UNIVERSITY OF TORONTO

FACULTY OF APPLIED SCIENCE AND ENGINEERING

FINAL EXAMINATION, APRIL 23. 2001

Fourth Year - Program 6 – Type A Exam

CHE 462H1S - FOOD ENGINEERING

Examiner – Toks Oshinowo

Q1.

a) Calculate the calorie content of a meal consisting of a 125 g hamburger patty on a 225 g bun, with 125 g french fries, and 225 ml milk. The following compositions are given

Component	Protein %	Carbohydrate %	Fat %
Hamburger	25	2	28
Bun	10	60	5
Fries	5	60	32
Milk	2	3	4

b. (i) Comment on the nutrient balance, including both the micronutrients, and the components tabulated above, in this meal.
(ii) What nutrients may be used to balance it better?
(iii) What foods could provide the required nutrients?

c. List the major fat-soluble vitamins, and their physiological function. Name three vitamins, and the diseases related to their deficiency.

d. State at least four (4) reasons why it is important to know the ash content of a food.

Q2

A. Fill in the blanks using one of the following:

Clostridium botulinum, spore-forming, ionizing radiation, dehydration, anaerobic environment, Staphylococcus aureus.

1. Salt acts as a food preservative because of the --------------------effect.

2. The organism which is the most important one to eliminate from canned foods is ----------------.

3. Spoilage of canned foods is due mainly to -------------------- bacteria, since these organisms are the ones most likely to survive the heat treatment used in the canning process.

4. To accomplish "cold sterilization", you would have to employ ------------------ as the sterilizing agent.

B. Fungal growth is more likely to occur on fruits than is bacterial growth because:

a) the high pH inhibits bacteria;
b) mechanical handling of fruits is more likely to introduce fungi;
c) fungi are not inhibited by the acidity of fruits.

Q3

a) What value of thermal death time, F, is typically used in thermal processing of shelf-stable foods?

b) If the z value of a microorganism is 16.5°C and $D_{121°C}$ is 0.35 minute. What is $D_{110°C}$?

c) The spoilage microorganism for a raw food has a D value of 5 minutes. Compute the spoilage probability of the initial population per can is 10 and a process equivalent to F_o = 3 minutes.

d) The temperature- time profile of a pilot test of a food product subjected to a high-temperature-short-time (HTST) sterilization process is as follows.

Process	*Time, s*	*T, °C*
(Start)	0	30
Heating	1	138
Holding	2	138
Holding	3	138
Holding	4	138
Cooling	5	84
Cooling	5	30

The thermal resistance z = 8.5°C.

(i) Sketch the lethal rate – time curve.

(ii) Estimate the total lethality at 121°C.

Q4.

(a) List five (5) of the several important characteristics that must be identified in choosing a refrigerant.

(b) Using ASHRAE designation, what are the refrigerant numbers of the following chemicals

i. Methylene Chloride
ii. Dichlorotetrafluoroethane
iii. Ethane
iv. Ammonium Chloride

(c) 5000 lb/h of a dairy product is pumped at 80°F to a refrigerated working space, which is maintained at 20°F. The product is chilled to 20°F, solidified and packaged. The product spends on average 20 minutes in this room from the time of entry until it is removed to the freezer. Its thermal properties match those of butter.

Calculate the heat-load on the refrigeration system given the following information:

- The room outside dimensions are 50 x 50 feet, with 12 foot ceiling.
- The room shares two walls with the plant, which is maintained at 68°F.
- The one outside wall is facing south, and its effective outside temperature is the same as that of the roof: 120°F.
- The product passes to a freezer at -20°F through the remaining wall.
- The walls are insulated by 6" expanded polystyrene; the roof has 8" fibreglass insulation, while the floor is 4" corkboard on grade, which can be assumed to be at 50°F.

- assume normal traffic density
- lighting is provided by 24 light fixtures consuming 100W each
- the installed motor capacity of the equipment is 12HP
- three people work in the room during each shift
- 1HP = 2600BTU/h= 750W

Q5.

If two geometrically similar turkey at initial temperature To are cooked by roasting at a given surface temperatureT1 to the same degree with the same dimensionless temperature distribution, then the dimensionless time for cooking given by $\tau = \alpha.t/L^2$, is the same for both turkeys, where t is cooking time, and α is thermal diffusivity. A typical timetable for roasting a turkey at 350°F (179°C) is as follows:

Mass of Turkey (lb_m)	Roasting Time per Unit Mass (min/lb_m)
6-10	20-25
10-16	18-20
18-25	15-18

a) Show that

$$(\textit{Cooking Time}) \times (\textit{Mass of Turkey})^{-2/3} = \textit{Constant}$$

b) Show that the value of the constant in the above equation is ~ 45.

Q6.

a) Why is it necessary to degum the crude edible oil before refining?
b) Draw a block flow diagram of edible oil refining process with a degummed crude oil feed.
c) What are the advantages and disadvantages of physical refining process over chemical refining of a typical vegetable oil, such as canola oil?

Q7.

(a) A shell-and-leaf filter, similar to the one we saw at Canamera Foods Inc., has been chosen for the evaluation of the effectiveness o f a diatomaceous clay as a filter aid in cleansing a vegetable oil and because of the need for a very effective washing of the cake produced. A test run at a constant slurry flowrate, Q_0 = 1.15 l/min showed that the cake formed is incompressible and also gave the following pressure- time relationship:

$$P\ (kPa) = 27.5.\ t\ (min) + 20.5$$

Using the same slurry and filter, the filtration cycle was run in the following manner:

- The filtrate was forced through at a constant rate of 1.89l/m until the differential pressure reached 345 kPa. In this step, the operating pressure is given by

  $$P = K_1 .\ Q_o^2 .t - K_2 .Q_0 \qquad \text{(K1 and K2 are cake constants)}$$

- The filtration was then continued at 345 kPa until the total filtrate collected, V_f was 56.8litres. In this step, the relationship between filtrate volume, Vf and time t_f is

  $$t_f = (K_1/2P).V_f^2 + (K_2/P).\ V_f$$

- The cake was washed with 11.5 litres of water.
- The time required to dump and clean the leaf filters was kept at 10 minutes.

What is the capacity of this filtration cycle?

b) How will your results above be affected by temperature and particle size of the filter aid?

Q8.

a) What are the differences between dialysis, nanofiltration, ultrafiltration and reverse osmosis in terms of driving force molecular solute particle size, and fate of low- and high-molecular weight components?

b) Which membrane-based process is used for the clarification of apple juice? Use block flow diagrams, without process data, to show how the application of this membrane-based process leads to substantial savings over the conventional process.

MARKING SCHEME

Question No.	(a)	(b)	(c)	(d)	Total
Q1	6	3	2	4	15
Q2	8	2			10
Q3	2	2	4	7	15
Q4	5	4	7		16
Q5	7	3			10
Q6	2	4	4		12
Q7	7	3			10
Q8	5	5			12
					100

WALL HEAT GAIN TABLE

BTU/24 HR./SQ. FT. OF OUTSIDE SURFACE

Table 1

INSULATION* — TEMPERATURE DIFFERENCE IN °F. (Ambient Temperature Minus Storage Temperature)

K-Factor	Ins Thk	1	10	20	30	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150
.30	4	1.8	18	36	54	72	81	90	99	108	117	126	135	144	153	162	171	180	189	198	207	216	225	234	243	252	261	270
	6	1.2	12	24	36	48	54	60	66	72	78	84	90	96	102	108	114	120	126	132	138	144	150	156	162	168	174	180
	8	.90	9.0	18	27	36	41	45	50	54	59	63	68	72	77	81	86	90	95	99	104	108	113	117	122	126	131	135
.24	1	5.8	58	115	173	230	260	290	320																			
	2	2.9	29	58	86	115	130	144	158	173	187	202	216	231	245	260	274	288	303									
	3	1.9	19	38	58	77	86	96	106	115	125	135	144	154	163	173	183	192	202	211	221	231	240	250	259	269	278	288
	4	1.4	14	29	43	58	65	72	79	86	94	101	108	115	123	130	137	144	151	159	166	173	180	188	194	202	209	216
	6	.96	9.6	19	29	38	43	48	53	58	62	68	72	77	82	87	91	96	101	106	111	115	120	125	130	134	139	144
	8	.72	7.2	14	22	29	32	36	40	43	47	50	54	58	61	65	68	72	76	79	83	86	90	94	97	101	104	108
.16	2	1.9	19	38	58	77	86	96	106	115	125	135	144	154	163	173	183	192	202	211	221	231	240	250	259	269	278	288
	3	1.3	13	26	38	51	58	64	71	77	83	90	96	102	109	115	122	128	135	141	147	154	160	167	173	179	186	192
	4	.96	9.6	19	29	38	43	48	53	58	62	68	72	77	82	87	91	96	101	106	111	115	120	125	130	134	139	144
	6	.64	6.4	13	19	26	29	32	35	38	42	45	48	51	54	58	61	64	67	70	74	77	80	83	86	90	93	96
.14	2	1.7	17	34	50	67	76	84	92	100	111	117	126	134	143	151	160	168	176	185	193	202	210	218	227	235	244	252
	3	1.1	11	22	34	45	50	56	62	67	73	78	84	90	95	101	106	112	118	123	129	134	140	145	151	157	162	168
	4	.84	8.4	17	25	34	38	42	46	50	55	59	63	68	71	75	80	84	88	92	97	101	105	109	113	118	122	126
	6	.56	5.6	11	17	22	25	28	31	34	36	39	42	45	48	50	53	56	59	62	64	67	70	73	76	78	81	84
6" Conc. Floor		5	50	100	150	200																						
Single Glass		27	270	540	810																							
Double Glass		11	110	220	330	440	495	550	600	660	715	770	825	880	935	990												
Triple Glass		7	70	140	210	280	320	350	390	420	454	490	525	560	595	630	665	700	740	770	810	840	875	910	945	980		

*INSULATION K-FACTORS:
.30 Corkboard
.24 Glass Fibre, Expanded Polystyrene
.16 Foam Urethane Sheets, Urethane Foam Panels
.14 Urethane Foam Panels

Table 2a

Average Air Changes/24 Hours for Storage Rooms Above 32° F. Due to Door Opening and Infiltration

Room Volume Cu. Ft.	Air Changes Per 24 Hrs	Room Volume Cu. Ft.	Air Changes Per 24 Hrs	Room Volume Cu. Ft.	Air Changes Per 24 Hrs	Room Volume Cu. Ft.	Air Changes Per 24 Hrs
200	44.0	1000	17.5	8000	5.5	50,000	2.0
250	38.0	1500	14.0	10,000	4.9	75,000	1.6
300	34.5	2000	12.0	15,000	3.9	100,000	1.4
400	29.5	3000	9.5	20,000	3.5	150,000	1.2
500	26.0	4000	8.2	25,000	3.0	200,000	1.1
600	23.0	5000	7.2	30,000	2.7	300,000	1.0
800	20.0	6000	6.5	40,000	2.3	500,000	0.9

NOTE: For heavy usage multiply the above values by 2

Table 2b

Average Air Changes/24 Hours for Storage Rooms Below 32° F. Due to Door Opening and Infiltration

Room Volume Cu. Ft.	Air Changes Per 24 Hrs	Room Volume Cu. Ft.	Air Changes Per 24 Hrs	Room Volume Cu. Ft.	Air Changes Per 24 Hrs	Room Volume Cu. Ft.	Air Changes Per 24 Hrs
200	33.5	1000	13.5	8000	4.3	50,000	1.6
250	29.0	1500	11.0	10,000	3.8	75,000	1.3
300	26.2	2000	9.3	15,000	3.0	100,000	1.1
400	22.5	3000	7.4	20,000	2.6	150,000	1.0
500	20.0	4000	6.3	25,000	2.3	200,000	0.9
600	18.0	5000	5.6	30,000	2.1	300,000	0.85
800	15.3	6000	5.0	40,000	1.8	500,000	0.8

NOTE: For heavy usage multiply the above values by 2

Table 3

Heat Removed in Cooling Air to Storage Conditions — BTU/CUBIC FOOT

COOLER STORAGE TEM. °F	OUTSIDE AIR CONDITION									
	35° DB 80% RH	50° DB 60% RH	85° DB 50% RH	85° DB 60% RH	90° DB 50% RH	90° DB 60% RH	95° DB 50% RH	95° DB 60% RH	100° DB 50% RH	100° DB 60% RH
55	–	–	1.12	1.34	1.41	1.66	1.72	2.01	2.06	2.44
50	–	–	1.32	1.54	1.62	1.87	1.93	2.22	2.28	2.65
45	–	.04	1.50	1.73	1.80	2.06	2.12	2.42	2.47	2.85
40	–	.14	1.69	1.92	2.00	2.26	2.31	2.62	2.67	3.06
35	–	38	1.86	2.09	2.17	2.43	2.49	2.79	2.85	3.24
30	16	.55	2.00	2.24	2.26	2.53	2.60	2.94	2.95	3.35
25	29	68	2.09	2.42	2.44	2.71	2.79	3.16	3.14	3.54
20	46	85	2.27	2.61	2.62	2.90	2.97	3.35	3.33	3.73
15	59	96	2.45	2.74	2.80	3.07	3.16	3.54	3.51	3.92
10	73	1.13	2.57	2.87	2.93	3.20	3.29	3.66	3.64	4.04
5	85	1.26	2.76	3.07	3.12	3.40	3.48	3.87	3.84	4.27
0	.94	1.41	2.92	3.23	3.28	3.56	3.64	4.03	4.01	4.43
-5	1.12	1.54	3.04	3.36	3.41	3.69	3.78	4.18	4.15	4.57
-10	1.24	1.67	3.19	3.49	3.56	3.85	3.93	4.33	4.31	4.74
-15	1.38	1.81	3.29	3.60	3.67	3.96	4.05	4.46	4.42	4.86
-20	1.51	1.94	3.49	3.72	3.88	4.18	4.27	4.69	4.66	5.10
-25	1.65	2.08	3.61	3.84	4.00	4.30	4.39	4.80	4.78	5.21
-30	1.78	2.22	3.86	4.05	4.21	4.51	4.56	5.00	4.90	5.44

Tables 2a, 2b, & 3 Reprinted by permission from 1972 ASHRAE Handbook of Fundamentals

COMMODITY STORAGE DATA

Table 4

Product	COL. 1 Storage Temp. °F	COL. 2 Relative Humidity %	COL. 3 Sp. Ht. BTU/(Lb.)(°F.) Above Freezing	COL. 4 Sp. Ht. BTU/(Lb.)(°F.) Below Freezing	COL. 5 Latent Heat of Fusion Btu/lb	COL. 6 Average Freezing Point F	COL. 7 Heat of Respiration Btu/lb/24 Hr	COL. 8 Approximate Storage Life	COL. 9 Percent Water
VEGETABLES									
Artichokes (Globe)	31-32	90-95	0.87	0.45	120	29.1	5.07	1-2 Weeks	83.7
Asparagus	32	90-95	0.94	0.48	134	29.8	5.85-11.55	2-3 Weeks	93
Beans, string	45	85-90	0.91	0.47	128	29.7	4.85	8-10 Days	88.9
Beans, Lima	32-40	85-90	0.73	0.40	94	30.1	2.15-3.05	10-15 Days	66.5
Beans, dried	–	–	0.30	0.24	18	–	–	–	12.5
Beets (Topped)	32	90-95	0.90	0.46	126	31.1	1.35	1-3 Months	87.6
Broccoli	32	90-95	0.92	0.47	130	29.2	5.5-8.5	7-10 Days	89.9
Brussels sprouts	32	90-95	0.88	0.46	122	31	3.3-5.5	3-4 Weeks	84.9
Cabbage	32	90-95	0.94	0.47	132	31.2	.85	3-4 Months	92.4
Carrots (Topped)	32	90-95	0.90	0.46	126	29.6	1.05	4-5 Months	88.2
Cauliflower	32	90-95	0.93	0.47	132	30.1	2.25	2-3 Weeks	91.7
Celery	31-32	90-95	0.95	0.48	135	29.7	.80	2-4 Months	93.7
Corn (green)	31-32	85-90	0.79	0.42	106	28.9	3.6-5.65	4-8 Days	75.5
Corn (dried)	–	–	0.28	0.23	15	–	–	–	10.5
Cucumbers	45-50	90-95	0.97	0.49	137	30.5	–	10-14 Days	96.1
Eggplant	45-50	85-90	0.94	0.48	132	30.4	–	10 Days	92.7
Endive (escarole)	32	90-95	0.94	0.48	132	30.9	–	2-3 Weeks	93.3
Horseradish	32	90-95	0.78	0.42	104	26.4	–	10-12 Weeks	73.4
Kale	32	90-95	0.89	0.46	124	30.7	–	2-3 Weeks	86.6
Kohlrabi	32	90-95	0.92	0.47	128	30	–	2-4 Weeks	90
Lettuce	32	90-95	0.96	0.48	136	31.7	1.15	3-4 Weeks	94.8
Mushrooms	32-35	85-90	0.93	0.47	130	30.2	3.1	3-5 Days	91.1
Olives	45-50	85-90	0.80	0.42	108	28.5	–	4-6 Weeks	75.2
Onions	32	70-75	0.90	0.46	124	30.1	.35-.55	6-8 Months	87.5
Parsnips	32	90-95	0.84	0.46	112	29.9	–	2-6 Months	78.6
Peas (green)	32	85-90	0.79	0.42	106	30	6.6-8.0	1-2 Weeks	74.3
Peas (dried)	–	–	0.28	0.22	14	–	–	–	9.5
Peppers (sweet)	45-50	85-90	0.94	0.47	132	30.1	7.35	8-10 Days	92.4
Potatoes (white)	38-50	85-90	0.82	0.43	111	28.9	.65-.90	–	77.8
Potatoes (sweet)	55-60	90-95	0.75	0.40	97	28.5	.85	4-6 Months	68.5
Pumpkin	50-55	70-75	0.92	0.47	130	30.1	–	2-6 Months	90.5
Radishes	32	90-95	0.95	0.48	134	30.1	–	10 Days	93.6
Rhubarb	32	90-95	0.96	0.48	134	28.4	–	2-3 Weeks	94.9
Sauerkraut	–	–	0.92	0.47	129	26	–	–	89
Spinach	32	90-95	0.94	0.48	132	30.3	4.0	10-14 Days	92.7
Squash (Acorn)	45-50	75-85	0.92	0.47	130	30.1	–	5-8 Weeks	90.5
Tomatoes (green)	57-70	85-90	0.95	0.48	134	30.4	3.12	2-4 Weeks	94.7
Tomatoes (ripening)	57-70	85-90	0.95	0.48	134	30.4	6.3	2-7 Days	94.1
Turnips	32	90-95	0.93	0.47	130	30.5	.95	4-5 Months	90.9
Vegetables (mixed)	–	–	0.90	0.45	130	30	2.0	–	90
MEATS AND FISH									
Bacon	34-40	85	0.50	0.30	29	–	–	2-6 Weeks	20
Beef (dried)	–	–	0.22-0.34	0.19-0.26	7-22	–	–	–	5-15
Beef (fresh-lean)	30-34	88-92	0.77	0.40	100	29	–	1-6 Weeks	68
Beef (fresh fat)	30-34	88-92	0.60	0.35	79	28	–	1-6 Weeks	–
Brined meats	–	–	0.75			–	–	–	–
Cod fish (fresh)	33-35	90-95	0.90	0.49	119	28	–	5-15 Days	–
Cut meats	30-34	88-92	0.72	0.40	95	29	–	–	65
Fish (frozen)	-10	90-95	0.76	0.41	101	28	–	8-10 Months	70
Fish (iced)	32-35	90-95	0.76	0.41	101	–	–	5-15 Days	70
Fish (dried)	40-50	50-60	0.56	0.34	65	–	–	6-8 Months	–
Hams and loins (fresh)	32-34	85-90	0.68	0.38	86.5	27	–	7-12 Days	60
Lamb	32-34	85-90	0.67	0.30	83.5	29	–	5-12 Days	58
Livers	32-34	80-85	0.72	0.40	93.3	29	–	1-6 Weeks	65.5
Oyster (shell)	33	90-95	0.83	0.44	116	27	–	3-7 Days	80.4
Oysters (tub)	33	90-95	0.90	0.46	125	27	–	–	87
Pork (fresh)	32-34	85-90	0.68	0.38	86.5	28	–	3-7 Days	60
Pork (smoked)		–	0.60	0.32	–	–	–	–	57
Poultry (fresh)	32	85-90	0.79	0.37	106	27	–	1 Week	74
Poultry (frozen)	-20-0	90-95	0.79	0.37	106	27	–	9-10 Months	74
Sausage (casings)	40-45	85-90	0.60	–	–	–	–	–	–
Sausage (drying)	–	–	0.89	0.56	93	26	–	–	65.5
Sausage (franks)	–	–	0.86	0.56	86	29	–	–	60
Sausage (fresh)	–	–	0.89	0.56	93	26	–	–	65
Sausage (smoked)	40-45	85-90	0.86	0.56	86	25	–	6 Months	60
Scallops	33	90-95	0.89	0.48	116	28	–	3-7 Days	80.3
Shrimp	33	90-95	0.83	0.45	119	28	–	3-7 Days	70.8
Veal	32-34	90-95	0.71	0.39	91	29	–	5-10 Days	63

COMMODITY STORAGE DATA

Table 4

Product	COL. 1 Storage Temp °F	COL. 2 Relative Humidity %	COL. 3 Sp. Ht. BTU/(Lb.)(°F.) Above Freezing	COL. 4 Sp. Ht. BTU/(Lb.)(°F.) Below Freezing	COL. 5 Latent Heat of Fusion Btu/lb	COL. 6 Average Freezing Point F	COL. 7 Heat of Respiration Btu/lb./24 Hr.	COL. 8 Approximate Storage Life	COL. 9 Percent Water
MISCELLANEOUS									
Beer	—	—	1.0	—	—	28	—	—	92
Bread	0	—	0.70	0.34	46-53	—	—	Several Weeks	32-37
Bread (dough)	—	—	0.75	—	—	—	—	—	58
Butter	32-40	80-85	0.64	0.34	15	30.0	—	2 Months	15
Candy	0-50	40-65	0.93	—	—	—	—	—	—
Caviar (tub)	—	—	—	—	—	20	1.91	—	55
Cheese (American)	30-45	65-70	0.64	0.36	79	17	2.34	—	60
Cheese (Camembert)	30-45	65-70	0.70	0.40	86	18	2.46	—	60
Cheese (Limburger)	30-45	55-70	0.70	0.40	86	19	2.46	—	55
Cheese (Roquefort)	30-45	65-70	0.65	0.32	79	3	2.0	—	55
Cheese (Swiss)	30-45	65-70	0.64	0.36	79	15	2.33	—	55
Chocolate (coating)	—	—	0.30	0.55	40	95-85	—	—	55
Cream (40%)	33	—	0.85	0.40	90	28	—	7 Days	73
Eggs (crated)	29-31	80-85	0.76	0.40	100	27	—	6-9 Months	—
Eggs (frozen)	0 or Below	—	—	0.41	100	27	—	1 Year Plus	—
Flour	—	—	0.38	0.28	—	—	—	—	13.5
Flowers (cut)	31-45	80-85	—	—	—	32	—	—	—
Furs - Woolens	34-40	45-55	—	0.40	—	—	—	Several Years	—
Honey	—	—	0.35	0.26	26	—	.71	1 Year Plus	18
Hops	29-32	50-60	—	—	—	—	.75	Several Months	—
Ice cream	−15	—	0.78	0.45	96	27.0	—	Several Months	58 − 66
Lard	45	90-95	0.52	—	—	—	—	4-8 Months	—
Malt	—	—	—	—	—	—	75	—	—
Maple sugar	—	—	0.24	0.21	7	—	71	—	5
Maple syrup	—	—	0.49	0.31	52	—	.71	—	36
Milk	33	—	0.93	0.49	124	31	—	7 Days	87.5
Nuts (dried)	32-50	65-75	0.21-0.29	0.19-0.24	4.3-14	—	50	8-12 Months	3-10
Oleomargarine	35	60-70	0.32	0.25	22	—	—	1 Year	15.5
Tobacco and cigars	—	—	—	—	—	25	—	—	—
Yeast	31-32	—	0.77	0.41	102	—	—	—	70.9
FRUITS									
Apples	30-32	85-90	0.86	0.45	121	28.4	42	2-6 Months	84.1
Apricots	31-32	85-90	0.88	0.46	122	28.1	—	1-2 Weeks	85.4
Avocadoes	45-55	85-90	0.91	0.49	136	27.2	6.6-19.85	4 Weeks	94
Bananas	—	85-95	0.80	0.42	108	28	4.2-4.6	—	74.8
Blackberries	31-32	85-90	0.88	0.46	122	28.9	—	7 Days	85.3
Blueberries	31-32	85-90	0.86	0.45	118	28.6	.65-1.1	3-6 Weeks	82.3
Cantaloupes	32-40	85-90	0.94	0.48	132	29	1.0	5-15 Days	92.7
Cherries	31-32	85-90	0.87	0.45	120	26	—	10-14 Days	83
Cranberries	36-40	85-90	0.90	0.46	124	27.3	—	1-4 Months	87.4
Currants	32	80-85	0.88	0.45	120	30.2	—	10-14 Days	84.7
Dates (dry)	32	50-60	0.36	0.26	29	−4.1	—	9-12 Months	20
Dates (fresh)	28-32	85-90	0.82	0.43	112	27.1	—	5-7 Days	78
Figs (fresh)	28-32	85-90	0.87	0.43	112	27.1	—	5-7 Days	78
Figs (dried)	32-40	50-60	0.39	0.27	34	—	—	9-12 Months	24
Gooseberries	31-32	80-85	0.90	0.46	126	28.9	—	3-4 Weeks	88.3
Grapefruit	50	85-90	0.91	0.46	126	28.4	.53	4-8 Weeks	88.8
Grapes	31-32	85-90	0.86	0.44	116	26.3	42	3-8 Weeks	81.7
Honey Dew Melon	45-50	85-90	0.94	0.48	132	20	5	2-4 Weeks	92.6
Lemons	32/50-58	85-90	0.92	0.46	127	28.1	41	1-4 Months	89.3
Limes	48-50	85-90	0.89	0.46	122	29	41	6-8 Weeks	86
Mangoes	50	85-90	0.90	0.46	134	32	—	2-3 Weeks	93
Nectarines	31-32	85-90	0.90	0.49	119	29	—	2-4 Weeks	82.9
Oranges	32-34	85-90	0.90	0.46	124	28	39	8-12 Weeks	87.2
Peaches	31-32	85-90	0.90	0.46	124	29.4	.56	2-4 Weeks	86.9
Pears	29-31	85-90	0.86	0.45	118	28.5	38	—	83.5
Persimmons	30	85-90	0.84	0.43	112	28.3	—	2 Months	78.2
Pineapples (Ripe)	40-45	85-90	0.88	0.45	123	29.4	—	2-4 Weeks	85.3
Plums	31-32	80-85	0.88	0.45	122	28	—	3-4 Weeks	85.7
Pomegranates	34-35	85-90	0.87	0.48	112	28	—	2-4 Months	77
Prunes (fresh)	31-32	80-85	0.88	0.45	123	28	—	3-4 Weeks	85.7
Quinces	31-32	85-90	0.88	0.45	122	28.1	—	2-3 Months	85.3
Raspberries	31-32	85-90	0.85	0.45	122	30.1	3.4-4.25	7 Days	82
Strawberries	31-32	85-90	0.92	0.47	129	29.9	—	7-10 Days	90
Tangerines	31-38	90-95	0.93	0.51	126	28.0	1.63	3-4 Weeks	87.3
Watermelons	36-40	85-90	0.97	0.48	132	29.2	—	2-3 Weeks	92.1

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HEAT EQUIVALENT OF OCCUPANCY

Table 5

Cooler Temperature F	Heat Equivalent/Person Btu./24 Hrs.
50	17,300
40	20,200
30	22,800
20	25,200
10	28,800
0	31,200
-10	33,600

Derived, By Permission, from 1972 ASHRAE Handbook of Fundamentals

AVERAGE DAILY PRODUCT LOADS

Table 6

ROOM VOLUME - CU. FT.	AVERAGE DAILY PRODUCT LOADS (LBS.) FOR COOLERS	AVERAGE DAILY PRODUCT LOADS (LBS.) FOR FREEZERS
500 - 3000	1500 - 8000	500 - 2000
3000 - 4600	8000 - 11,000	2000 - 2500
4600 - 8100	11,000 - 17,000	2500 - 4000
8100 - 12,800	17,000 - 26,000	4000 - 6200
12,800 - 16,000	26,000 - 33,000	6200 - 7500
16,000 - 20,000	33,000 - 40,000	7500 - 9500
20,000 - 28,000	40,000 - 56,000	9500 - 13,000
28,000 - 40,000	56,000 - 66,000	13,000 - 17,000
40,000 - 60,000	66,000 - 110,000	17,000 - 25,000
60,000 - 80,000	110,000 - 150,000	25,000 - 34,000
80,000 - UP	150,000 - UP	34,000 - UP

BEER COOLING DATA

Table 7

KEG BEER

Type and Size	Capacity Gal.	Dimensions, in.		Weight, lb.		BTU to Cool 1°F. When Full
		Max. Width	Height	Empty	Full	
Wood						
1/8	4	13½	16	22	55	41
1/4	8	17	21	35	105	80
1/2	15	20	24	65	195	155
Full	31	24	31	105	365	300
Insulated Steel						
1/4	8	16	17¼	33	95	60
1/2	16	19	23½	60	184	120
Cast Aluminum						
1/8	4	13	15	22	53	35
1/4	8	16	17¼	32	94	64
1/2	16	19¼	23½	70	194	130

Table 8

Bottled Beer

Size, oz.	Weight full, oz.	Height, in.	Diam. or Width, in.	Length, in.	Weight, oz.		BTU to Cool Full Bottle 1°F
					Empty	Full	
6	20	7¾	2½	..	14	20	0.54
7	21	7⅞	2⅜	..	14	21	0.62
8	22	7¼	2½	..	14	22	0.70
9	23	9⅛	2¼	..	14	23	0.76
12	26	9¾	2⅜	..	14	26	0.98
12	28	9¾	2⅜	..	16	28	1.00
Case 24-10 oz.	42 lb	10¼	13¾	21	39*	57*	32.0*

*Include case of 15 lb.

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Table 9

ICE CREAM HARDENING DATA

Percent of Overrun	Hardening Load, BTU per Gal. Ice Cream
60	532
70	500
80	470
90	447
100	425
110	405
120	386

Percent Overrun Equals

$$100 \times \frac{(\text{Wt./Gal. of Mix}) - (\text{Wt./Gal. Ice Cream})}{\text{Wt./Gal. of Ice Cream}}$$

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