

**StellarSteam, CAPELLA
Electric Steamer Performance Test**

Application of ASTM Standard
Test Method F 1484-99

FSTC Report 5011.01.94

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Executive Summary

The Food Service Technology Center (FSTC) tested the StellarSteam, CAPELLA steamer under the tightly controlled conditions of the American Society for Testing and Materials (ASTM) Standard Test Method for the Performance of Steam cookers.¹ Steamer performance is characterized by preheat energy consumption and duration, idle energy rate, cooking energy efficiency, production capacity, water consumption and condensate temperature from product testing. The spectrum of test products includes: full-load frozen green peas, light-load frozen green peas, full-load red potatoes and light-load red potatoes. The CAPELLA was tested in both of its operational cooking modes, “Steam” and “Super Steam.” Since the CAPELLA is without a condensate drain, the measurement of condensate temperature was not applied. In general, water usage was less than 2 gallons for even the heaviest of test days.

The StellarSteam CAPELLA is a prime example of an appliance that has evolved in its technological refinement in order to optimize its cooking performance. The Vermont based company, StellarSteam has taken full advantage of the data collected from the earlier testing of a prototype CAPELLA model at Pacific Gas and Electric’s Food Service Technology Center and used that knowledge to better its product. The end result is a connectionless electric steamer that is not only energy efficient, but competitive in all aspects of cooking performance.

¹American Society for Testing and Materials. 1999. *Standard Test Method for the Performance of Steam Cookers*. ASTM Designation F1484-99, in *Annual Book of ASTM Standards*, Philadelphia: American Society for Testing and Materials.

Executive Summary

A summary of the test results is presented in Table ES-1. Figure ES-1 illustrates the CAPELLA cooking energy efficiency for different cooking scenarios. The production capacities are shown in Figure ES-2. The steamer's part-load production capacities are illustrated in Figures ES-3 and ES-4. The cooking energy consumption profiles are shown in Figures ES-5 and ES-6.

Executive Summary

Table ES-1. Performance Summary: StellarSteam, Model Capella.

Preheat and Idle (Preheat to “Steam” and “Super Steam”, Idle in “Stand-by”)

Rated Energy Input Rate (kW)	8.0
Measured Energy Input Rate (kW)	7.7
Preheat Time (min)	16.6
Preheat Energy (kWh)	2.0
Idle Energy Rate (kW)	0.2

Full-Load Frozen Green Peas (4 pans)

	<i>Steam</i>	<i>Super Steam</i>
Cook Time (min)	27.2	25.7
Cooking Energy Efficiency (%)	84.0	83.1
Production Capacity (lb/h)	70.6	78.9
Water Consumption (gal/h)	<2.0	<2.0

Light-Load Frozen Green Peas (1 pan)

Cook Time (min)	10.4	9.3
Cooking Energy Efficiency (%)	62.3	58.9
Water Consumption (gal/h)	<2.0	<2.0

Full-Load Red Potatoes (4 pans)

Cook Time (min)	25.1	22.8
Cooking Energy Efficiency (%)	54.7	63.1
Production Capacity (lb/h)	77.8	85.6
Water Consumption (gal/hr)	<2.0	<2.0

Light-Load Red Potatoes (1 pan)

Cook Time (min)	19.3	19.2
Cooking Energy Efficiency (%)	31.8	19.9
Water Consumption (gal/hr)	<2.0	<2.0

Executive Summary

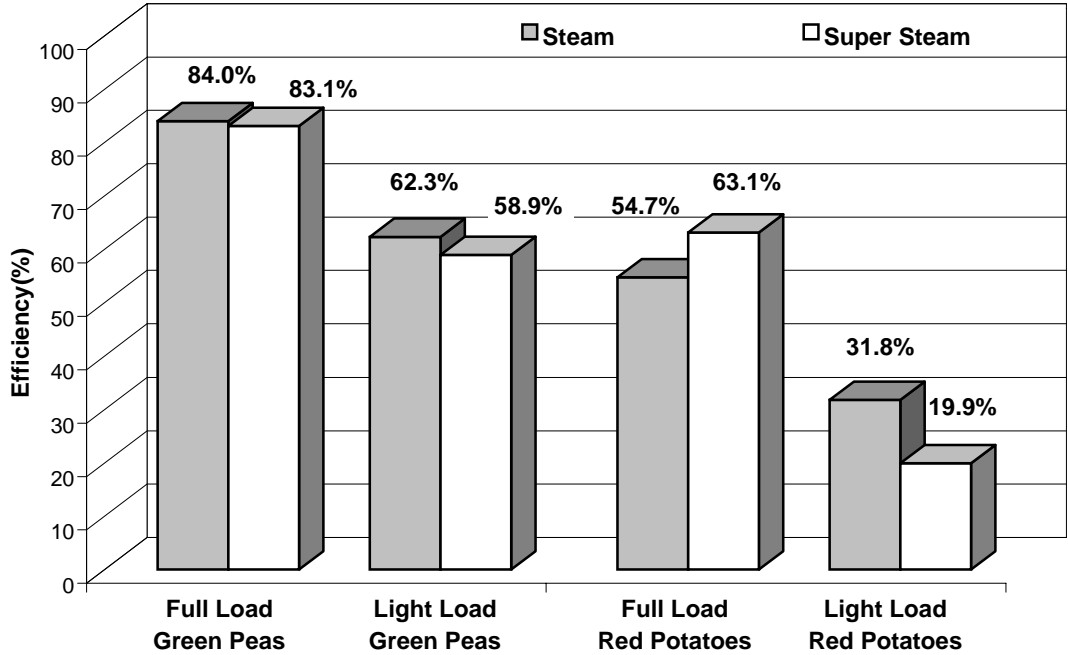


Figure ES-1.
Steamer Cooking Energy Efficiency Under Two Loading Scenarios.

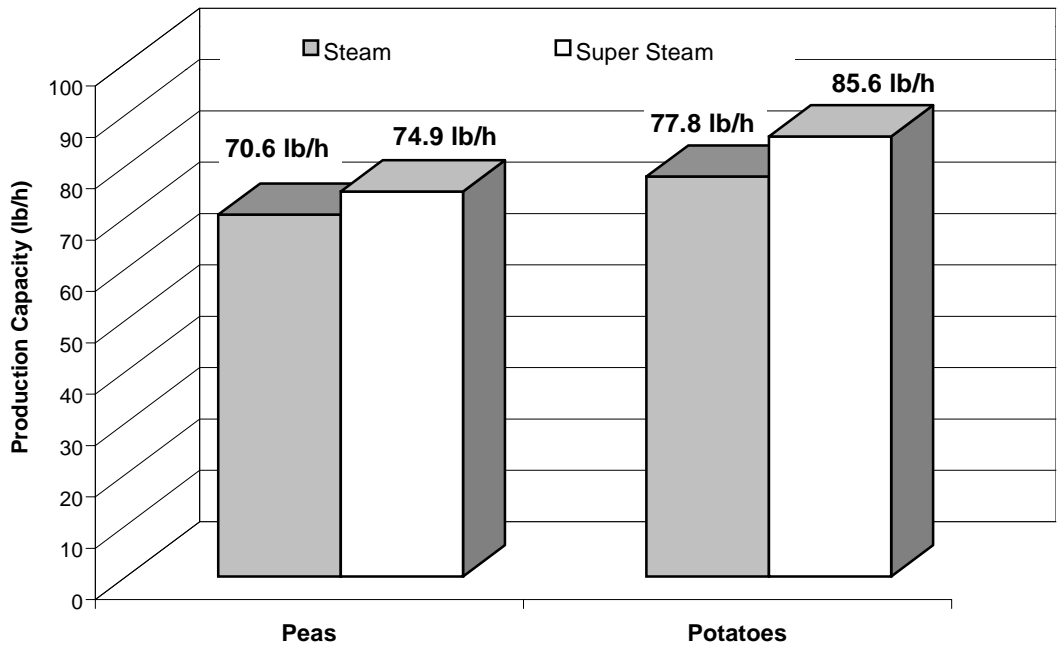


Figure ES-2.
Steamer Production Capacity.

Executive Summary

Figure ES-3.
*Steamer Part-Load
 Green Pea Cooking
 Efficiency.*

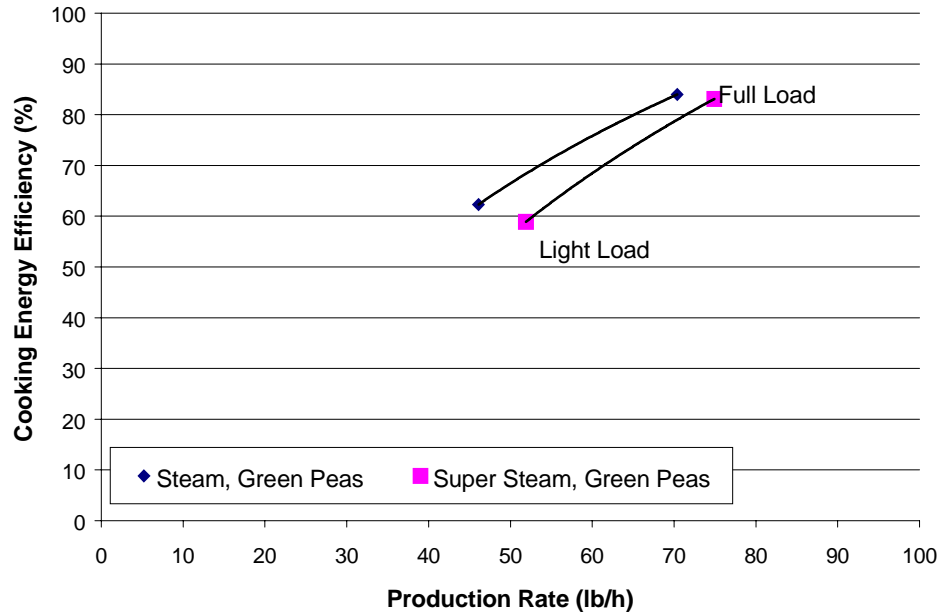
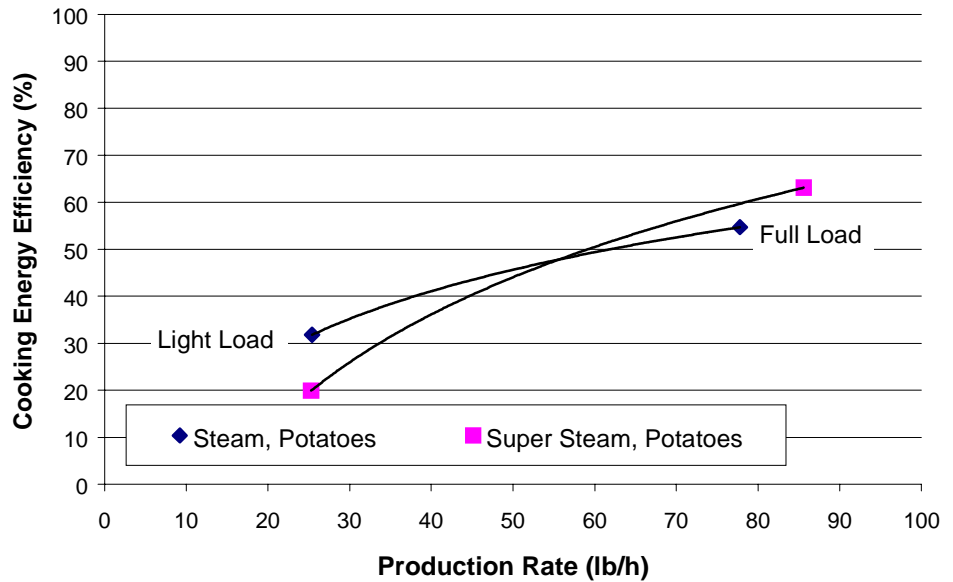


Figure ES-4.
*Steamer Part-Load
 Red Potato Cooking
 Efficiency.*



Executive Summary

Figure ES-5.
Steamer Cooking Energy Consumption Profile, Green Peas.

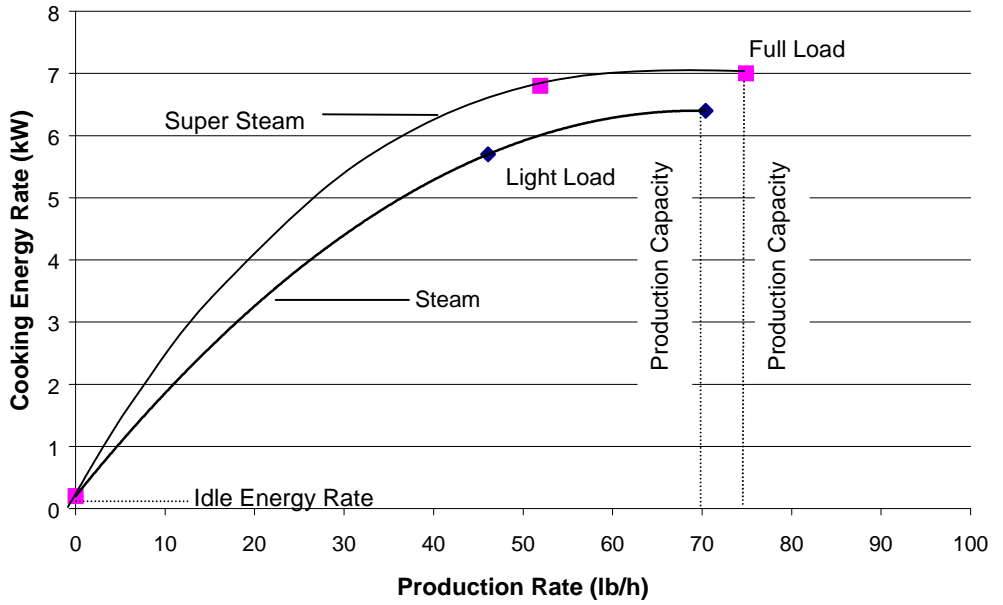
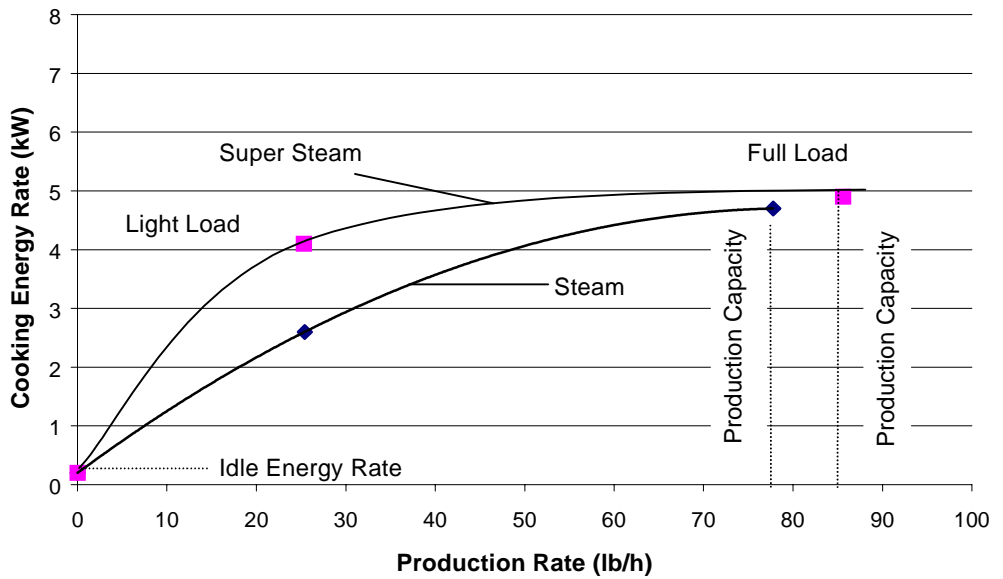


Figure ES-6.
Steamer Cooking Energy Consumption Profile, Red Potatoes.



1 Introduction

Background

Steaming provides a fast-cook option for preparing large quantities of food while retaining vital nutrients in the cooked product. Beyond the capital cost, steamers should be evaluated with regard to long-term performance and operational costs characterized by cooking energy efficiency, production capacity and water consumption.

With support from the Electric Power Research Institute (EPRI), the Gas Research Institute (GRI), the Pacific Gas and Electric Company's Food Service Technology Center (FSTC) developed a uniform testing procedure to evaluate the performance of gas and electric steam cookers. This test procedure was submitted to the American Society for Testing and Materials (ASTM) and accepted as a standard test method in December 1993. In keeping with ASTM's policy that a standard be periodically reviewed, the FSTC revised the steamer test method in February 1999 under Designation F 1484-99¹ (originally published as F 1484-93²). Modification to the test method included replacing the ice-load test with frozen green peas to emulate real-world application and reducing the three loading scenarios to two. Pacific Gas & Electric Company's *Development and Validation of a Uniform Testing Procedure for Steam Cookers* documents the developmental procedures and presents test results for both gas and electric steamers.³

The StellarSteam, CAPELLA is a one-compartment, electric connectionless steamer. The heating element is positioned under the cooking compartment, eliminating the need for a separate boiler. The CAPELLA steamer was tested according to the ASTM procedure, and this report documents the results. The glossary in Appendix A provides a quick reference to the terms used in this report.

Introduction

Objectives

The objective of this report is to examine the operation and performance of the StellarSteam CAPELLA steamer, under the controlled conditions of the ASTM Standard Test Method. The scope of this testing is as follows:

1. Verify that the appliance is operating at the manufacturer's rated energy input.
2. Determine the preheat duration and energy consumption of the steamer.
3. Measure the idle energy rate.
4. Determine the cooking energy efficiency under 4 scenarios: full-load frozen green peas (4 pans), light-load frozen green peas (1 pan), full-load red potatoes (4 pans) and light-load red potatoes (1 pan) in both modes of operation, "Steam" and "Super Steam".
5. Determine the production capacity, cooking energy rate and cook time of each loading scenario in both modes of operation, "Steam" and "Super Steam".

Appliance Description and Operation

The CAPELLA is a stainless-steel, pressureless steamer powered by four, 1.8 kW heating elements (Figure 1-1). Steam is generated within the food compartment without a separate boiler. Water is added and drained manually at the beginning and end of the day, eliminating the need for water feed and drain hookups. The cooking chamber accommodates four 12" x 20" x 2½" perforated steam pans.

The CAPELLA has two modes of cooking operation, "Steam" and "SuperSteam". In "Steam" mode the steamer's heating elements cycle on and off every 20-30 seconds once a cavity temperature of 212°F has been achieved. In "SuperSteam" the elements' cycling rate shortens to every 15 -20 seconds once the cavity temperature reaches 212°F.

Appliance specifications are listed in Table 1-1, and the manufacturer's literature is in Appendix B.

Introduction



Figure 1-1.
The StellarSteam,
CAPELLA

Table 1-1. Appliance Specifications.

Manufacturer	StellarSteam
Model	CAPELLA
Generic Appliance Type	1-compartment, natural-convection, electric.
Rated Input	8 kW
Technology	Boiler-less steamer with natural-convection.
Construction	304 stainless steel, #4 finish (exterior). 356.1 aluminum (interior). Dupont Teflon® baked-on scratch resistant double coated non-stick finish (interior).
Controls	Main ON-OFF switch. "Stand-by" idle mode, "Steam" and "Super Steam" atmospheric steaming modes selector switch. Indicator lights: heating, ready, cooking and add water. 60-minute mechanical timer with buzzer (optional).
Compartment Capacity	6 (12" x 20" x 1½") pans 4 (12" x 20" x 2½") pans 2 (12" x 20" x 6") pans 1 (12" x 20" x 6") pans
Dimensions	24" x 24" (plus 4" legs) x 28½" (w×h×d)

2 Methods

Setup and Instrumentation

The steamer was installed in accordance with the manufacturer's instructions under a 4-foot-deep canopy hood, with the lower edge of the hood 6 feet, 6 inches above the floor and a minimum of 6 inches inside the vertical front edge of the hood. The exhaust ventilation operated at a nominal rate of 150 cfm per linear foot of hood with the ambient temperature maintained between $75 \pm 5^\circ\text{F}$. All test apparatus were installed in accordance with Section 9 of the ASTM test method.¹

Power and energy were measured with a watt/watt-hour transducer that generated an analog signal for instantaneous power and a pulse for every 10 Wh. The transducer and thermocouples were connected to a computerized data acquisition unit that recorded data every 5 seconds. A voltage regulator, connected to the steamer, maintained a constant voltage for all tests. Figure 2-1 shows the CAPELLA instrumented with the data acquisition system and voltage regulator during an actual test.



*Figure 2-1.
The CAPELLA Instrumented
for Testing.*

Methods

Revisions to the ASTM Test Method

The steam cooker test method, originally published as F 1484-93, was revised as F 1484-99. The ice-load test, due to its simplicity, repeatability, and reproducibility, was applied during the developmental phase of the test procedure as a quick indicator of steamer efficiency and productivity. However, ice-load test results do not always mirror the results of food products, particularly with respect to real-world cook times and associated production capacities. The F 1484-99 test method lists the ice-load test as an optional procedure.

The potato tests remain in the revised test method with two modifications. The original method specified whole, U.S. No. 1, size B, red potatoes with an average weight of 0.14 ± 0.02 lb. Repetition of tests showed that the potatoes typically had a higher average weight of around 0.16 lb. The revised test method calls for red potatoes weighing 0.16 ± 0.02 lb. Furthermore, the prescribed cook temperature of 205°F was high since the maximum attainable temperature of steam under atmospheric pressure is 212°F. Qualitative tests, using texture, taste, and consistency as criteria, showed that potatoes were cooked to an acceptable doneness at $195 \pm 2^\circ\text{F}$.

The three loading scenarios described in the original test method were reduced to two scenarios (full- and light-load tests). The full-load test (4 pans) determines the steamer's peak cooking energy efficiency and production capacity, while the light-load test (1 pan) evaluates partial-load performance.

Full- and light-load tests of frozen green peas were incorporated into the ASTM test method as a replacement for the ice-load tests. Since probing proves difficult and erroneous in measuring temperature of the small-sized green peas, a water-bath calorimeter was utilized to measure the final bulk temperature of the cooked green peas. Figure 2-2 shows the food products tested in the CAPELLA steamer: frozen green peas, and red potatoes.

Methods



*Figure 2-2.
Products For Steamer
Tests: Red Potatoes
and Frozen Green
Peas.*

Measured Energy Input, Preheat and Idle Rate

The energy input rate was determined by measuring the energy consumed by the steamer during a complete preheat cycle. The maximum power draw during this period was reported as the measured energy input rate. Preheat tests recorded the time and energy required for the steamer to reach operating temperature from a cold start, as when turned on for the first time in a day. Recording began when the steamer was turned on and ended when its elements first cycled off. An hour after the preheat cycle, idle energy consumption was monitored for a 2-hour period.

Green Peas Full- and Light-Load Efficiency Tests

Individually flash-frozen, grade A green peas represented one of two food products for steamer performance testing. Standard, perforated, stainless-steel hotel pans (12" x 20" x 2½") are specified for cooking the green peas. The CAPELLA required 4 pans of green peas for a full load, while 1 pan, placed on the center rack of the steamer cavity, comprises a light load. Each pan contained 8.0 ± 0.2 lb of green peas. Pre-weighed green peas in perforated pans were stored in sealed plastic bags at $0 \pm 5^\circ\text{F}$ for at least 24 hours. The pans of peas were transferred into an insulated box and transported to the

Methods

testing location where the plastic bags were removed, and the pan(s) of green peas were loaded into the steamer according to the loading time prescribed in section 10.7.6 of the ASTM test method.¹

Red Potatoes Full- and Light- Load Efficiency Tests

Freshly packed, size B, red potatoes served as the second food product for steamer performance testing. Again, the CAPELLA required 4 pans of red potatoes for a full load and 1 pan for a light load, each pan containing 8.0 ± 0.2 lb. of potatoes.

The red potatoes were loaded into perforated pans prior to the test and stabilized to a room temperature of $75 \pm 5^\circ\text{F}$. The potatoes were cooked to $195 \pm 2^\circ\text{F}$ using a predetermined cook time. The final bulk temperature was determined by randomly probing potatoes using a hand-held digital thermocouple meter within 3 minutes after cooking was terminated.

3 Results

Manufacturer's Rated Input and Maximum Energy Input Rate

Measured energy input rate and the manufacturer's nameplate value were compared prior to any testing to ensure that the steamer was operating within its specified parameters. The CAPELLA drew a maximum input rate of 7.7 kW, 3.8% lower than the nameplate rate of 8.0 kW, but within the 5% tolerance of the ASTM standard.

Preheat and Idle Tests

Preheat Energy and Time

The cavity was manually filled with 2 gallons of water at $70 \pm 5^\circ\text{F}$. The preheat consumed 2.0 kWh during the 16.6 minute period. The preheat time reflects the point from when the unit was turned on until it reached full operational capacity in either "Steam" or "Super Steam" mode of operation.

Idle Energy Rate

Following the preheat period, the steamer was placed in "Stand-by" mode and allowed to stabilize for one hour. Thereafter, the energy consumption was monitored over a 2-hour period and the idle energy rate was calculated to be 0.2 kW.

"Stand-by" mode keeps the water temperature just below boiling to prevent excessive evaporation and energy use, but hot enough to ensure a rapid return to full operational capacity when the CAPELLA is placed in "Steam" or "Super Steam" mode of operation. Typically, the time to bring the steamer back to full operational capacity was 1.5 minutes.

Results

Test Results

Rated energy input, preheat energy and idle rate test results are summarized in Table 3-1.

Table 3-1. Average Input, Preheat and Idle Test Results.

Rated Energy Input Rate (kW)	8.0
Measured Energy Input Rate (kW)	7.7
Preheat to Operational Capacity	
Time (min)	16.6
Energy (kWh)	2.0
Idle Energy Rate (kW)	0.2

Cooking Tests

The steamer was tested with two test products under two loading scenarios: full-load green peas (4 pans), light-load green peas (1 pan), full-load red potatoes (4 pans), and light-load red potatoes (1 pan). Both loading scenarios for each food product were conducted in both the “Steam” and “Super Steam” cooking modes. The energy consumption, elapsed cook time, ambient temperature and product temperature were monitored for the duration of each test at five-second intervals.

The CAPELLA does not employ a separate boiler, water connection or drain. Therefore, water consumption and condensate temperature were not monitored. Two gallons of water were poured into the bottom of the cooking compartment before testing began. The steamer was emptied at the end of the day as directed by the manufacturer’s instructions. Typical water usage was 2.0 gallons per test day.

Results

Full- and Light-Load Green Peas Test

Moisture content of the frozen green peas was 81% by weight corresponding to specific heats (C_p) of 0.44 Btu/lb°F for frozen and 0.85 Btu/lb°F for thawed peas.³ In “Steam” mode the CAPELLA required 27.2 minutes to cook the full load of frozen green peas with a cooking energy efficiency of 84.0% and a production capacity of 70.6 lb/h. When operated in “Super Steam” mode, the cook time reduced to 25.7 minutes, the efficiency remained effectively unchanged at 83.1%, and the productivity increased to 74.9 lb/h.

The light-load test required an average of 10.4 minutes when cooking a single pan of frozen green peas in “Steam” mode and 9.3 minutes in “Super Steam” mode. Cooking energy efficiency and productivity were determined to be 62.3% and 46.1 lb/h, respectively in “Steam” mode, while in “Super Steam” mode they were determined to be 58.9% and 51.9 lb/h, respectively.

Full- and Light-Load Potatoes Test

The red potatoes contained 84% moisture by weight with the specific heat (C_p) of 0.87 Btu/lb°F.³ In “Steam” mode, a full load of potatoes averaged 25.1 minutes to reach a bulk cook temperature of 195°F. The cooking efficiency and production capacity were 54.7% and 77.8 lb/h, respectively. In “Super Steam” mode the cook time lowered to 22.8 minutes and the cooking efficiency improved to 63.1%. The production capacity was calculated to be 85.6 lb/h.

The single pan of red potatoes cooked in “Steam” mode required 19.3 minutes to achieve an average bulk temperature of 195.0°F. The light-load potato test lowered the energy efficiency to 31.8% and productivity to 25.4 lb/h. In “Super Steam” mode, the cook time was 19.2 minutes. The cooking efficiency was 19.9% and the production capacity was 25.3 lb/h.

Results

Result Discussion

The rate at which steam condenses on food depends on the surface temperature and area of the food. Therefore, frozen green peas (at 0°F) and red potatoes (at room temperature) represent two extremities in steam cooking. Frozen green peas, having large surface area to volume ratio, promote condensation. The energy transfer from steam to frozen food is high, resulting in greater cooking energy efficiency and productivity. Potatoes are “tough” to cook due to the slow nature of condensation.

Appendix D lists the physical properties and measured values of each test run. Using the detailed equations provided in section 11 of the steamer ASTM Standard Test Method, the cooking energy efficiencies can readily be calculated. Table 3-2 summarizes the CAPELLA’s cooking performance. Figures 3-1 and 3-2 compare these results in a graphical format. Figures 3-3 and Figure 3-4 illustrate the steamer’s part-load energy efficiencies. Figure 3-5 and Figure 3-6 illustrate the steamer’s cooking energy profile.

Table 3-2. Cooking Energy Efficiency and Production Capacity Test Results.

	Full Load		Light Load		Full Load		Light Load	
	Peas		Peas		Potatoes		Potatoes	
	Steam	Super Steam	Steam	Super Steam	Steam	Super Steam	Steam	Super Steam
Number of Pans	4	4	1	1	4	4	1	1
Cook Time (min)	27.2	25.7	10.4	9.3	25.1	22.8	19.3	19.2
Cooking Energy Rate (kW)	6.5	7.0	5.7	6.8	4.7	4.5	2.6	4.1
Cooking Energy Efficiency (%)	84.0	83.1	62.3	58.9	54.7	63.1	31.8	19.9
Production Rate (lb/h)	70.6	74.9	46.1	51.9	77.8	85.6	25.4	25.3
Energy Consumption (Btu/lb)	312.1	320.0	426.6	460.8	197.4	175.4	353.7	565.7

Results

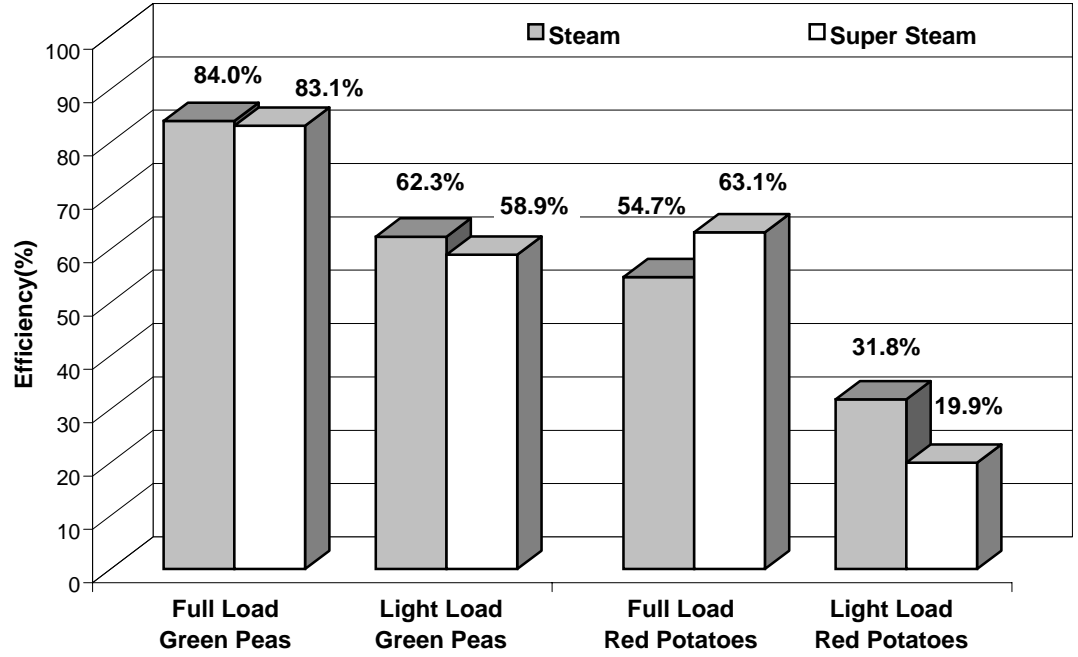


Figure 3-1.
Steamer Cooking Efficiency Under Full- and Light-Load Scenarios.

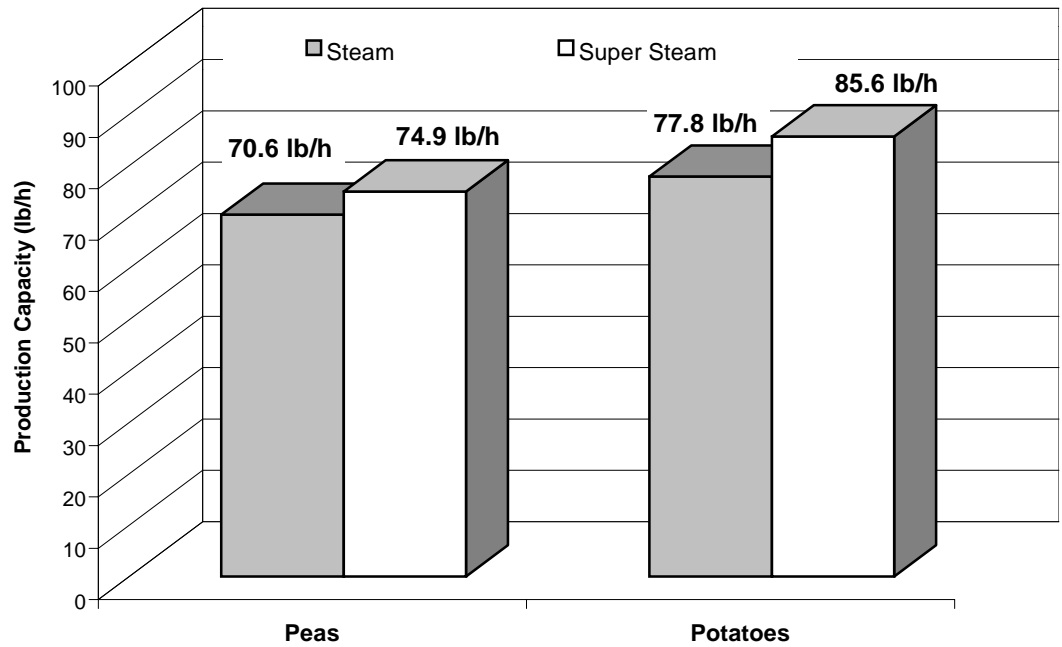
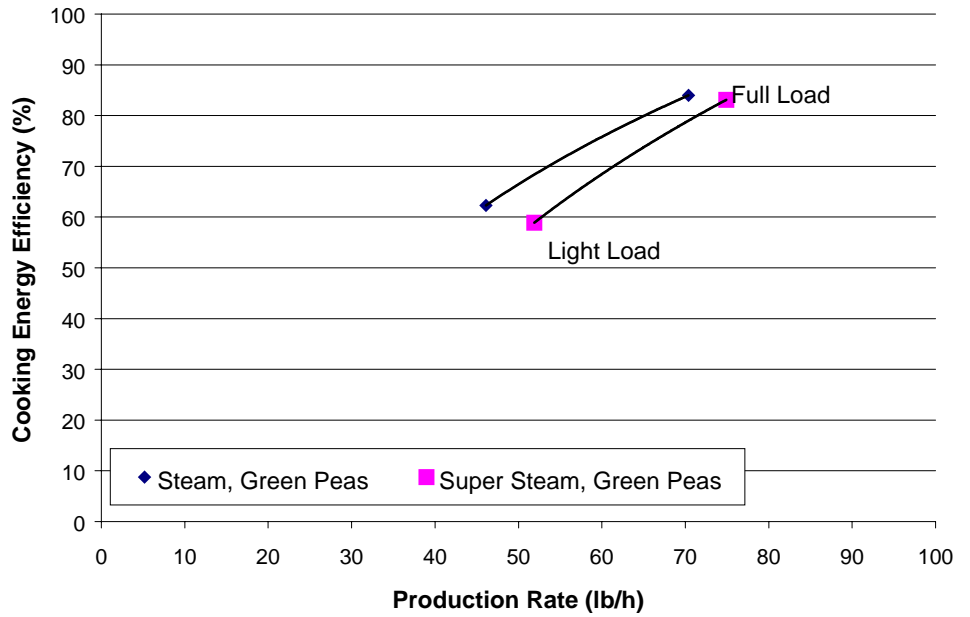


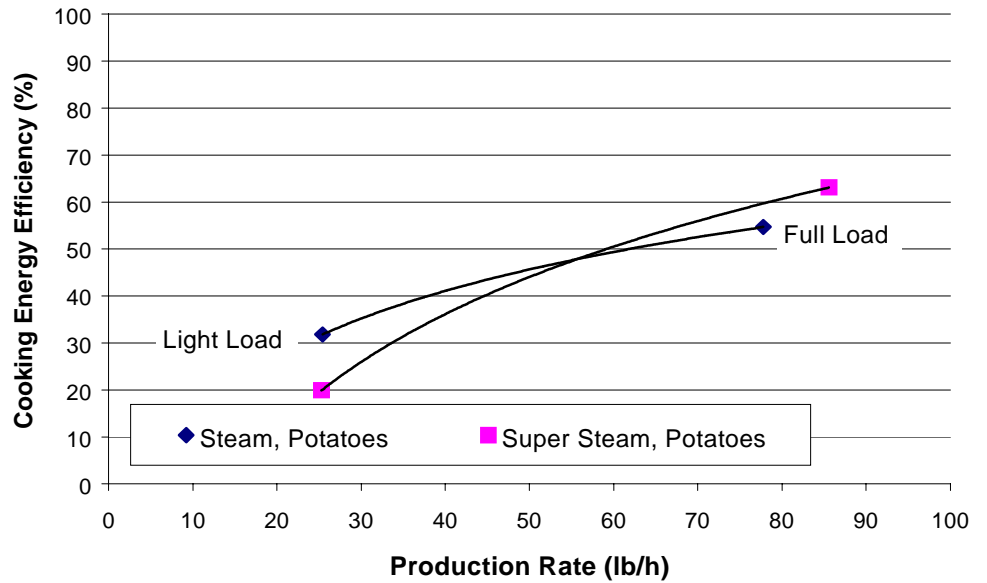
Figure 3-2.
Steamer Production Capacities.

Results

*Figure 3-3.
Steamer Part-Load
Green Pea Cooking
Efficiency.*



*Figure 3-4.
Steamer Part-Load Red
Potato Cooking
Efficiency.*



Results

Figure 3-5.
Steamer Cooking Energy Consumption Profile, Green Peas.

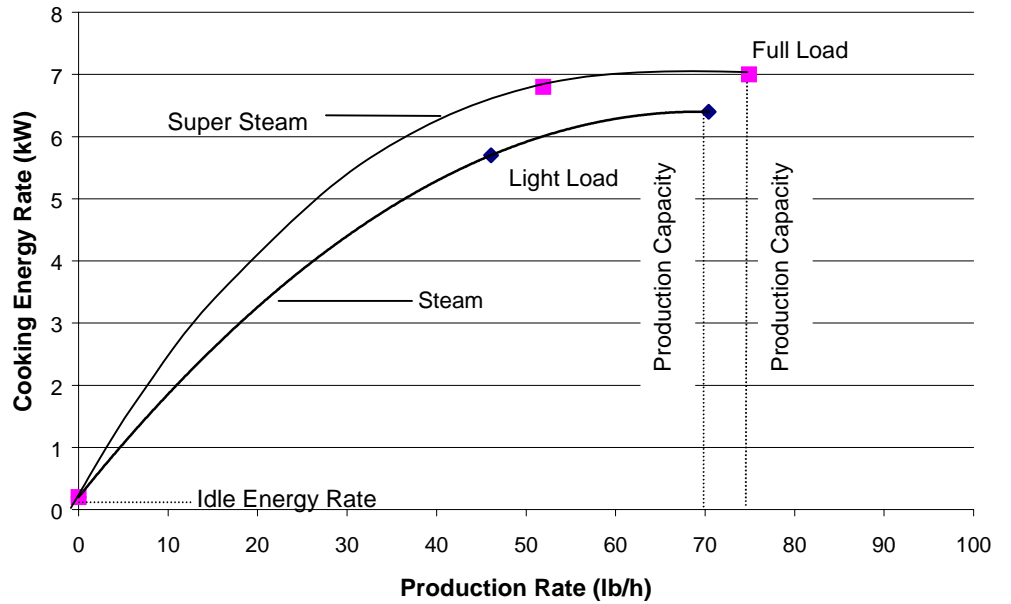
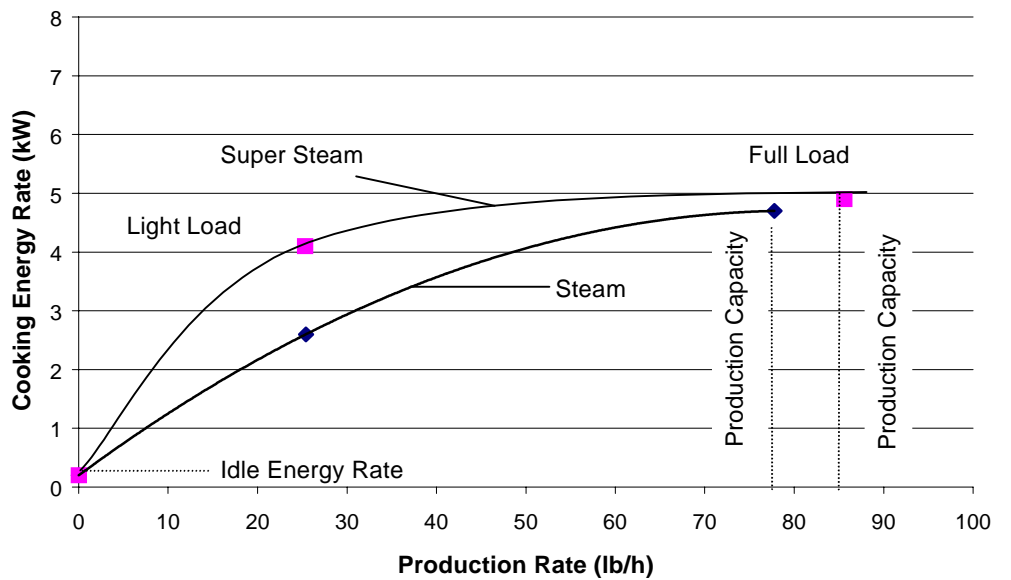


Figure 3-6.
Steamer Cooking Energy Consumption Profile, Red Potatoes.



4 Conclusions

The StellarSteam, CAPELLA electric steamer is one of the most energy efficient connectionless steamers tested to date by the FSTC. Not only does the CAPELLA deliver high cooking energy efficiency with competitive cooketimes, as a connectionless steamer it has the added virtue of being easy to operate. It truly is a “plug and play” appliance that only requires pouring two gallons of water into the cooking cavity and turning the unit on.

Its use in both cooking modes delivers high cooking energy efficiencies. The 83-84% cooking energy efficiency for a full-load of frozen green peas is an example. Further, the faster cook times for frozen green peas in “Super-Steam” did not cause an appreciable reduction in the steamer’s energy efficiency. When tasked with cooking a full-load of red potatoes, a “tough” food product, the CAPELLA stacks up well against other connectionless steamers as reflected by the 63% cooking energy efficiency and 22.8 minutes cook time when operated in “Super Steam” mode.^{4,5,6}

Although the maximum loading capacity can differ from steamer to steamer, the light-load, with its single pan of food product, serves to simplify performance comparisons between different models. When challenged with a light-load cooking scenarios, the CAPELLA’s cook time performance surpassed that of other connectionless steamers tested to date at the FSTC, regardless of which cooking mode an operator chooses. For example, the 9.3-minute cook time in “Super Steam” for a single pan of frozen green peas is approximately 2 minutes faster than any other tested connectionless steamer. The same can be said of the 19.2 minute “Super Steam” cook time for one pan of red potatoes.

Left to idle, the CAPELLA uses a trickle of energy, 0.2 kW in “Stand-by” mode. This mode leaves the appliance ready to quickly bring the cooking cavity up to full operation capacity in either “Steam” or “Super Steam”

Conclusions

cooking modes in less than 2 minutes. Leaving the steamer in one of the two cooking modes negates the energy and water savings associated with the “Stand-by” mode as the heating elements continually cycle at a much faster rate in order to maintain the reservoir water at a full boil.

Another important highlight of the CAPELLA’s overall performance is its very low water consumption. Compared to a boiler based, atmospheric steamer or an atmospheric, steam generator type steamer, the CAPELLA is a true water miser. Typically, a boiler based, atmospheric steamer consumes 60.0 gal/h during a full-load cooking event. A steam generator type easily consumes over 20.0 gal/h.^{3,7} The CAPELLA’s water consumption on the other hand never exceeded 2.0 gallons per cooking event.

Other design features show innovation in this new category of atmospheric steamers. A food service operator will appreciate the easy quick release drain attachment at the front of the unit. The Dupont Teflon® coating on the cavity interior facilitates clean up. Heating elements external to the water reservoir eliminates the need for de-liming chemicals and the impact of corrosion. Couple all these design features; respectable cooking performance, ease of use, set-up and maintenance and the StellarSteam, CAPELLA steamer is a candidate for any commercial kitchen.

5 References

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6. Food Service Technology Center. 1999. *Southbend Simple Steam, Model EZ-3 Electric Steamer Performance Test*. Report 5011.99.83. Report 5011.99.75. Product and Services Department. San Francisco, California: Pacific Gas and Electric Company.
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Glossary

Boiler

Self-contained electric, gas, or steam coil powered vessel wherein water is boiled to produce steam for the steam cooker. Also called a steam generator.

Boiler Idle Energy Rate

Idle Energy Rate

Idle Rate

Idle Energy Consumption Rate

Rate of energy consumed by the steam cooker while maintaining boiler operating pressure or temperature with no cooking taking place.

Boiler Preheat

Preheat

Process of bringing the boiler water from potable supply temperature to operating temperature (pressure).

Boiler Preheat Duration

Preheat Time

Preheat Period

Total time required for preheat, from preheat initiation at controls to when the steam cooker is ready to cook.

Boiler Preheat Energy

Preheat Energy Consumption

Amount of energy consumed by the steam cooker during a preheat.

Boiler Preheat Energy Rate

Preheat Energy Rate

The rate of appliance energy consumption while it is preheating to a predetermined temperature.

Condensate

A mixture of condensed steam and cooling water, exiting the steam cooker and directed to the floor drain.

Condensate Temperature

The temperature at which the condensate enters the floor drain.

Cooking Energy Efficiency

Energy Efficiency

Quantity of energy imparted to the specified food product expressed as a percentage of energy consumed by the steam cooker during the cooking event.

Cooking Energy Rate

Cooking Energy Consumption Rate

Average rate of energy consumption (kBtu/h or kW) during the cooking energy efficiency test. Refers to any loading scenario in the ice, pea or potato load tests.

Cook Time

Cooking Period

The period of time that the steamer is used for cooking.

Energy Input Rate

Peak rate at which a steamer consumes energy, typically reflects during preheat.

Frozen Green Peas Load

12 x 20 x 2½ in. (300 x 500 x 65 mm) hotel pan filled with 8.0±0.2 lb (3630±90 g) of frozen, grade A, green peas subsequently frozen to 0±5°F (-18±2°C). One of two food product used to determine cooking energy efficiency and production capacity.

Glossary

High-Pressure Steam Cooker

Steam cooker wherein cooking compartment operates between 10 and 15 psig (ASTM F1217-92 Classification Type III).

Idle Energy Consumption

Idle Energy Use

The amount of energy consumed by an appliance operating under an idle condition over the duration of an idle period.

Ice Load

12 x 20 x 2½ in. (300 x 500 x 65 mm) hotel pan filled with 8.0±0.2 lb (3630±90 g) of water and subsequently frozen to 0±5°F (-18±2°C). This is used to simulate a food product load in the ice load cooking energy efficiency and production capacity test.

Low-Pressure Steam Cooker

Steam cooker wherein cooking compartment operates between 3 and 9.9 psig (ASTM F1217-92 Classification Type II).

Maximum Energy Input Rate

Measured Energy Input

Measured Peak Energy Input Rate

Peak Rate of Energy Input

Peak rate at which an appliance consumes energy.

Potato Load

12 x 20 x 2½ in. (300 x 500 x 65 mm) hotel pan filled with 8.0±0.2 lb (3.6±0.1 kg) of fresh, whole, US No. 1, size B, red potatoes. One of two food product used to determine cooking energy efficiency and production capacity.

Atmospheric Steam Cooker

Steam cooker wherein cooking compartment operates between 0 and 2.9 psig (ASTM F1217-92 Classification Type I).

Production Capacity

Maximum rate (lb(kg)/h) at which steam cooker can bring the specified food product to a specified "cooked" condition.

Production Rate

Rate (lb(kg)/h) at which steam cooker brings the specified food product to a specified "cooked" condition.

Rated Energy Input Rate

Input Rating (ANSI definition)

Nameplate Energy Input Rate

Rated Input

The maximum or peak rate at which an appliance consumes energy as rated by the manufacturer and specified on the nameplate.

Steam Cooker

Cooking appliance wherein heat is imparted to food in a closed compartment by direct contact with steam. The compartment can be at or above atmospheric pressure. The steam can be static or circulated.

Water Consumption

Water consumed by the steam cooker. Includes both water used in the production of steam and cooling water (if applicable) for condensing/cooling unused steam.

B Appliance Specification Sheet

Appendix B includes the product literature for the StellarSteam, model CAPELLA steamer.

C Results Reporting Sheets

Manufacturer: StellarSteam
Model: CAPELLA
Date: January 2001

Section 11.1 Test Steam Cooker

ASTM F 1216 Classification (check one for each classification)

- Type I - Zero to 2.9 psig compartment pressure
- Type II - Three to 9.9 psig compartment pressure
- Type III - Ten to 15 psig compartment pressure

- Size 1-3 - One Compartment, 3 full-size pan capacity
- Size 1-4 - One Compartment, 4 full-size pan capacity
- Size 1-5 - One Compartment, 5 full-size pan capacity
- Size 1-6 - One Compartment, 6 full-size pan capacity
- Size 2-6 - Two Compartment, 6 full-size pan capacity
- Size 2-8 - Two Compartment, 8 full-size pan capacity
- Size 2-10 - Two Compartment, 10 full-size pan capacity
- Size 2-12 - Two Compartment, 12 full-size pan capacity
- Size 2-16 - Two Compartment, 16 full-size pan capacity
- Size 3-12 - Three Compartment, 12 full-size pan capacity
- Size 3-15 - Three Compartment, 15 full-size pan capacity
- Size 3-18 - Three Compartment, 18 full-size pan capacity
- Size 3-24 - Three Compartment, 24 full-size pan capacity

- Style A - Counter mounted
- Style B - Floor mounted on an open stand
- Style C - Floor mounted on a cabinet base
- Style D - Wall Mounted

- Class A - Direct connection to potable external steam source
- Class B - Self-contained steam coil steam generator
- Class C - Self-contained gas fired steam generator
- Class D - Self-contained electric steam generator

Description of operational characteristics: Approximately two gallons of water is manually poured in the bottom of the cooking compartment. The power switch is placed in the "ON" position and the cook setting is dialed to "Stand-by" mode. The heating elements activate when the door is closed. When a cooking event is to occur, the operator selects "Steam" or "Super Steam" cooking mode depending on desired cooking effect. Water is manually drained at the end of the day or after each cooking event.

Results Reporting Sheets

Section 10.7 Apparatus

The steamer was installed in accordance with the manufacturer's instructions under a 4-foot-deep canopy hood, with the lower edge of the hood 6 feet, 6 inches above the floor and a minimum of 6 inches inside the vertical front edge of the hood. The exhaust ventilation operated at a nominal rate of 150 cfm per linear foot of hood with the ambient temperature maintained between $75 \pm 5^\circ\text{F}$. All test apparatus were installed in accordance with Section 9 of the ASTM test method.¹

The steamer was instrumented with an electric transducer to measure power and energy; a voltage regulator was used to maintain constant voltage for all tests. A computerized data acquisition system recorded test information at 10-second intervals for the red potato tests and 5-second intervals for the rest. All test apparatus were installed in accordance with Section 9 of the ASTM test method.

Section 11.4 Energy Input Rate

Measured	7.7 kW
Rated	8.0 kW
Percent Difference between Measured and Rated	3.8%

Section 11.5 Appliance Preheat Energy Consumption and Duration

Energy Consumption	2.0 kWh
Duration	16.6 min

Section 11.6 Appliance Idle Energy Rate

Idle Energy Rate	0.2 kW
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Results Reporting Sheets

Section 11.8 Frozen Green Peas Cooking Time, Energy Efficiency, Energy Rate, Production Capacity, and Water Consumption Rate

Full Load:	Steam	Super Steam
Cooking Time	27.3 min	25.7 min
Cooking Energy Efficiency	84.0 ± 3.4 %	83.1 ± 1.7%
Cooking Energy Rate	6.4 ± 0.3kW	7.0 ± 0.6kW
Production Capacity	70.4 ± 3.5 lb/h	74.9 ± 5.5 lb/h
Water Consumption Rate	<2.0 gal/h	<2.0 gal/h
Light Load:		
Cooking Time	10.4 min	9.3 min
Cooking Energy Efficiency	62.3 ± 1.7 %	58.9 ± 4.3%
Cooking Energy Rate	5.7 ± 0.3kW	6.8 ± 0.1kW
Production Rate	46.1 ± 1.6 lb/h	51.9 ± 3.5 lb/h
Water Consumption Rate	<2.0 gal/h	<2.0 gal/h

Section 11.9 Whole Red Potatoes Cooking Time, Energy Efficiency, Energy Rate, Production Capacity, and Water Consumption Rate

Full Load:	Steam	Super Steam
Cooking Time	25.1 min	22.8 min
Cooking Energy Efficiency	54.7 ± 2.7%	63.1 ± 4.4%
Cooking Energy Rate	4.7 ± 0.3kW	4.5 ± 1.2kW
Production Capacity	77.8 ± 5.3lb/h	85.6 ± 3.7lb/h
Water Consumption Rate	<2.0 gal/h	<2.0 gal/h

Results Reporting Sheets

Light Load:	Steam	Super Steam
Cooking Time	19.3 min	19.2 min
Cooking Energy Efficiency	$31.8 \pm 1.6\%$	$19.92 \pm 1.5\%$
Cooking Energy Rate	$4.7 \pm 0.3\text{kW}$	$4.1 \pm 0.1\text{kW}$
Production Capacity	$25.4 \pm 0.8\text{lb/h}$	$\pm 0.3\text{lb/h}$
Water Consumption Rate	$<2.0 \text{ gal/h}$	$<2.0 \text{ gal/h}$

D Cooking Energy Efficiency Data

Table D-1. Preheat and Idle Data

Measured Values	Replication 1	Replication 2	Replication 3
Preheat Time (min)	16.83	16.25	16.83
Preheat Energy (kWh)	2.00	2.04	2.00
Idle Time (min)	120.0	120.0	120.0
Idle Energy (kWh)	0.42	0.42	0.44
Calculated Values			
Preheat Energy Rate (kW)	7.13	7.53	7.13
Idle Energy Rate (kW)	0.21	0.21	0.22

Cooking Energy Efficiency Data

Table D-2. Full-Load Peas Data (Steam)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	4	4	4
Cook Time (min)	28.17	26.50	27.00
Initial Water Temperature (°F)	47.7	46.5	47.2
Final Water Temperature (°F)	100.2	99.0	97.7
Frozen Food Temperature (°F)	-4.0	-4.0	-4.4
Weight of Empty Calorimeter (lb)	44.4	44.3	44.2
Weight of Full Calorimeter (lb)	115.8	114.8	114.4
Weight of Calorimeter Water (lb)	40.1	40.1	40.3
Weight of Cooked Food (lb)	31.4	30.4	29.9
Weight of Frozen Food (lb)	32.0	32.0	32.0
Weight of Stainless-Steel Pans (lb)	7.6	10.0	11.2
Moisture Content (%)	81.0	81.0	83
Condensate Temperature (°F)	N/A	N/A	N/A
Water Consumption (gal/h)	N/A	N/A	N/A
Calculated Values			
Moisture Weight in Green Peas(lb)	25.9	25.9	25.9
Final Food Temperature (°F)	179.1	180.3	178.2
Cooking Energy (Btu)	2.96	2.90	2.92
Energy Consumed by Green Peas (Btu)	8235.7	8267.2	8096.5
Energy Consumed by Pans (Btu)	153.4	202.7	215.6
Energy of Boiler Re-init (Btu)	0	0	0
Energy Consumed by the Steamer (Btu)	10102.5	9897.7	9966.0
Cooking Energy Rate (kW)	6.3	6.6	6.5
Productivity (lb/h)	68.2	72.5	71.1
Energy Efficiency (%)	83.0	85.6	83.4

Cooking Energy Efficiency Data

Table D-3. Light-Load Peas Data (Steam)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	1	1	1
Cook Time (min)	10.50	10.50	10.25
Initial Water Temperature (°F)	42.3	47.0	48.0
Final Water Temperature (°F)	77.9	81.4	81.7
Frozen Food Temperature (°F)	-4.0	-4.0	-4.0
Weight of Empty Calorimeter (lb)	44.3	44.6	44.5
Weight of Full Calorimeter (lb)	72.9	73.0	72.5
Weight of Calorimeter Water (lb)	20.2	20.0	20.0
Weight of Cooked Food (lb)	8.4	8.4	8.0
Weight of Frozen Food (lb)	8.0	8.0	8.0
Weight of Stainless-Steel Pans (lb)	2.8	2.8	3.4
Moisture Content (%)	81.0	81.0	81.0
Condensate Temperature (°F)	N/A	N/A	N/A
Water Consumption (gal/h)	N/A	N/A	N/A
Calculated Values			
Moisture Weight in Green Peas(lb)	6.5	6.5	6.5
Final Food Temperature (°F)	179.2	178.5	181.0
Cooking Energy (Btu)	1.00	0.98	1.00
Energy Consumed by Green Peas (Btu)	2059.6	2054.2	2043.3
Energy Consumed by Pans (Btu)	56.8	55.9	65.8
Energy of Boiler Re-init (Btu)	0	0	0
Energy Consumed by the Steamer (Btu)	3413.0	3344.7	3413.0
Cooking Energy Rate (kW)	5.7	5.6	5.9
Productivity (lb/h)	45.7	45.7	46.8
Energy Efficiency (%)	62.0	63.1	61.8

Cooking Energy Efficiency Data

Table D-4. Full-Load Potatoes Data (Steam)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	4	4	4
Cook Time (min)	24.42	25.83	24.92
Temperature of Uncooked Potatoes (°F)	74.00	74.00	71.00
Temperature of Cooked Potatoes (°F)	195.0	195.0	195.0
Weight of Stainless-Steel Pans (lb)	10.45	10.63	15.76
Weight of Potatoes (lb)	32.39	32.47	32.56
Total Potato Count	194.0	194.0	193.0
Moisture Content (%)	84.07	84.07	84.07
Condensate Temperature (°F)	N/A	N/A	N/A
Water Consumption (gal/h)	N/A	N/A	N/A
Calculated Values			
Moisture Weight in Potatoes (lb)	27.23	27.30	27.37
Average Weight of Each Potatoes (lb)	0.17	0.17	0.17
Cooking Energy (Btu)	1.88	1.96	2.00
Energy Consumed by Potatoes (Btu)	3431.10	3440.32	3535.14
Energy Consumed by Pans (Btu)	139.52	141.90	215.52
Energy of Boiler Re-init (Btu)	0	0	0
Energy Consumed by the Steamer (Btu)	6416.44	6689.48	6826.00
Cooking Energy Rate (kW)	4.62	4.55	4.82
Productivity (lb/h)	79.58	75.42	78.41
Energy Efficiency (%)	55.65	53.55	54.95

Cooking Energy Efficiency Data

Table D-5. Light-Load Potatoes Data (Steam)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	1	1	1
Cook Time (min)	19.50	19.25	19.08
Temperature of Uncooked Potatoes (°F)	70.00	71.40	73.40
Temperature of Cooked Potatoes (°F)	195.00	195.0	195.0
Weight of Stainless-Steel Pans (lb)	2.81	2.43	2.42
Weight of Potatoes (lb)	8.16	8.10	8.17
Total Potato Count	49.0	50.0	50.0
Moisture Content (%)	84.07	84.07	84.07
Condensate Temperature (°F)	N/A	N/A	N/A
Water Consumption (gal/h)	N/A	N/A	N/A
Calculated Values			
Moisture Weight in Potatoes (lb)	6.86	6.81	6.87
Average Weight of Each Potatoes (lb)	0.17	0.16	0.16
Cooking Energy (Btu)	0.84	0.85	0.83
Energy Consumed by Potatoes (Btu)	890.30	873.96	867.30
Energy Consumed by Pans (Btu)	38.64	33.09	32.32
Energy of Boiler Re-init (Btu)	0	0	0
Energy Consumed by the Steamer (Btu)	2865.31	2912.51	2839.71
Cooking Energy Rate (kW)	2.58	2.66	2.62
Productivity (lb/h)	25.10	25.25	25.69
Energy Efficiency (%)	32.42	31.14	31.68

Cooking Energy Efficiency Data

Table D-6. Full-Load Peas Data (Super Steam)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	4	4	4
Cook Time (min)	25.50	26.50	25.00
Initial Water Temperature (°F)	44.2	44.3	47.2
Final Water Temperature (°F)	99.2	98.7	99.0
Frozen Food Temperature (°F)	-4.0	-4.0	-4.0
Weight of Empty Calorimeter (lb)	44.5	44.3	44.4
Weight of Full Calorimeter (lb)	117.3	116.0	115.5
Weight of Calorimeter Water (lb)	40.2	40.2	40.3
Weight of Cooked Food (lb)	32.6	31.5	30.9
Weight of Frozen Food (lb)	32.0	32.0	32.0
Weight of Stainless-Steel Pans (lb)	11.2	10.0	10.0
Moisture Content (%)	81.0	81.0	81.0
Condensate Temperature (°F)	N/A	N/A	N/A
Water Consumption (gal/h)	N/A	N/A	N/A
Calculated Values			
Moisture Weight in Green Peas(lb)	25.9	25.9	25.9
Final Food Temperature (°F)	179.2	180.5	178.8
Cooking Energy (Btu)	3.00	2.96	2.98
Energy Consumed by Green Peas (Btu)	8237.1	8273.8	8225.2
Energy Consumed by Pans (Btu)	226.7	203.0	201.0
Energy of Boiler Re-init (Btu)	0	0	0
Energy Consumed by the Steamer (Btu)	10239.0	10102.5	10170.7
Cooking Energy Rate (kW)	7.1	6.7	7.2
Productivity (lb/h)	75.3	72.5	76.8
Energy Efficiency (%)	82.7	83.9	82.8

Cooking Energy Efficiency Data

Table D-8. Light-Load Peas Data (Super Steam)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	1	1	1
Cook Time (min)	9.50	9.00	9.25
Initial Water Temperature (°F)	49.4	47.0	48.8
Final Water Temperature (°F)	85.4	79.5	81.1
Frozen Food Temperature (°F)	-4.0	-4.0	-4.0
Weight of Empty Calorimeter (lb)	44.3	44.7	44.6
Weight of Full Calorimeter (lb)	73.2	72.6	72.5
Weight of Calorimeter Water (lb)	20.0	20.1	20.0
Weight of Cooked Food (lb)	8.8	7.8	7.8
Weight of Frozen Food (lb)	8.0	8.0	8.0
Weight of Stainless-Steel Pans (lb)	3.2	3.4	3.4
Moisture Content (%)	81.0	81.0	81.0
Condensate Temperature (°F)	N/A	N/A	N/A
Water Consumption (gal/h)	N/A	N/A	N/A
Calculated Values			
Moisture Weight in Green Peas(lb)	6.5	6.5	6.5
Final Food Temperature (°F)	181.7	178.3	178.2
Cooking Energy (Btu)	1.08	1.02	1.06
Energy Consumed by Green Peas (Btu)	2076.6	2052.9	2024.3
Energy Consumed by Pans (Btu)	65.6	67.8	64.8
Energy of Boiler Re-init (Btu)	0	0	0
Energy Consumed by the Steamer (Btu)	3686.0	3481.3	3617.8
Cooking Energy Rate (kW)	6.8	6.8	6.9
Productivity (lb/h)	50.5	53.3	51.9
Energy Efficiency (%)	58.1	60.9	57.7

Cooking Energy Efficiency Data

Table D-9. Full-Load Potatoes Data (Super Steam)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	4	4	4
Cook Time (min)	22.50	23.25	22.50
Temperature of Uncooked Potatoes (°F)	71.70	70.30	71.20
Temperature of Cooked Potatoes (°F)	195.0	195.0	195.0
Weight of Stainless-Steel Pans (lb)	10.28	10.19	11.23
Weight of Potatoes (lb)	32.49	32.52	32.36
Total Potato Count	204.0	204.0	200.0
Moisture Content (%)	84.07	84.07	84.07
Condensate Temperature (°F)	N/A	N/A	N/A
Water Consumption (gal/h)	N/A	N/A	N/A
Calculated Values			
Moisture Weight in Potatoes (lb)	27.32	27.34	27.21
Average Weight of Each Potatoes (lb)	0.16	0.16	0.16
Cooking Energy (Btu)	1.67	1.76	1.66
Energy Consumed by Potatoes (Btu)	3497.36	3539.79	3497.38
Energy Consumed by Pans (Btu)	139.37	139.76	152.99
Energy of Boiler Re-init (Btu)	0	0	0
Energy Consumed by the Steamer (Btu)	5699.51	6021.43	5666.52
Cooking Energy Rate (kW)	4.45	4.55	4.43
Productivity (lb/h)	86.64	83.91	86.29
Energy Efficiency (%)	63.81	61.11	64.42

Cooking Energy Efficiency Data

Table D-10. Light-Load Potatoes Data (Super Steam)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	1	1	1
Cook Time (min)	19.58	19.08	19.00
Temperature of Uncooked Potatoes (°F)	74.50	72.10	73.40
Temperature of Cooked Potatoes (°F)	195.0	195.0	195.0
Weight of Stainless-Steel Pans (lb)	2.62	2.41	2.42
Weight of Potatoes (lb)	8.07	8.05	8.18
Total Potato Count	51.0	51.0	48.0
Moisture Content (%)	84.07	84.07	84.07
Condensate Temperature (°F)	N/A	N/A	N/A
Water Consumption (gal/h)	N/A	N/A	N/A
Calculated Values			
Moisture Weight in Potatoes (lb)	6.78	6.77	6.88
Average Weight of Each Potatoes (lb)	0.16	0.16	0.17
Cooking Energy (Btu)	1.34	1.31	1.29
Energy Consumed by Potatoes (Btu)	848.62	863.70	868.20
Energy Consumed by Pans (Btu)	34.73	32.55	32.37
Energy of Boiler Re-init (Btu)	0	0	0
Energy Consumed by the Steamer (Btu)	4582.43	4469.07	4406.53
Cooking Energy Rate (kW)	4.11	4.12	4.08
Productivity (lb/h)	24.72	25.31	25.83
Energy Efficiency (%)	19.28	20.05	20.44

