they measured *it* by omers, he who gathered much had nothing left over, and he who gathered little had no lack. Every man had gathered according to each one’s need. 19 And Moses said, “Let no one leave any of it till morning.” 20 Notwithstanding they did not heed Moses. But some of them left part of it until morning, and it bred worms and stank. And Moses was angry with them. 21 So they gathered it every morning, every man according to his need. And when the sun became hot, it melted. 22 And so it was, on the sixth day, *that* they gathered twice as much bread, two omers for each one. And all the rulers of the congregation came and told Moses. 23 Then he said to them, “This *is what* the LORD has said: ‘Tomorrow *is* a Sabbath rest, a holy Sabbath to the LORD. Bake what you will bake *today,* and boil what you will boil; and lay up for yourselves all that remains, to be kept until morning.’” 24 So they laid it up till morning, as Moses commanded; and it did not stink, nor were there any worms in it.

31 And the house of Israel called its name Manna. And it *was* like white coriander seed, and the taste of it *was* like wafers *made* with honey.

Numbers 11:7-8

7 Now the manna *was* like coriander seed, and its color like the color of bdellium. 8 The people went about and gathered *it,* ground *it* on millstones or beat *it* in the mortar, cooked *it* in pans, and made cakes of it; and its taste was like the taste of pastry prepared with oil.

Key points:

- One omer per person each day. Each man's need would have depended on the number of people in his family
- Manna was like a grain.
  - It was ground into flour (Num 11:8)
  - It was baked and boiled (Ex 16:23)
  - It was like coriander seed (Ex 16:31)
- The nutrition in Manna was complete and tasted like
  - wafers made with honey. (Ex. 16:31)
  - pastry made with oil. (Num 11:8)

The FE Reference Handbook indicates these body weight ranges for USA Civilian Body Dimensions ages 20 to 60. The caloric requirements are from ChartsGraphsDiagrams.com

	Female		**Male**		**Average**
	kg	Kcal	kg	Kcal	Kcal
5 percentile	46.2	1450 low activity 1805 mid activity 2190 high activity	56.2	1720 low activity 2150 mid activity 2580 high activity	1585 low activity
50 percentile	61.1	1610 low activity 2000 mid activity 2410 high activity	74.0	2050 low activity 2500 mid activity 3050 high activity	2250 mid activity
95 percentile	89.9	1900 low activity 2450 mid activity 2950 high activity	97.1	2410 low activity 3000 mid activity 3620 high activity	3285 high activity

Calories in wafers

Wafer	Kcal	Kcal/cup
Graham Cracker (1 cup crushed, 85g)	355	355
Saltines (1 cup crushed, 70g)	295	295

Simulated Manna:

We based our test omer as 8 C, a commly-reported value. We then added ½ C oil, which is based on ¼ of the Egyptian hin of 2 C. We then added honey in the ratio of oil/honey as a modern recipe for the Mideastern halvah from http://www.thefoodmaven.com/diary/00000146.html. As you can see, this size for the omer yields more Kcal than is what is recommended as a daily allowance. This is one reason the omer needs to re-evaluated. We then scaled the Kcal of the whole recipe to per C, and using the daily recommended Kcal for different weights and activity levels of men and women, determined the range of the omer.

Grains	Kcal	Kcal/cup
Wheat Flour, 8 cups Olive Oil, 0.5 cups Honey, 0.375 cups Estimating total of 9 cups (using modern USA wheat)	407*8 = 3256 1910/2 = 955 1031*3/8 = 387 Total 4898 Kcal /9 cups	511 (not couting oil absorbed while cooking)
Wheat Flour (kamut), 8 cups Olive Oil, 0.5 cups Honey, 0.375 cups Estimating total of 9 cups (Ancient Egyptian wheat)	627*8 = 5016 1910/2 = 955 1031*3/8 = 387 Total 6358 Kcal /9 cups	706
Barley Flour, 8 cups Olive Oil, 0.5 cups Honey, 0.375 cups Estimating total of 9 cups	511*8 = 4088 1910/2 = 955 1031*3/8 = 387 Total 5430 Kcal /9 cups	603
Spelt Flour, 8 cups Olive Oil, 0.5 cups Honey, 0.375 cups Estimating total of 9 cups	588*8 = 4704 1910/2 = 955 1031*3/8 = 387 Total 6046 Kcal /9 cups	672
Brown Rice Flour, 8 cups Olive Oil, 0.5 cups Honey, 0.375 cups Estimating total of 9 cups	574*8 = 4592 1910/2 = 955 1031*3/8 = 387 Total 5934 Kcal /9 cups	659
Quinoa Flour, 8 cups Olive Oil, 0.5 cups Honey, 0.375 cups Estimating total of 9 cups	626*8 = 5008 1910/2 = 955 1031*3/8 = 387 Total 6350 Kcal /9 cups	706
Amaranth Flour, 8 cups Olive Oil, 0.5 cups Honey, 0.375 cups Estimating total of 9 cups	716*8 = 5728 1910/2 = 955 1031*3/8 = 387 Total 7070 Kcal /9 cups	786
Maize Flour, 8 cups Olive Oil, 0.5 cups Honey, 0.375 cups Estimating total of 9 cups	442*8 = 3536 1910/2 = 955 1031*3/8 = 387 Total 4878 Kcal /9 cups	542
Chia Seed, 8 cups	137*8*8 = 8768	1123

Olive Oil, 0.5 cups Honey, 0.375 cups Estimating total of 9 cups	1910/2 = 955 1031*3/8 = 387 Total 10110 Kcal /9 cups	
Rye Flour, 8 cups Olive Oil, 0.5 cups Honey, 0.375 cups Estimating total of 9 cups	361*8 = 2888 1910/2 = 955 1031*3/8 = 387 Total 4230 Kcal /9 cups	470

Average (excluding Chia) is 628. low = 470 and high is 786.

Range of US cups/omer	Low: 470 kcal/cup	Mid: 628 kcal/cup	High: 786 kcal/cup
Low: 1585 kcal/day	3.37 C	2.52 C	2.02 C
Mid: 2250 kcal/day	4.79 C	3.58 C	2.86 C
High: 3285 kcal/day	6.99 C	5.23 C	4.18 C

The range for an omer based on calories per day is 2 to 7 cups with a mid of 3.58 cups .

The range for an ephah based on calories per day is 20 cups (1.25 gal) to 70 cups (4.28 gal) with a mid of 35.8 cups (2.24 gal).

3. Hin's minimum daily water ration

Ezekiel was told in Ezekiel 4:11 to be an example to the Children of Israel, and show that dire circumstances were coming. He was told to measure out 1/6 of a hin, and drink it at set times during the day. There is some ambiguity as to whether that is the total amount of water he was to drink for the day, or if that was just the portion or aliquot of the maximum he could drink at a time, with unlimited times to drink during the day. Since water consumption need is based on many factors, such as temperature, humidity, activity, caloric intake, and water in food, it seems reasonable to us that God would not prescribe a set total amount for Ezekiel to drink each day, but rather a set amount to drink at one particular time during the day. Also, after doing an exhaustive search on the internet for an authoritative study on how much water is absolutely needed per day, we were surprised to find there is not such a document to be found. Many places presumed the standard 6-8 glasses of water per day, but provided no evidence to support the numbers. Some went as low as 1 pint, up to nearly 1 gallon per day as minimum water consumption. Most of them clearly stated this was not to be tested out, as it was not tested in humans, but only speculation. Therefore, we are only using this to be a check against other methods of computing a hin.

Most published Christian Bible-study, Jewish, and secular unit conversion site values for the hin (12-40 C), would have Ezekiel measuring out a pint (2.0 US C or .477 L) minimum, to a quart and a half (6.7 US C or 1578 mL) to drink at a time. Based on Shelley's own water consumption patterns, we think this amount of water would not particularly show that there was a dire famine and drought coming, and think this makes the hin value too high.

There is a pretty well-established value for the Egyptian hin, however, based on tomb paintings, that puts the Egyptian hin at 2.02 US Cups, or 0.477 L. This would make Ezekiel measuring out 1/3 US C (79.5 mL) at a time, and drinking it several times per day to get in his daily need of water. This seems more likely to be showing a famine and dire circumstances coming.

Modern Water Emergency Rations:

We did a search to see if there was any standard in modern emergency rations for water. We found two sizes of rations, a 4.2 oz pouch, and a 22-fl oz can. The 4.2 oz pouch was much more common, and we only found one source for the 22-fl. Oz can.

1. 4.2 ounce pouches are the industry standard emergency water ration. One seller,

http://www.nitro-pak.com/emergency-water-pouch-case-of-64 , states: "When determining how many cases you wish to purchase, we suggest planning on using at least 4 and as many as 8 pouches per day, per person. (Just a quick side note— a daily 'lifeboat' ration is 2 pouches of water per day. Yep, that's only 8.4 oz! Just pray you're found fast). - See more at: http://www.nitro-pak.com/emergency-water-pouch-case-of-64#sthash.4krZlQaE.dpuf "

This suggests that 1/6 of a hin is equal to 4.2 ounces. = a little more than ½ C with each drink, with up to 8 drinks per day. This seems very reasonable. If this is true, then

1 hin = 25.2 ounces = 3.15 cups. (if Ezekiel could drink up to 8 times per day)

2. The 22-fl. Oz can: Http://www.beprepared.com has canned water at 22 fl. Oz per pack, and 3 per day as a ration.

22 fl. Oz x 3 = 66 oz per day/8 oz = 8.25 C water per day per person.

This suggests that 1/6 hin could be equal to 22 fl oz. = 18.9 dry oz = 2.3 C or a little more than a pint with each drink, and only 3 drinks per day.

1 hin = 132 fl oz /1.1636 fluid oz/dry oz / 8 dry oz / C = **14 C maximum** (if Ezekiel could drink only 3 times per day.)

Conclusion:

I think the first situation is the most likely situation. Ezekiel would be measuring out a smaller volume of water for each drink (½ C) , to show more of a dire situation, than in the second scenario, where he would be measuring out more than a pint. A pint seems to be a "normal" to even excessive amount of water to drink at a time. That opinion is based on Shelley's own pattern of water consumption.

4. Bath's size according to Solomon's Temple's Laver

I Kings 7:23-25 describe the brasen sea or laver that Solomon built for the temple. It is described as being circular, and 10 cubits across from rim to rim. It is also 30 cubits around, measured linear length, and 5 cubits high. It's rim, at least, is described as being like a lily, or the edge of a cup. It also held 2000 baths.

Calculating the maximum volume of a bath according to these dimensions:
If we assume it is mostly a cyllinder, with just a flare out at the top rim, that will give us the maximum volume. Volume of a cyllinder is πrrh. We can see that their circumference is close to being pi times the diameter, which was measured at 30 cubits. If it were an exact circle, it would be 31.4 cubits around. Therefore, we will be erring on the side of being more than less.

V = 3.14 x 5 x 5 x 5 = 392.5 cubic cubits.

(392.5 cubic cubits)(18 inches / cubit)(18 inches /cubit)(18 inches)/cubit) = 2,289,060 cubic inches.

2289060 cubic inches \ 231 cubic inches/ gallon = 9,909 gallons.

If 2,000 baths = 9,909 gallons, then within the error of the dimensions of the brass sea, we can conclude that 2000 baths = 10,000 gallons, or
1 bath = 4.95 gallons Max.

If the sea was a hemisphere: then the volume would be ½ of 4/3 pi x r x r x r = 4/6 x 3.14 x 5 x 5 x 5 = or 2/3 of 5 gallons, which is **3.31 gallons per bath. Mid range**

If it were a cone, then the volume would be 1/3 Area of base x height. = 1/3 x pi x 5 x 5 x 5 = or then it would be **1/3 of 5 gallons or 1.6677 gallons per bath. There is no minimum value.**

How this related to an omer:
Ezekiel 45:11 states that the bath is equal to the ephah. Since the ephah = 10 omers, then the bath = 10 omers.. Conversely, the omer = 0.1 bath. The values for the omer stated in the chart at the beginning of the paper are based on this Biblical equivalency.

I have found no Biblical equivalent of the bath to the hin. There are some equivlency sites on the web that state that 6 hin = a bath, but no references are given for that statement. I have found no primary source for that equivalent statement, so we are not using that in our constraints, or Biblical equivalency charts.

5. Table of Shewbread Size :

There is no description of when God told Moses how to make the table of shewbread for anything like racks to be placed above the table to hold the bread. Therefore, the 12 loaves of bread, made with 2 omers each, must be able to be placed in an array of 6 x 2 on the top of the table.

The table is specified to be 1 cubit x 2 cubits on the top. There needed to be 2 rows of 6; so each would be 0.5 cubit x 0.33 cubit. If 1 cubit = 18 inches, then the surface area of the base including the space between loaves would be 9” x 6” = 54 square inches maximum.

Our first fruits bread was made with 16 cups and became a loaf 20” x 4” x 3.5” = 280 in^3. This means there are17.5 in^3 per cup of flour.

The maximum height seems like it would be 1.5 * width = 9” tall. → 27 cups/ 2 omers → 13.5 cups / omer

Typical traditional US loaf size is 9” x 5” x 2.5” = 6.428 cups/2 omers = 3.2 cups / omer

6. Mishnah's Showbread Size ((With Finger width and Barley Seed Size):

One source says the loaves of the shewbread were : "The Mishnah describes the loaves as being 10 Etzba long, and 5 Etzba wide, with rims/*horns* that were 7 Etzba long;" (https://en.wikipedia.org/wiki/Showbread) [

Another source states that 1 etzba = 7 barley corns laid side by side. (https://en.wikipedia.org/wiki/Biblical_and_Talmudic_units_of_measurement)

A. Deriving the Etzba from barley seed:

The modern barley seeds can be sized according to this source:

"Six-row and two-row barley seed lots can be sized with 5 1/2 /64

to 6/64 x 3/4 inch slotted screens. Air settings need to be determined by the operator for individual air-screen cleaners.
Six-row barley with 11,000 to 14,000 and two-row barley with 9,000-12,000 seeds/lb are considered good quality." http://wintercereals.us/Documents/Growing%20WW/Production%20Articles/General%20Seeding%20Issues/Small%20Grains%20Seed%20Size.pdf

From this data, the etzba can be calculated as follows:
Assuming the barley corns were to be lined up side by side, meaning all the long ends were parallel, and the etzba was a measure of their combined widths, not their successive lengths: Then:

1 etzba = 7 barley kernel widths.
1 barley kernel width can fit through a 5 ½ /64-inch screen = 0.0859 inches (low)
0.0859 x 7 = **0.60 inches (15.3 mm) = etzba (low estimate)**
1 ertzba = 7 barley kernel widths
1 barley kernel width can fit through a 6/64-inch screen = 0.09375 inches (high)
0.09375 x 7 = **0.656 inches (16.6 mm) = etzba (high estimate).**

Therefore: The loaf size reported is in this range:

Low: = 10 x 5 x 7 = 10 x 0.6 = 6 inches long x
5 x 0.60) = 3 inches wide x 7(0.60) = 4.2 inches high.
Recap; 6" x 3" x 4.2". = 75.6 cubic inches.

This probably was not a perfect rectangular solid, since the description makes it sound like the tops were domed, and not flat.

High: = 10 x 5 x 7 = 10 x 0.656 = 6.56" x 5(0.656) = 3.28" x 7(0.656) = 4.59" high
Recap: 6.56" x 3.28" x 4.59" = 98.76 cubic inches

These loaves would fit on the table. This would explain why there are no racks needed to display them,

and why no racks are described either in the Bible, or on the Titus arch when talking about or showing the Table of Shewbread.

B. Deriving the Etzba from Finger-width:
Since the word "etzba" seems to be translated "finger" most often, but is used as a measurement in Jeremiah 52:11, I looked for a standardized "man's hand".
https://en.wikipedia.org/wiki/Hand_%28unit%29 says one finger-width is ¾ inch.

Therefore: an etzba = 0.75 inches.

This matches at least one source for the etzba, according to the *Rambam*, is 1.9–1.92 cm (0.748–0.756 in). (Source 23)

Converted Showbread measurements: 10(0.75) x 5 (0.75) x 7(0.75) = **7.5 in x 3.75 in x 5.25 in. This would fit on the table.**

August 21, 2015
Calculating density of yeast wheat bread, with 9.5 C flour per loaf.

Procedure: Yeast bread was made with 9.5 C flour, approx.

Parameter	Loaf 1	Loaf 2	Average
Weight of finished bread, g	1922 g	1861 g	1891 g
Dimensions, L W H, inches	7.25 x 7.25 x 4.375max. 7.25 x 7.25 x 4.125 avg	7.125 x 7.25 x 4.625 max. 7.125 x 7.25 x 4.375 avg	7.19 x 7.25 x 4.25
Cubic inches, by average dimension calculation.	217 Cubic inches	226 Cubic inches	222. Cubic inches
Cu. in. bread/C flour, by dimensions:	22.8 cu. in. /C	23.8 cu. in. /C	23.4 cu. in. / C
Water displaced,g 68 deg.	3808 g	3626 g	3717 g
Water displaced, mL 68 deg	3814.8 mL	3632.5 mL	3724 mL
Water displaced, cubic inch	232.8 Cubic in.	221.7 Cubic in.	227.3 Cubic inches
Cu. in. bread/C flour, by water displacement	24.5 Cu. in./C	23.3 cu. in. / C	23.9 cu. in. / C
Finished bread, g/mL by water displacement	0.504 g/mL	0.513 g/mL	0.508 g/mL
Average of method calculations:	23.7 cu. in. / C	23.6 cu. in. / C	23.7 cu. in. / C

Range for the Etzba, Based on the NCEES Reference Handbook:

Per NCEES FE Reference Handbook, 9.3 Version for Computer-Based Testing.
ISBN 978-1-932613-67-4 p. 225

Digit 2 (Pointer finger) width for Men, ages 20-60: This matches for Digit 3 as well.
Breadth, distal joint: 5th percentile = 1.7 cm 50th percentile = 1.85 cm 95th percentile = 2.0 cm

Calculating the range for the etzba:
Low = 1.7/2.54 = 0.67 inches/etzba
Mid = 1.85/2.54 = 0.73 inches/etzba
High = 2.0/2.54 = 0.79 inches /etzba

Calculating the range for the showbread:

Josephus states the showbread was unleavened, and The Mishnah describes the loaves as being 10 Etzba long, and 5 Etzba wide, with rims/*horns* that were 7 Etzba long;
https://en.wikipedia.org/wiki/Showbread

Calculating Omer Based on NCEES Etzba Ranges

	Dimensions 10 etzba x 5 etzba x 7 etzba	Would this fit on the table?	Cubic inches	Estimated C/omer Using yeast bread average of 23.7 cubic inches / C flour
Low 0.67 inches	6.7 x 3.35 x 4.69	yes	105.3	2.22 C per omer,
Med 0.74 inches	7.3 x 3.65 x 5.11	yes	136.2	2.87 C per omer
High, 0.79 inches	7.9 x 3.95 x 5.53	yes	172.6	3.65 C per omer

Comparing modern loaf bread baking pans:

Loaf		Loaf	
8 x 4 x 2 1/2 in.	4 cups	20 x 10 x 6 cm	948 ml
8 1/2x4 1/2x2 1/2	6 cups	21 x 11 x 6 cm	1.4 liters
9 x 5 x 3 inches	8 cups	23 x 13 x 8 cm	1.9 liters

Read more: http://www.joyofbaking.com/PanSizes.html#ixzz3jUrzApHO

Since there were 2 omers per loaf of bread, then the modern range for the loaf sizes put the omer at 2C to 4 C.

Note: Shelley has a bread pan that might be what the Mishna is describing. The depth is 2 ½ inches from bottom to top. However, at the very base, making the bottom flat, it is 6 inches x 3 inches. It has rounded corner, and sloped sides. At the extreme part of the "bottom", it is 7.5 inches x 4 5/8 inches. At the top of the pan, the flare on the width 5 5/8 inches, instead of only 4 inches. Perhaps this is what the person describing the loaves was trying to convey, in saying that the width was 5 etzba, with 7

etzba horns/rims.

This loaf pan states it has a capacity of 1.5 Quarts, which would make the omer 6C/2 = 3 C.

C. Relating this to the Omer:
1. By Barley size:
Using our dense yeast bread as an example to calculate the number of cups in this 2-omer representation:

Low range bread: 75.6 cubic inches /17.5 cubic inches of yeast bread/C of flour. = 4.32 C per 2 omer **= 2.16 C per omer.**

High range bread: 98.76 cubic inches / 17.5 cubic inches of yeast bread/C of flour = 5.6 C per 2 omer **= 2.82 C per omer.**

2. Calculating the Etzba by Fingerwidth:

Finger-width loaf cubic inches = 147.7 cubic inches/17.5 cubic inches /C flour = 8.4 C per 2 omer **= 4.2 C per omer.**

This needs to be repeated with unleavened bread, because most-likely the showbread would have been unleavened, to be able to be on the tables during Passover and Feast of Unleavened Bread. Josephus states they were unleavened bread. (https://en.wikipedia.org/wiki/Showbread)

Experimental Showbread:

Since Leviticus 24:5 does not mention any oil with the recipe for the bread, I had the first trial to be with just flour, salt and water to make a dough that would form into bread. Subsequent trials will use 0.33 hin oil, which would correspond to the amount of oil prescribed for a grain offering with 0.2 deal of flour.

8 C whole wheat flour
1 Tbs salt
43 Tbs water

Method: Put flour and salt in bowl and mix well. Add 40-45 Tbs water to make a moderately-stiff dough. Knead in bowl a few times, until the dough forms a ball. Shape into a loaf and bake at 350 F until top of loaf is nicely browned, and the top sounds hollow when tapped, approximately minutes.

Notes: Dough made a ball that was well under the maximum size it would need to be to still fit on the table. I formed it into a loaf that was approximately **6.5 inches x 4 inches x 4.5 inches high** to bake. Compare to the recorded value of the showbread range above: (Smallest: 6.7 inch x 3.35 inch x 4.69 inch Largest: 7.9 inches x 3.95 inches x 5.53 inches, max)

The density of the resulting dough was 1286 g water = 6 C + 3 Tbs water at 70 F. Density of water =

1.000 at 70 F, (68F reference). So, the dough weighs 2.83 US pounds, and takes up the volume of 1,286 mL, or 1.286 L.

The finished bread weighs 1499 grams. Density of bread to Cups of flour: 6.5 inches x 4 x 4.5/8= 117/8 = 14.62 cubic inches per Cup of flour.

Subsequent loaves were made with commercially available wheat flour, and white flour. The table below summarzes the loaves.

Loaf #	Type of flour	Cups of flour	Dimensions (in inches)	Weight of Loaf, g	Cubic inches (by finished loaf size) Formula: L x W x 3 inches for base + (1/3 L x W x (H-3) = total	Cubic inches per C of flour:
1	local	8	6.5 x 4 x 4.5	1499 g	78 + 13 = 91	11.38
2	Com. Whole wheat (CWW)	8	6.5 x 4.5 x 4.25	1670 g	87.8 +12.2 = 100	12.5
3	Com. White	8	6.5 x 4.5 x 4.25	1643 g	87.8 + 12.2 = 100	12.5
4	CWW	6	I forgot to test	1178 g		
4	C WW British quart	9.66	7 1/8 x 5 5/8 x 5.5	1929 g	120 + 33.4 = 153.4	15.9
5	CWW	6	I forgot to test	1015 g		
Avg.						13.0 cu.in/C

Comparing with Josephus' loaf sizes:

Etzba estimate	Resulting loaf size	Will it fit on table?	Cubic Inches Formula: L x W x 3 (to 3 inches) + (1/3 L x W x (H-3)	Estimated Cups of flour in bread from unleavened factor 13 cu in/C	Estimated Cups of flour in omer
Low 0.67 inches	6.7 x 3.35 x 4.69	yes	67 + 15 = 82	6.3 C	3.2 C
Med 0.74 inches	7.3 x 3.65 x 5.11	yes	79.9 + 18.7= 98.6	7.6 C	3.8 C/omer
High, 0.79 inches	7.9 x 3.95 x 5.53	yes	93.6 + 26.3 = 119.9	9.2 C	4.61 C/omer

7. Sheaf size

How big of a sheaf is needed to get an Omer? In 2011 and 2012, the sheaf needed to be 28 to 31 inches in circumference to get 3.6 liters of grain. This sheaf now can be smaller, but we don't have any calculations for that yet, as of 2015. A web site providing the "International Guild of Knot Tyers Forum" includes a post from Derek Smith on October 18, 2009 which says the he remembers when wheat was harvested with a Sail Reaper drawn by 2 horses. The men would bind the sheaves using the straw. So, the size of the sheaf was limited by the height of the wheat. He says that the old wheat was taller than it is today. It was often 3 feet long.

A YouTube video of hand harvesting barley in the Atlas Mountains, http://thedeserttabernacle.blogspot.com/search/label/Value%20of%20an%20Omer, shows sheaves with about 3 inch diameters.

In 2012:

I counted 393 kernels in 1 Tablespoon. (using a previous year's wheat)
I counted 38 kernels in 1 head (this year). This is about ¼ teaspoon.
I counted 111 heads between thumb and middle finger = small canning jar ring. = 6 inch circumference = an area of 3 in^2.

Based on this, we want to estimate the grain volume produced from a 3 inch diameter sheaf:

3 inch diameter → area of 1.5^2 * 3.14 = 7.06 in^2.
Heads of wheat = 7.06/3*111 = 261.4 heads of wheat
kernals of wheat: (2012 harvest yield) = 261.4 * 38 = 9,933 kernals of wheat = or 261.4*0.25 = 65.4 tsp.
Cups of wheat: 65.4 tsp/48 tsp = 1.36 C of wheat. = omer

8. The Quatern and the Quaternloaf:

While searching for the size of a British quart vrs a US quart, I found the following unit:

The Quatern =

quartern [2]

a traditional English unit of weight equal to 1/4 stone, 3.5 pounds, or about 1.5876 kilogram. See also quartern-loaf, below.

quartern [3]

a traditional unit of volume for dry goods equal to 1/4 peck or 2 quarts. This corresponds to 2.2731 liters in the British Imperial system or 2.2025 liters in the U.S. system. The unit is much more common in Britain.

And the Quaternloaf:

quartern-loaf

a traditional English unit of weight for bread. A quartern-loaf is made from a quartern [2] of flour. The finished loaf usually weighs somewhere between 4 and 5 pounds (very roughly 2 kilograms).

This seems to validate the omer as being 1 quart, and the showbread, and the loaves of bread brought for firstfruits to be made with 2 omers, or 2 quarts of flour.

Appendix A: Pictures of the Experiment of Flour to Oil Ratio and the Resulting Bread:

Seven teaspoons of oil in 1/3 C of flour.

After 4 teaspoons of water was added, 2 teaspoons of oil was squeezed back out.

It took 4 teaspoons of water and ½ hour of kneading to get gluten development.

Dough passed all tests for (L to R) pan-fried, deep-fat fried, and baked in 4 different thicknesses.

I was evenly pleasantly surprised that most of the deep-fat-fried specimens puffed, in a repeated experiment using white flour. This description of “cakes mingled with oil” for how the consecration bread was to be brought for Aaron and his sons in Exodus 29:1-2 , and also in the description in how a grain offering can be brought in Leviticus 2:1-7. I think the additional water added to the dough contributed to the puffing, as well as the lighter density white flour. The steam is probably what has raised this unleavened bread.

Ways a grain offering can be brought: 1. Sheaf of roasted ears 2. Pile of flour with oil poured over (not mixed) 3. Baked as thicker cakes, or thinner wafers 4. Pan fried two ways with oil (shallow-oil shown in middle bottom picture and deep-fat-fried shown in bottom right picture.) Leviticus 2:1-7

Appendix B: Recipe for the Grain Offering for the Morning and Evening Sacrifice (Based on 4 C per Omer)

4 C wheat flour, sifted

½ C olive oil

1 1/2 tsp salt

1 ½ C water, to make a moderately soft dough (20-22 TBS)

Method: Put the olive oil, water, and salt in a bowl, and mix until a thick emulsion forms. Add the flour and stir until a moderately soft dough forms. Adjust with small amounts of water or flour, if necessary. Form into 1-2 small balls. Cover with damp cloth until ready to roll out.

For baking: Either make 1-inch balls and place them on a greased cookie sheet. Flatten slightly with hand or a fork, if desired. Or, roll out on well-floured surface to the thickness of pie dough. Transfer to greased cookie sheet and cut into strips or squares in desired size for eating. Poke with a fork, and bake in 350 deg. Oven for approximately 10-14 minutes, or until golden brown. Transfer to cooling rack and sprinkle lightly with salt.

For pan frying: Take a 1-inch ball of dough, and flatten in the palms of your hands, until the patty is about 1/4-inch thick. Or, roll out on well-floured surface to the thickness of pie dough, about 1/4-1/8 inch. Cut into strips or squares in desired size for eating. Place in a hot pan with about 1-2 tsp oil. Fry until golden brown on one side, about 1-2 minutes. Flip and fry on other side until brown, about another 20-30 seconds. Drain on paper towels. Sprinkle lightly with salt.

For deep-fat-frying: Take a 1-inch ball of dough, and flatten in the palms of your hands, until the patty is about 1/4-inch thick. Or, roll out on well-floured surface to the thickness of pie dough, about 1/4-1/8 inch. Cut into strips or squares in desired size for eating. Place in pan which has about 1-2 inches

of oil in the bottom, which has been heated, but is not at the smoking point. Carefully place the dough in the hot oil. Fry for 30 seconds to one minute on one side. Dough will rise to the top of the oil, and may puff slightly, depending on oil temperature, and amount of water in the dough. Flip carefully to the other side, and fry another 10-20 seconds. Take out with tongs or slotted spoon, and drain on paper towels to cool. Sprinkle lightly with salt.

Puffing even seen with whole wheat flour, in one specimen.

Appendix C: The Showbread Loaf:

A trial to determine if 8 C of flour will make a loaf that will fit on the Table of Showbread.

Since Leviticus 24:5 does not mention any oil in the recipe for the showbread, I left it out of the first trial.

8 Cups of whole wheat flour
1 Tablespoon (15 mL) salt
42-45 Tablespoons (630-675 mL) or 2.5-2.66 Cups water.

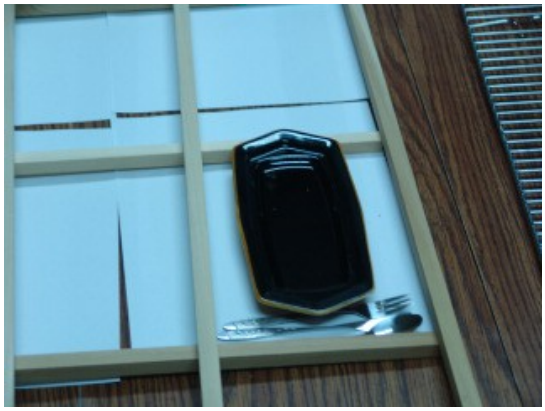
Put flour and salt in bowl and mix. Add water to make a moderately stiff dough, approximately 2.5 Cups. Add small amounts of water at a time, so you don't get it too wet and sticky. When the dough comes together as a ball, knead it a few times in the bowl, or on a greased surface. Form into a small loaf, approximately 6.5 inches by 4 inches. Place in greased and floured loaf pan, and bake at 350 F until the top is golden brown, and sounds hollow when tapped lightly, approximately 45 minutes. You may need to turn down the heat to 325 F the last 15 minutes, to prevent the top from burning. Take out of oven and cool on cooling rack.

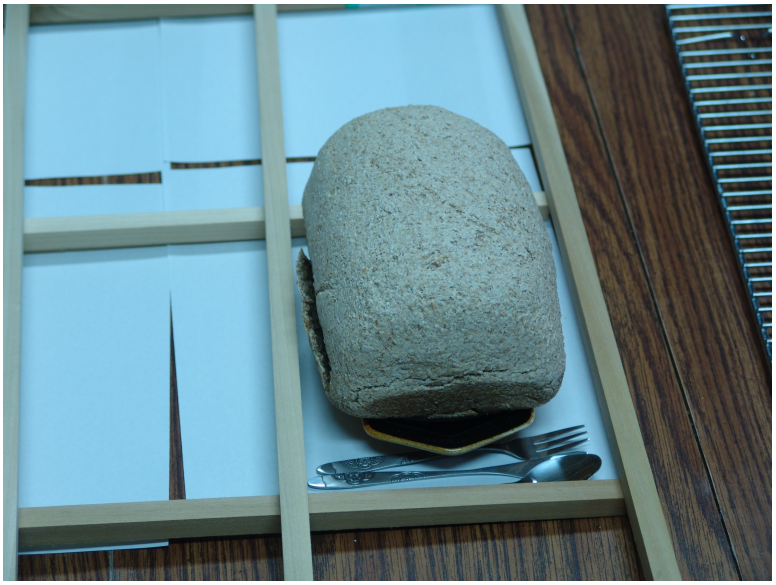
Specification: Dough volume: It was equivalent to 1286 g of water at 70 F, or 1.286 L, or 6 C plus 2 Tablespoons of water. The dough ball shrank in size from 8 C flour to a little over 6 C total.

After baking: The finished loaf weighs 1499 g, or is 3.3 pounds.

Size: At the very bottom of the loaf, it is 3.5 inches wide. At the maxium width, a little further up (perhaps the "horns" talked about in the Jewish literature for the loaf?) it is 4.5 inches. It is 6.5 inches long, and 4 inches tall. **So: 3.5 inches wide (with a max of 4.5 inches) x 6.5 inches long x 4 inches tall.**

Twelve of them will fit, with the utensils, on a table that is 18 inches x 36 inches.





The experiment was repeated, using different amounts of flour as the omer, with the British quart being the highest amount used as the base. I did not use the lowest amount of flour (2 C), because if the higher amounts of flour per loaf would fit on the table, then the lower amounts would, too.

As you can see, the British loaf (Bottom picture, First row, second to last loaf , largest loaf on table), seems that it is at the limit of what can fit on the table, barring special pans that would force the dough up taller. **The British loaf measured: 7.18 inch long x 5 5/8 inch wide x 5.5 inch tall.**

Compare to the **Maximum value for the loaf, using the Etzba: 7.9 inch x 3.95 inch x 5.53 inch**.

The experiment was repeated as follows: From Left to Right, top row to bottom row:

1. Loaf 1: My home-milled wheat locally grown in Evansville, IN. 4 C per omer. 8 C. total
2. Loaf 2: Commercially available whole wheat flour, 4 C per omer. 8 C total.
3. Loaf 3: Commercially available white flour, 4 C per omer. 8 C total.
4. Gap
5. Loaf 4: Commercially available wheat flour, 4.8 C per omer (The British quart), 9.66 C total.
6. Loaf 4: Commercially available wheat flour, 3 C per omer, 6 C total.
7. Second row: Basing a 6-ounce C (Roman pound), then 4 C per omer. (6 oz/C x 4 C per omer = 24 oz per omer, or 24/8 oz/US C = 3 US C per omer x 2 omers/loaf) = 6 C total.

Discussion:

Since there is no practical minimum for the loaf, I focused on the maximum value. The maximum seems to be using the amount of flour in a British quart, or approximately 4.8 C per omer. The recipe needs to be refined, however, because the the showbread baked up to little hard bricks, if baked long enough to not be doughy in the middle. The last loaf in row one was not baked long enough, and upon cooling, the doughy middle started to break out of the thinner baked crust edges. When we tried to slice these loaves, they were almost impossibly hard to cut. We tried using a saw, and a hammer with Bill's full force on it. One blow with the hammer made no dent in the top of the crust. After my son Alex pounded on it for about 20 minutes, he was able to get a dent in the top of the crust. So, unless these really were mostly for show, I think the loaves need to be made with some oil. That would be the next experiment to try. For now, though, I think we can cap the top of the omer at 4.8 C, or the British quart.

Update: Showbread with Oil

On January 23, 2017 I tried the showbread recipe again, with new pans, and added oil to the recipe. I found some 1.5 pound foil loaf pans that were approximately the correct size for the dimentions listed by Josephus. http://www.webstaurantstore.com/dw-fine-pack-15640-1-1-2-lb-aluminum-foil-loaf-pan-500-case/612A80.html

The pan dimensions are as follows:

Top Outside: 8"L x 4 1/4"W
Top Inside: 7 3/8"L x 3 5/8"W
Bottom: 6 3/4"L x 3"W
Depth: 2 5/16"

The recipe is derived from the amount of oil used for the grain offering that is to be brought with a ram offering, which is found in Num 15:6. Since the amount of flour is the same, at .2 deal, I thought that would be a reasonable amount of oil to use in the showbread. The amount of oil specified is 0.33 hin. If the hin is 2 US C, then 0.33 hin would be 2/3 C oil.

Newer Recipe for 1 loaf of showbread:

7 C fine-ground wheat flour (assuming the omer is approximately 3.4 C)

2/3 C olive oil

2 tsp salt

2-2.6 C water, enough to make a workable dough

Method:

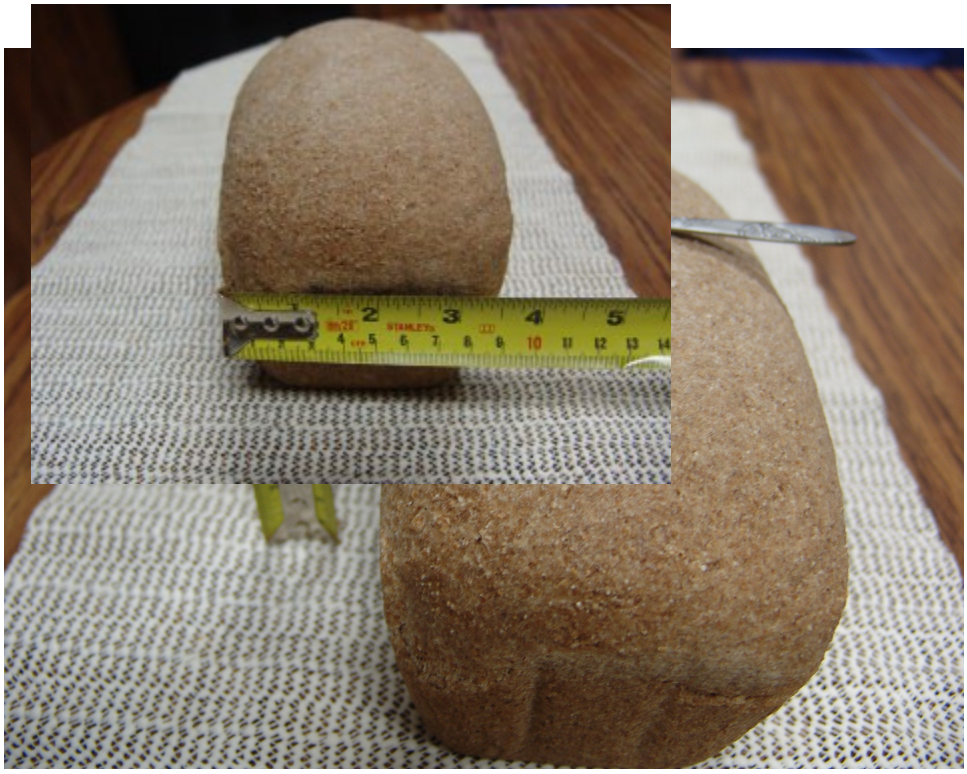
Measure the flour into a medium bowl. Add salt, and mix well. Add the oil, and mix until all the flour is moistened. It will just barely moisten all the flour. Add ¾ C water, and mix well. If the dough is still too dry, add water in ¼ C increments, and mix until the dough is wet enough to form small gluten strands. (see picture for the oil/flour experiment at the beginning of Appendix A). Put on an oiled surface, and knead 5-10 minutes, or until the dough ball is smooth and satiny. Roll out, or pat into a rectangle, about 1-inch thick. Put oil on the surface, and spread out. Fold the dough in half, and put more oil on that surface. Fold in half again, and spread oil on that surface. Form again into a ball, and roll or pat it out again, repeating the oil and folding procedure. May repeat an additional time, or shape into a loaf shape at this time, smoothing the top, and folding the seam on the bottom of the loaf.

Put olive oil in the pan, and spread liberally. Flour the bottom and sides of the pan, and gently ease the dough into the pan. Tuck it down on the sides, and smooth the top before baking.

Bake in a 350 degree F oven for 30 minutes. Check for browning, and turn down the temperature, if necessary. Continue baking until the top is browned, and sounds hollow when tapped on the top. Approximately 45 mintues to an hour total baking time.

Finished loaf:

Picture 1: Length is 7 1/8 inches or about 18.1 cm.




9


800
1kg
200
400
600
800
2kg
200
12
2lbs
4
8
12
3lbs
4
8
12
4lbs
4
8
12
5lbs

Appendix D: The First-Fruits Yeast Bread:

Discussion: Every household was commanded to bring two loaves of yeast bread out of their houses for part of the celebration of the first fruits. The loaves of bread were to be made with two omers of flour each. (Exodus 23:16, Exodus 34:26, Leviticus 23: 17)

By using a 4-C omer, the size of the loaves for the first-fruits bread becomes much more managable, than if one uses the 8-C omer commonly reported. No unusual pans are needed to bake the loaves, and two can fit in our modern ovens easily. This in itself may not be a “proof” that the omer is smaller than 8 C, but it is definitely a consideration, in how big the Israelites' ovens would need to be, in order to bake such large loaves with the larger omer.

Here is a picture of the loaves of bread which are made from an 8-C omer, or 16 C of flour per loaf: They do not both fit into the oven at once, and Bill had to make a special pan in which to bake the loaves.

So, then, here is a recipe, and pictures that would show the size of the loaves of bread that would be made from a 4-C per omer loaf, or 8 C of flour total per loaf.

Appendix D2: Recipe for the Two Loaves of Bread Like was Brought for First-Fruits, or Pentecost

(Exodus 23:19, Exodus 34:22, Leviticus 23:17)
(Based on a modern recipe for yeast bread, but using the amount of flour listed in Lev. 23:17, based on 4 C per omer of flour, 8 oz per Cup)

Recipe for one loaf of bread:

3 tsp yeast
1 C warm water

2.5-3 C water
1 TBS salt
2/3 C olive oil (try ½ C, also)
8 C sifted wheat flour More flour than the 8 C will be needed for kneading, up to 4-5 C more, so have extra on hand already prepared.

Method:

Soften yeast in 1 C warm water. Let sit until bubbly. While you are waiting, put flour and salt in bowl and mix well. Add the oil, and mix until there are pea-sized globs uniformly distributed in the flour. Add the yeast, and rinse the yeast bowl with another cup of warm water. Add the rinsing to the flour. Add 1/2C more warm water, and stir to mix. If it is still too crumbly to make a moderately-stiff loaf, then add more water in 1/4C increments, or so, until you can start to knead the dough. If you make it too thin and sticky, then add more flour until the dough is suitable for kneading.

Turn out onto either a well-floured, or well-oiled surface for kneading. Knead by folding and turning, adding more oil, or more flour on your kneading surface, until you get a smooth, satiny dough. This could be from 15 minutes to 2 hours, depending on the gluten content of your dough, and whether it was sifted or includes the bran.

You are finished when a small piece of dough can be stretched out thin, like pizza dough, without breaking. This is also called the window-pane test, if you can stretch it enough to see some light come through the dough when holding it up to a light source. If you can't get it to this point after two hours of kneading, then go ahead and proceed with the rising and baking.

Put dough in a well-greased and floured pan. If you don't have a large loaf pan for French bread, then use a 3-quart square casserole dish or 10-12-inch round pizza pan. Cover and let rise in a warm place until doubled, or about 45-60 minutes. Bake at 325 degrees F for about 45 minutes, or until top is well-browned and hollow-sounding when tapped. If necessary, turn the oven temperature down the last 15 minutes, to ensure the middle of the bread is baked, without burning the top of the loaf.

Take out and cool on cooling racks.

Repeat for second loaf of bread, or, if you have room in your oven to make the second loaf at the same time, then just use the recipe for the larger amount below.

Recipe for the two loaves of bread:

6 tsp yeast
1 C water

hot water, 5-6 C
¼ C salt
1 1/3C olive oil (Try 1 C also)
16 C flour, plus more for kneading. Plan an extra 4-6 C more.

Soften yeast in 1 C of warm water. Let sit until bubbly. Combine flour, salt, and oil. Put in the softened yeast into the flour, and add 3 more C of water. Stir to mix. Add more water, or flour, until it makes a moderately stiff dough. Turn out on a well-oiled or well-floured table, if it is sticky. Knead until smooth and satiny, about 15 minutes, for well-sifted flour, or up to 2 hours for unsifted flour. It is finished being kneaded when a small ball of dough can be stretched thin enough to see some light through it, like pizza dough. This is called the window-pane test. If you can't get it to this stage after 2 hours of hand kneading, then just start letting it rise anyway. I have the best raised bread if I let it rise only once, so at this point I shape into two round loaves and put in 2- 3- quart greased and floured

casserole dishes, or on 2 greased and floured 12" cookie sheets or pizza pans that have a small rim on them. Let rise until double, about an hour. Bake in a 325 degree F oven until golden brown, and top sounds hollow when you tap on it., about 45 minutes. If necessary, turn down the heat after about a half hour, to make sure the inside of the loaf gets done before the outside gets too dark.

Note: This bread was quite crumbly, and did not slice well until it was at least 1 day old. I may not have kneaded it enough, or else there is too much oil in with this recipe. Since the oil added was based on the unleavened bread recipe for the amount of oil, you may experiment around with adding less oil.

Rochelle A. Houser

1. Sifting and Measuring: Sift and Measure 8 C per loaf of bread. Make sure you have about 22C total, for kneading, and flouring pans.

2. **Meaure out yeast and water:** 3 teaspoons yeast for 1 loaf, Softened in 1 C warm water. Let it get foamy before adding to flour mixture. Do step 3 while waiting. (Showing 1 loaf batch).
3. **Measure out flour, salt, and oil:** Measure out 8 C flour, ¾ C oil, and 1 tablespoon salt.

4. **Mix flour, salt and oil until small dough balls appear uniformly throughout.**

5. **Add yeast to flour mixture.**

6. **Add 2 C water, or until you get a moderately stiff dough. Add more water, or flour to get to where you can knead the dough.**

7. **Knead on well-oiled, or lightly floured surface until sponge is smooth and satiny, and passes the "window pane test". This is what the "window pane test" looks like**

The window-pane test results will depend on how much gluten is in your flour, and how long you knead it. These are all acceptable results to stop kneading. Left bottom one is with very finely sifted whole wheat flour, until it was almost white, higher gluten flour. The other two are with unsifted, stone-ground wheat flour with a low gluten content.

8. **Cover and let rest 5-10 minutes. Grease and flour your pan while you are waiting.**
9. **Transfer dough to pan. Cover, and let rise until double. (About 45 minutes). Wash dishes and clean off the table while you are waiting for it to rise. Preheat oven to 325 degrees F.**

10. **Bake at 325 degrees F for about 45 minutes, or until golden brown, and loaves are hollow-sounding when tapped.**
11. **Remove from oven, and cool on cooling racks. Enjoy!**

Conclusion:

Most commonly reported values for the omer and the hin are too large. Based on experimental evidence of the amount of oil that wheat flour can absorb and still make unleavened bread that can be baked and prepared two ways with oil, a reasonable estimate of the size of a sheaf of barley, an estimate of caloric value of a simulated manna, the size of the unleavened bread that would need to fit on the showbread, and the sizes of the leavened bread that needed to be brought for first-fruits, we have shown that the minimum amount an omer can be is 2 US Cups. The maximum it can be is 4.8 C, and still fit on the table, and may be less than that, based on the actual yield of a sheaf of barley. The corresponding hin would be 2.5 C or less, up to We will show 2 C of oil for the hin, and 3.5 C of flour or grain for the omer.

Rochelle A. and William P. Houser, September 6, 2015

Sources:

1. https://books.google.com/books?id=O6F9VYz74aUC&pg=PT2118&lpg=PT2118&dq=hin+is+1/6+of+bath?&source=bl&ots=LCPxGYR_8V&sig=I-J51l3wCSkcU-qWMdHTHbYv-BQ&hl=en&sa=X&ved=0CDAQ6AEwA2oVChMIgeOqm5j6xgIViWk-Ch2_YQ5M#v=onepage&q=hin%20is%201%2F6%20of%20bath%3F&f=false
2. https://en.wikipedia.org/wiki/Biblical_and_Talmudic_units_of_measurement
3. https://en.wikipedia.org/wiki/Ancient_Egyptian_units_of_measurement#Volume.2C_capacity_and_weight
4. http://www.touregypt.net/featurestories/measures.htm#ixzz3h3Wv5Cb5
5. http://www.touregypt.net/featurestories/measures.htm#ixzz3h3XOJq6y
6. http://www.thefreedictionary.com/hin (says hin is of Egyptian origin)
7. http://www.biblestudytools.com/dictionary/hin/
8. http://www.convert-me.com/en/convert/volume/biblhin.html
9. http://www.biblestudytools.com/commentaries/gills-exposition-of-the-bible/exodus-29-40.html
10. http://www.biblestudytools.com/commentaries/jamieson-fausset-brown/ezekiel/ezekiel-4.html
11. https://books.google.com/books?id=raKRY3KQspsC&pg=PA1013&lpg=PA1013&dq=an+Egyptian+hin&source=bl&ots=lUSQu562kd&sig=hARbB9Z1dl9blcQQG6w1J6aeOlc&hl=en&sa=X&ved=0CB8Q6AEwAGoVChMIlaif3ImDxwIVQ6keCh0_YQA9#v=onepage&q=an%20Egyptian%20hin&f=false (This is an amazing resource on Ancient Egyptian measuring systems)
12. http://biblehub.com/hebrew/374.htm (says the ephah compares to the Egyptian *ôipi*,)
13. http://www.thefreedictionary.com/epha (says the ephah is probably the Egyptian `'pt`.)
14. https://en.wikipedia.org/wiki/Ephah#Measurement (This one says the ephah and the bath were 4.65 gallons)
15. http://dictionary.reference.com/browse/ephah
16. http://www.convert-me.com/en/convert/volume/bibephah.html
17. http://www.lexic.us/definition-of/ephah
18. http://www.keyway.ca/htm2002/20021011.htm
19. http://biblestudio.com/weights_and_measures/
20. https://www.academia.edu/4132470/ON_NEW_EXAMPLES_OF_EGYPTIAN_WEIGHTS_AND_MEASURES.1_By_W._M._FLINDERS_PETRIE (This is an amazing paper on Ancient Egyptian measuring cups he studied.)

21. http://www.thefreedictionary.com/epha (on this page is a reference to the Thesaurus, wordnet 3.0, Farlex clipart collection, (c) 2003-2012 Princeton University, Farlex Inc. that states the kor, homer = 10 baths, or 10 ephas. The word, "kor", is translated "homer". I think this could be the ancient Egyptian khar. More study is needed on this.)
22. https://www.biblegateway.com/resources/encyclopedia-of-the-bible/Weights-Measures This source states: … (the) *qa*, equivalent of the Sumer. *sila*; it has been estimated to be between 1.004 liters and 1.34 liters. Our quart!
23. https://en.wikipedia.org/wiki/Biblical_and_Talmudic_units_of_measurement states 1 etzba = 7 barley corns side by side.
24. Sizes of barley: http://wintercereals.us/Documents/Growing%20WW/Production%20Articles/General%20Seeding%20Issues/Small%20Grains%20Seed%20Size.pdf
25. Shewbread loaf size: https://en.wikipedia.org/wiki/Showbread
26. https://www.biblegateway.com/resources/encyclopedia-of-the-bible/Weights-Measures
27. https://en.wikipedia.org/wiki/Hand_%28unit%29 (noticed the Egyptian Djeba is the same definition as the Hebrew "etzba", or one fingerwidth. This was also standardized by Henry VIII to be 1 inch. I am wondering if the term "inch", "etzba", and "Djeba" "dactyl" are all of similar origin.)
28. https://en.wikipedia.org/wiki/Finger_%28unit%29
29. http://www.thefoodmaven.com/diary/00000146.html
30. https://en.wikipedia.org/wiki/Peck This could show that the hekat = peck, if the conversions to the New Kingdom were 1 hin = 0.477 L, then 16 hin = hekat and 10 hekat = 1 khar. = 160 hin.
31. https://en.wikipedia.org/wiki/Hekat_%28unit%29 (Tanya Pommerang states the hekat in the MK and NK is 1.26 US gallons.)
32. The quatern and quaternloaf: http://www.unc.edu/~rowlett/units/dictQ.html
33. http://jewishencyclopedia.com/articles/14821-weights-and-measures#anchor8 probably where the term "gallon" comes from. 300 qa = 60 gin = 1 gur = 303L = 80 US gallons.
From this, 60 gin = 80 US gallon, which makes each gin = 1.33 US gallons. This matches pretty closely to the hekat in the NK as being 1.26 US gallons. It also could also explain why the British gallon is about 20% larger than the US gallon (1 British Imperial gallon = 1.2 US gallons). Their term for gallon is stated as being unknown. The Jewish encyclopedia article here, makes the gin = hin, but it is a larger unit than the qa, and roughly corresponds with the Egyptian hekat. I think this is where the discrepency lies! Also, in this article, they quote the qa = 99-102 mL, but also equal to the weight of water equal to 1 great mina. They say the great mina = 1010 grams. Therefore, the two statements cannot both be true. If the qa is ten times greater than the stated number, or 990-1002 mL, then it is closer to being possible for it to equal the great mina of 1010 grams. This then would show a specific gravity of water to be 1010 g/1002 mL = 1.0079 g/mL This is only possible, if the reference temperature for the specific gravity of water is at the boiling point, and the capacity was measured when the water was at 172.5 degrees F. This might be possible, but only if the water was boiling, and then cooled down to 172.5 degrees F during the measuring process. I think this article is not a reliable source of information.
34. Sugar is sold by the Egyptian Old Kingdom system: 1 pound, 2 pounds, 4 pounds, 10 pounds, 20 pounds, 40 pounds. See http://www.bulkfoods.com/sweeteners-distributor/1140-Maple-Sugar-20-pounds.html for 20 pounds, and http://www.amazon.com/Mansfield-Maple-Granulated-Maple-Sugar/dp/B00XIO1YFA for 40 pounds. From their website, they also sell 120 lbs, and 1200 lbs. http://www.maplesyrupwholesale.com/buy_wholesale_maple_sugar.htm http://vermontpuremaple.com/buy_maple_sugar.htm sells maple sugar in some strange sizes: 3.4 oz jar, 6 oz jar, 11.5 oz jar, 23 oz jar, 5 lb tub, 5 lb bulk bag, 10 lb tub, 10 lb bulk bag, 20 lb bulk, 40 lb bulk. http://www.welchsmaple.com/granulatedsugar.htm sells maple sugar in 6 oz,

12 oz, and 24 oz jars, and then 10 lb bag. Maple sugar history: "Using maple products as sweetener started with the aboriginal Americans before the arrival of English settlers in the continent. It was their staple and only condiment and they used to add flavor to almost all of their food." http://maplecommunity.com/maple-sugar/

35. http://www.celticnz.co.nz/Weights_Measures_Volumes/Weights_Measures.htm This is just weird. Relating ancient units of measure to the size of the earth, etc.

36. The "great mina" and the mina : http://www.britannica.com/science/mina-unit-of-weight This source says that the great mina was 978 g, and the mina was 640 g. The Hebraic mina was 499 g.
37. The qa was set to be the volume of a great mina. Or a cube measuring a handbreadth. (They estimate 3.9-4 inches) http://www.britannica.com/science/qa This would say that the qa was 3.9 x 3.9 x 3.9 = 59.31 cubic inches. This is 59.31/231 cubic inches per gallon = 0.2567 gallon, or a little over a quart. Or, 4.0 x 4.0 x 4.0 = 64 cubic inches. This is 64/231 = 0.277 gallons. Metric: 9.9 cm x 9.9 cm x 9.9 cm = 970 cubic cm, or 970 mL. Or, 10.2 x 10. 2 x 10.2 = 1061 cubic cm, or mL.

    Why is this so close to our modern quart, but not exact? The size of the hand could have been bigger when this was set up, the atmospheric pressure could have been higher, to squish it down more, or
    978 g / 970 mL (low estimate for handbreadth) = 1.008 g/mL for water. That's pretty heavy!
    978 g /1071 mL (high estimate for handbreadth) = 0.913 g/mL for water. That's the specific gravity of water at 310 degrees F. That is an impossible standard to have set up, in my opinion.

    What would the atmospheric pressure have had to be for water to be 1.008 g/mL at 80 degrees F? (Assuming it was hot over there in Babylon, and a typical day would be about 80 degrees?)

    Low: PV = nRT
    P(0.970 L) =(978 g/18.015g/mole) x 0.08206 L atm/mol x 299.816667K = 1,316 atm Pressure!

    High: PV = nRT
    P(1.071 L) = (978g/18.015 g/mole) x 0.08206 L atm/mol x 299.816667K = 1,247.103 atm pressure!

Wow that's a lot of pressure.

However, if the system really was set up for 4,000 mL (the ideal gallon, instead of 3785 mL per gallon now, was to equal 1000 g (instead of the 978 g), then at STP

38. http://jewishencyclopedia.com/articles/13536-shekel This source states that Ezekiel 45:12 proports 50 shekels /mina. (Odd, because the text states 60 shekels per mina, but it works out to 50 "sanctuary" shekels per mina, if the sanctuary shekel is 10.0 g, instead of 8.33 g, like the Babylonian shekel was at the time.)