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A Comparison of Energy Usage in the Home Canning of Tomato Juice

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RINGKASAN

Satu kajian pemerosesan haba kepada jus tomato telah dijalankan dengan menggunakan kaedah kukusan air panas paras air rendah (PAR) berbanding dengan kukusan paras air tinggi (PAT) yang lazim disarankan. Kukusan PAR mengandungi satu-perlima dari yang disarankan untuk kukusan PAT. Hasil kajian ini menunjukkan bahawa suhu jus adalah sama bagi kedua-dua kaedah. Walaubagaimana pun, penggunaan kukusan PAT memakan masa selama 59 minit dan kuasa letrik sebanyak 1838 watt-jam bagi memanaskan kukusan dan memproses jus yang disi panas (92°C) untuk selama 15 minit. Sebaliknya pula, hanya 34 minit dan 1065 watt-jam kuasa letrik diperlukan apabila kukusan PAR digunakan.

SUMMARY

A study on the heat processing of tomato juice was conducted using a low water level (LWL) hot water bath in comparison to the conventional recommended high water level (HWL) bath procedure. The LWL bath contained one-fifth the amount of water recommended for the HWL bath. The results indicated that the temperatures of the juice during processing were similar in both procedures. However, use of the HWL bath required 59 minutes and 1838 watt-hours of electricity to heat the bath and process hot packed (92°C) juice for 15 minutes. In contrast, only 34 minutes and 1065 watt-hours of electricity were required when the LWL bath was used.

INTRODUCTION

In many parts of the developed world, there is a growing trend towards home canning of acid foods (Anon 1977; Harris *et al.* 1976; Zottola *et al.* 1978). This widespread practice is partially due to the belief that such foods are cheaper than commercial canned foods, but the cost of materials and heat processing can be expensive (Carey, 1978). Pressure cookers are recommended for the canning of low-acid foods with pH$\geqslant$ 4.5, e.g. vegetables, meat, poultry, fish, while water bath canners are recommended for the canning of acid foods with pH $<$ 4.5, e.g. fruits, tomatoes, jellies, pickles (Ball Corp., 1972; Henderson, 1977; Kerr, 1974; USADA, 1978). The choice of processing vessel is dictated by the type of food being processed, but the most apparent option available to control costs is the judicious application of heat in processing the canned product.

Recommendations for home canning specify that the hot water in the bath should cover the jars by 2.54 to 10.16 cm (Ball Corp., 1972; Kerr, 1974; USDA, 1978), yet reducing the volume of water could lower the cost for heating. Harris and Davis (1976) reported that bottled tomato juice processed in a covered water bath to a depth of 6.35 cm of water heated as rapidly as jars covered by 2.54 cm of hot water. They based the study on data for thermodynamic properties of water and steam which indicate that a product in a closed vessel will heat as well with a low level of boiling water as with a high level (Solbery and Brown, 1950).

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The present work was initiated to determine the effectiveness of using a low water level in the home canning of tomato juice.

MATERIALS AND METHODS

Tomato juice, pH 4.08, purchased from a grocery store was used for temperature measurements. The juice, contained in standard canning jars of 0.95L capacity, was processed in an 11.5L capacity Mason water bath canner.

Copper-constantan thermocouples were used to monitor temperatures. One thermocouple was placed 4 cm from the bottom of the canner to record the temperature of the water. Two thermocouples were placed 5 cm below the rim of the canner to record the temperature of the water or steam, depending on the depth of water used. The temperature of the juice was monitored by a thermocouple inserted through a hole in the jar lid and extended to the cold spot approximately 2 cm from the bottom of the jar. Thermocouple leads were placed between the lid and the rim of the canner and extended to a Kaye Instrument (System 8000) temperature recorder and temperatures measured at one minute intervals.

The juice was initially heated in a steam-jacketed kettle to approximately 95°C, filled hot into the jars to a headspace of 1.25 cm and closed with a two-piece closure (band and lid containing a thermocouple).

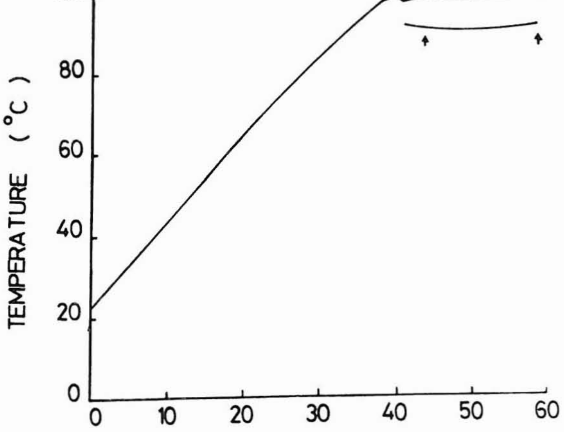

Fig. 1. Temperature profile of water bath and tomato juice in conventional HWL bath. **A** *indicates temperature decrease when jars were added. ↑↑ indicates the period during which the temperature of the juice was recorded.*

The juice was processed in a water bath in which two different levels of water were used. The high water level (HWL) bath contained 10 kg of water to a level 3.8 cm from the top of the jars. The low water level (LWL) bath was filled with 2 kg water to a depth of 5.1 cm from the bottom of the canner with the jars in place. The bath was heated by an electric coil plate, and the amount of electricity consumed recorded with a watt-hour meter.

For each process, seven jars were placed in the water bath containing boiling water, the lid placed onto the canning vessel, the water allowed to return to the boil, and the processing time of the juice (15 min.) recorded from this point. Each process was replicated three times.

RESULTS AND DISCUSSION

Figures 1 and 2 show heating curves for tomato juice heated in the HWL and LWL baths respectively. The water in the HWL bath required heating for 40 min before boiling commenced (Fig. 1). However, for the LWL bath, the water began boiling after only 14 min of heating (Fig. 2). During this period of heating, the tempe-

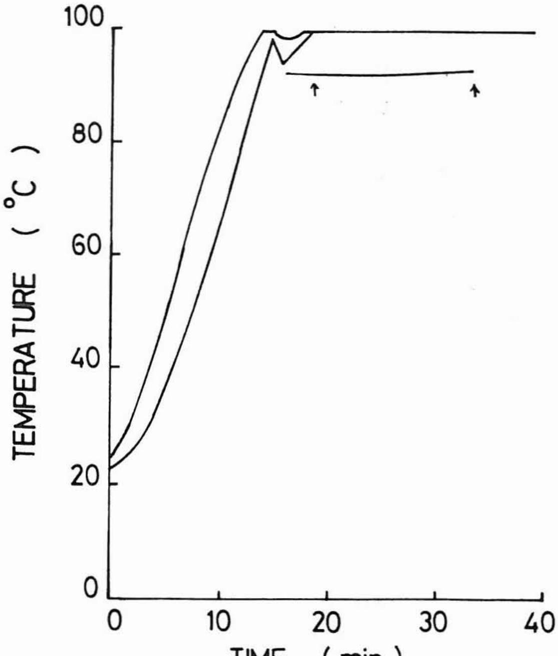

Fig. 2. Temperature profile of water bath and tomato juice in LWL bath. **A** *and* **E** *indicate temperature decrease of water and steam, respectively, when jars were added. ↑↑ indicate period during which the temperature of the juice was recorded.*

TABLE 1

Amount of time and electricity used to heat the water bath and process seven jars of tomato juice for 15 minutes.

Filling Temperature (°C)[a]	Water bath [b]	Time (mins.)[c]	Electricity (Watt-hours)[a]
92.3	HWL	59	1838
92.1	LWL	34	1065

[a] Each value is a mean of 21 observations

[b] HWL = water 3.8 cm above top of jars; LWL = 5.1 cm from bottom of canner.

[c] Each value is a mean of 3 measurements.

rature of the air space above the water in the LWL bath was lower than that of the water, while the maximum temperature of the steam was observed 1 min after the water began to boil. The temperatures of the water and steam decreased when the lid was removed from the canner and jars of products were added to the bath (points A and E, Fig. 2). After the lid was replaced and the water and steam had reached their maximum temperatures, the temperature of the water was 99.6°C and of the steam 99.2°C. The lower temperature of the steam was presumably due to the condensation of water onto the thermocouple. In both procedures, the temperature of the juice remained essentially the same, i.e. 92°C, during processing. Thus from the stand-point of temperature, the LWL bath was as effective for heating the juice as was the HWL bath. For the HWL bath, 59 minutes were required to heat the bath including 15 min to process the juice (Fig. 1, Table 1), while the LWL bath took only 34 minutes to process the juice for the same time (Fig. 2, Table 1), a saving in heating time of 42%.

The consumption of electricity to heat the bath and to process the juice was dependent upon the process used (Table 1). Heating the water of the HWL bath and processing the jars of juice required 1838 watt-hours of electricity, while 1063 watt-hour hours of electricity, or a 42% reduction, were used for the HWL bath. Thus it is clear that the LWL process described conserves energy and, accordingly, lowers costs in the home-canning of acid food products, without reducing the safety and effectiveness of such processes.

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