Optimization of Scraped Surface Heat Exchanger Process Parameters for Manufacture of Bottle Gourd Halwa

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ABSTRACT

The present investigation has been aimed to study the effect of various process parameters of scraped surface heat exchanger (SSHE) on the sensory characteristics of fresh bottle gourd halwa. The horizontal SSHE designed and fabricated at the Institute was used to manufacture bottle gourd halwa. The freshly prepared bottle gourd halwa samples were analyzed for their sensory characteristics prepared at different scraper speed (R1, R2, R3 at 20, 30 and 40 rpm respectively), and operating steam pressure (G1, G2, G3 at 0.75, 1.0 and 1.5 kg/cm² respectively) for varying batch size (B1, B2, B3 of 2, 3 and 4 kg respectively). A uniform quality product with respect to flavor, body and texture, color and appearance, and overall acceptability (sensory scoring) was obtained employing the combination of treatments G2B3S2 among the rest of combinations. Cost analysis of bottle gourd halwa prepared in SSHE under operating condition G2B3S2 was computed at ₹ 150.35; the raw materials cost and operating cost was ₹ 116.82 and ₹ 33.53, respectively.

Keywords: Bottle gourd halwa, Cost analysis, Mechanized production, Sensory analysis.

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INTRODUCTION

The milk revolution in India reveals an exceptional success story, as reflected by maintaining the first position in milk production since 1998. The milk production of India in the year 2015–2016 had reached 155.5 million tons, the estimated demand for milk is likely to be around 200 million tons in the year 2021–2022 (Anonymous, 2017). Milk utilization pattern reveals that indigenous dairy products are India’s largest selling and most profitable segment, accounting for 50–55 percent of milk produced in the country is diverted for preparation of indigenous milk products (Modha et al., 2015), while only 5–6 percent of total milk produced in India is used to manufacture western dairy products such as ice cream, butter, cheese, powder, etc., (Pal and Raju, 2010).

The mechanized production of traditional dairy products presents a unique opportunity to the organized dairy sector in India, and even many minuscule scale dairy entrepreneurs are intrigued to adopt mechanization in the manufacture of several traditional dairy products to get uniform and good quality products. Thus, expanding traditional Indian dairy products business through mechanization for large scale production will enable the dairy plant to be more economically viable due to higher profitability and export potential. Bottle gourd halwa prepared by traditional method is unhygienic, non-uniform in quality, has low keeping quality and involves intensive labor as well as energy. Consequently, there is an increase in the cost of production for such dairy product.

SSHE is most suitable for handling viscous products, with or without particulates; even products that tend to foul the heat transfer surfaces (Punjrath et al., 1990; Rajorhia et al., 1991; Dodeja, 2006). Since there is tremendous potential in manufacturing traditional dairy products, several attempts have been made to design SSHE suiting such technological interventions.

Therefore, the present study was conducted to study the sensory acceptability of the product made through mechanized processing.

MATERIALS AND METHODS

The work was carried out at Department of Dairy Engineering of Sheth M.C. College of Dairy Science, Anand Agricultural University (AAU), Anand, Gujarat.

Raw Materials

“SAGAR” brand skim milk powder manufactured by AmulFed Dairy, Gandhinagar was procured from the local market of Anand, Gujarat. Fresh ghee was procured from...
the Department of Dairy Processing Operations (Anubhav Dairy), Sheth M.C. College of Dairy Science, AAU, Anand. Crystalline sugar (sucrose) of the commercial grade was obtained from the local market of Anand, Gujarat. Good quality green cardamom and apple green color (Make: Bush) of food grade quality were obtained from the local market of Anand, Gujarat.

Scraped Surface Heat Exchanger
The horizontal SSHE having effective heat transfer area of 0.24017 m² designed and fabricated at AAU, Anand was used for the manufacture of bottle gourd halwa. The SSHE comprised of (i) product tube (ii) spring loaded scraper assembly (iii) drive arrangement for the scraper assembly, and (iv) measuring and control instruments. The SSHE was mounted on a stainless steel frame structure and was connected with electricity supply and LPG for the supply of thermal energy.

Product Tube
The product tube was fabricated from 0.006 m thick AISI 304 grade S.S. plate. The product tube has a bore of 0.3 m and a length of 0.5 m. The lower half of the product tube is provided with a water jacket. The total volume of the water jacket is 29.24 liters in which water was filled only up to 18.50 liters. The unjacketed area of product tube on the top consisted of 140 holes each of 0.012 m diameter for the vapor to escape. A feed hopper is provided on the top of the product tube towards the drive side of the machine. The product tube is provided with a hinged door fabricated from 0.01 m thick AISI 304 grade S.S. plate. Food grade gasket of thickness 0.003 m was fixed on the flange of the product tube to prevent any leakage of the product.

Rotor-scraper Assembly
The scraper assembly of the SSHE consists of a solid S.S. shaft of 0.025 m diameter on which supports for holding the blades were welded. The four scraper blades were fixed on these supports with S.S. springs to provide necessary contact pressure for effective scraping of the product during operation of the SSHE. The spring tension kept the scraper blades in contact with the inner heat transfer surface of SSHE. The scraper assembly could be easily dismantled for cleaning. The Samby type rotor-scraper assembly produced wiping action during the rotation. The scraper blades were made up of 0.002 m thick SS plate which was provided with replaceable Teflon strip having 0.275 m length and 0.01 m thickness.

Drive for Scrapper Assembly
An A.C. motor (1 HP, 3-phase, 415 volt, 1440 rpm) was used to drive the assembly through a worm gearbox having a speed reduction ratio of 36:1. The power is transmitted from motor drive to scraper assembly through the gearbox. The shaft, which drives the scraper assembly was supported on two pedestal ball bearings on the frame. A shaft seal is provided in SSHE to allow the insertion and rotation of the shaft for leak proof operation. The seal has a teflongland of food grade, which could withstand higher thermal (up to 290°C) and mechanical stresses that are likely to be encountered during actual operation.

Measuring and Control Instruments
The VFD (Make: Amtech Electronics Ltd., India; Model: THYFREC VT1305, Capacity: 2 HP) was used to regulate the speed of the motor which in turn controlled the speed of scraper assembly during experimental trials. Digital power analyzer (MICO, 3-Phase, 440-Volt) was used to measure the input power for motor drive.

Preparation of Bottle Gourd Halwa
Bottle gourd halwa was prepared according to the method reported by Velpulaet al. (2018). The flow diagram for the manufacture of bottle gourd halwa in the SSHE is depicted in Flowchart 1. Initially, LPG fuel supply for gas burner was started to build up steam pressure in the water jacket of the SSHE. When it reached the operating pressure (G1, G2, G3 of 0.75, 1.0 and 1.5 kg/cm² respectively), ghee @ 7.0 percent (w/w) of shredded bottle gourd mass was taken in a clean and dry SSHE and scraper assembly was started. On heating, the ghee shredded bottle gourd was poured in the SSHE through feed hopper. As heating continued, cooking of shredded bottle gourd took place. The cooking of shredded bottle gourd was detected by judging the softness after intermittent stopping of the machine. After 30–40 minutes when shredded bottle gourd was cooked properly in the aspect of softness, sugar @ 30.0 percent (w/w) of shredded material was added to the machine. After 5–6 min, 50.0 percent TS reconstituted skim milk (SMP @ 20.0 percent w/w of shredded material) was placed in the machine. The process of evaporation and concentration continued during this operation until it reached ‘lump formation’ stage which is considered to be the end of the operation. Finally permitted food grade apple green color was added at this stage to impart light green appearance to the product. Then LPG supply was put off, and the product was removed from the SSHE and transferred to previously greased (with ghee) stainless steel plates. Cardamom powder @ 0.02 (w/w) percent of shredded material was added before spreading the bottle gourd halwa evenly in the plate. The product was allowed to set for 4–5 hours before sensory evaluation. The experimental trials were taken by varying the batch size, steam pressure, and scraper blade speed. The quantity of sugar reconstituted skim milk, and ghee varied depending on the batch size of the product.

Treatment Details
In manufacturing of bottle gourd halwa, the performance of horizontal SSHE was evaluated at different scrapper speed (R1, R2, R3 at 20, 30 and 40 rpm, respectively), different operating steam pressure (G1, G2, G3 at 0.75, 1.0 and 1.5 kg/cm² respectively) and different batch size (B1, B2, B3 at 2,3 and 4 kg loading, respectively).
Sensory evaluation of bottle gourd halwa was carried out by a panel of eight judges selected from the Faculty of Dairy Science, Anand using “9 points Hedonic scale” (Gupta, 1976). The selection criterion was that subjects had to be regular consumers of typical dairy sweets as well as their similar behavior between sensory evaluation sessions.

Experimental Design and Analysis
Based on preliminary trials, the range of variables were selected. The experiment was replicated thrice, and the data were subjected to statistical analysis using factorial completely randomized design as per Steel and Torrie (1980). The significance was determined based on critical difference.

RESULTS AND DISCUSSION
The preparation of bottle gourd halwa mainly involved two stages viz., (i) cooking of bottle gourd shreds in ghee and (ii) evaporation of water from the mass comprising of bottle gourd shreds, sugar and reconstituted skim milk (50% TS) to achieve the desired consistency of the product. The preparation of bottle gourd halwa having uniform quality and having desired sensory quality is requisite for the successful development of any mechanized process. The time required for preparation of bottle gourd halwa in the SSHE ranged from 22.50 to 64.50 min depending on batch size, operating steam pressure and scraper speed. It can be seen that there was a decrease in the period for preparation of bottle gourd halwa in the SSHE with an increase of steam pressure and scraper speed for particular batch size.

Effect of Operating Conditions of SSHE on the Flavor Scores of Bottle Gourd Halwa
The average flavor scores of bottle gourd halwa manufactured in SSHE under operating conditions are given in Table 1. The mean values of flavor scores were in the range of 8.05–8.26.
The statistical analysis revealed that the varying operating conditions used during its preparation did not affect the flavor scores of bottle gourd halwa significantly.

The combination of treatments G2B3S2 led to the production of bottle gourd halwa having the highest flavor score (i.e., 8.26) as compared to remaining all treatments. Higher flavor scores at the treatment of G2B3S2 of bottle gourd halwa prepared in SSHE may be due to better control over heating and scrapping mechanism. The combination of treatments employing high steam pressure (G3 at 1.5 kg/cm\(^2\)) along with lower batch size (B1 at 2 kg) and scraper speed (R1 at 20 rpm) led to the burning problem, which resulted in a product having lower flavor scores.

Effect of Operating Conditions of SSHE on the Body and Texture Scores of Bottle Gourd Halwa

The body and texture scores of bottle gourd halwa prepared in SSHE under operating conditions are depicted in Table 2. It is evident from Table 2 that body and texture scores of bottle gourd halwa samples were significantly (p ≤ 0.05) affected by the scraper speed of SSHE. Use of treatment combination G2B3S2 resulted in halwa possessing the highest score for body and texture. It can also be noticed that lower batch size (B1 at 2 kg) with high scraper speed (R3 of 40 rpm), irrespective of the steam pressures used resulted in inferior body and texture score of the product. The use of higher scraper speed during mechanized preparation of bottle gourd halwa in SSHE might have resulted in the pasty bodied product. As the literature pertaining to mechanized manufacture of bottle gourd halwa in SSHE is scanty, wherever possible the results have been compared with other sweetmeats or dairy-based delicacies. Dodeja and Deep (2012) also reported that an increase in the scraper speed in 3-stage SSHE led to an inferior score for body and texture score of danedar khoa.

Effect of Operating Conditions of SSHE on the Color and Appearance Scores of Bottle Gourd Halwa

The mean scores for color and appearance of bottle gourd halwa prepared using different operating conditions in SSHE are presented in Table 3. It was revealed that steam pressure had a significant (p ≤ 0.05) effect on color and appearance scores of bottle gourd halwa. Operating the SSHE at high steam pressure (G3 at 1.5 kg/cm\(^2\)) led to brown discoloration in the final product. Few judges indicated the presence of brownish particles in the product, especially when prepared at the low batch size (B1 at 2 kg) and high steam pressure (G3 at 1.5 kg/cm\(^2\)) conditions. It was observed that combination treatment G2B3S2 resulted in the highest score for color and appearance among the rest of the operating conditions.

Effect of Operating Conditions of SSHE on the Overall Acceptability Scores of Bottle Gourd Halwa

The overall acceptability scores of bottle gourd halwa prepared in SSHE under operating conditions are shown in
Table 2: Body and texture scores of bottle gourd halwa prepared in SSHE under varying operating conditions

| Steam pressure G (kg/cm²) | Batch Size B (kg) | Scraper speed R (rpm) | Average | Average |
|---------------------------|-------------------|-----------------------|---------|---------|
|                           |                   | R1 (20)               | R2 (30) | R3 (40) |
| G1 (0.75)                 | B1 (2)            | 8.25 ± 0.27           | 8.31 ± 0.20 | 8.10 ± 0.30 | 8.22 | 8.25 |
|                           | B2(3)             | 8.27 ± 0.25           | 8.36 ± 0.24 | 8.13 ± 0.32 | 8.25 |
|                           | B3 (4)            | 8.30 ± 0.23           | 8.37 ± 0.27 | 8.18 ± 0.16 | 8.28 |
| G2 (1.0)                  | B1 (2)            | 8.32 ± 0.25           | 8.40 ± 0.24 | 8.24 ± 0.26 | 8.32 | 8.36 |
|                           | B2(3)             | 8.35 ± 0.27           | 8.43 ± 0.22 | 8.28 ± 0.27 | 8.35 |
|                           | B3 (4)            | 8.40 ± 0.26           | 8.45 ± 0.22 | 8.31 ± 0.25 | 8.39 |
| G3 (1.5)                  | B1 (2)            | 8.29 ± 0.27           | 8.33 ± 0.22 | 8.17 ± 0.19 | 8.26 | 8.30 |
|                           | B2(3)             | 8.31 ± 0.25           | 8.38 ± 0.20 | 8.19 ± 0.21 | 8.29 |
|                           | B3 (4)            | 8.34 ± 0.17           | 8.41 ± 0.19 | 8.22 ± 0.24 | 8.32 |
| Average (R)               |                   | 8.20                  | 8.23 |

CV %

| Source | SEM ± | CD (p ≤0.05) |
|--------|-------|--------------|
| G      | 0.05  | NS           |
| B      | 0.05  | NS           |
| G × B  | 0.08  | NS           |
| R      | 0.04  | 0.13         |
| G × R  | 0.08  | NS           |
| B × R  | 0.08  | NS           |
| G × B × R | 0.14 | NS         |

Each observation is a mean ± SD of three replicate experiments (n = 3); NS=Non significant at 5% level of significance

Table 3: Colour and appearance scores of bottle gourd halwa prepared in SSHE under varying operating conditions

| Steam pressure G (kg/cm²) | Batch Size B (kg) | Scraper speed R (rpm) | Average | Average |
|---------------------------|-------------------|-----------------------|---------|---------|
|                           |                   | R1 (20)               | R2 (30) | R3 (40) |
| G1 (0.75)                 | B1 (2)            | 8.20 ± 0.22           | 8.24 ± 0.17 | 8.26 ± 0.20 | 8.23 | 8.27 |
|                           | B2(3)             | 8.22 ± 0.19           | 8.27 ± 0.21 | 8.29 ± 0.18 | 8.26 |
|                           | B3 (4)            | 8.28 ± 0.20           | 8.31 ± 0.25 | 8.33 ± 0.22 | 8.31 |
| G2 (1.0)                  | B1 (2)            | 8.27 ± 0.19           | 8.30 ± 0.15 | 8.23 ± 0.17 | 8.27 | 8.30 |
|                           | B2(3)             | 8.30 ± 0.15           | 8.34 ± 0.23 | 8.25 ± 0.17 | 8.30 |
|                           | B3 (4)            | 8.32 ± 0.21           | 8.37 ± 0.19 | 8.28 ± 0.27 | 8.32 |
| G3 (1.5)                  | B1 (2)            | 8.08 ± 0.16           | 8.12 ± 0.18 | 8.15 ± 0.26 | 8.12 | 8.16 |
|                           | B2(3)             | 8.10 ± 0.17           | 8.16 ± 0.16 | 8.19 ± 0.21 | 8.15 |
|                           | B3 (4)            | 8.14 ± 0.21           | 8.20 ± 0.22 | 8.24 ± 0.17 | 8.19 |
| Average (R)               |                   | 8.21                  | 8.26 |

CV %

| Source | SEM ± | CD (p ≤0.05) |
|--------|-------|--------------|
| G      | 0.04  | 0.11         |
| B      | 0.04  | NS           |
| G × B  | 0.07  | NS           |
| R      | 0.04  | NS           |
| G × R  | 0.07  | NS           |
| B × R  | 0.07  | NS           |
| G × B × R | 0.12 | NS         |

Each observation is a mean ± SD of three replicate experiments (n = 3); NS=Non significant at 5% level of significance
Table 4: Overall acceptability scores of bottle gourd halwa prepared in SSHE under varying operating conditions

| Steam pressure G (kg/cm²) | Batch Size B (kg) | R1 (20) | R2 (30) | R3 (40) | B | G |
|--------------------------|------------------|---------|---------|---------|----|----|
| G1 (0.75)                | B1 (2)           | 8.23 ± 0.20 | 8.28 ± 0.17 | 8.14 ± 0.21 | 8.22 | 8.25 |
|                          | B2 (3)           | 8.27 ± 0.19 | 8.33 ± 0.15 | 8.11 ± 0.18 | 8.24 |    |
|                          | B3 (4)           | 8.30 ± 0.15 | 8.37 ± 0.20 | 8.17 ± 0.19 | 8.28 |    |
| G2 (1.0)                 | B1 (2)           | 8.27 ± 0.19 | 8.30 ± 0.19 | 8.18 ± 0.20 | 8.25 | 8.30 |
|                          | B2 (3)           | 8.31 ± 0.21 | 8.37 ± 0.19 | 8.21 ± 0.24 | 8.30 |    |
|                          | B3 (4)           | 8.36 ± 0.18 | 8.40 ± 0.22 | 8.25 ± 0.22 | 8.34 |    |
| G3 (1.5)                 | B1 (2)           | 8.10 ± 0.18 | 8.19 ± 0.22 | 8.03 ± 0.23 | 8.12 | 8.16 |
|                          | B2 (3)           | 8.14 ± 0.19 | 8.22 ± 0.17 | 8.08 ± 0.20 | 8.17 |    |
|                          | B3 (4)           | 8.16 ± 0.20 | 8.25 ± 0.19 | 8.11 ± 0.20 | 8.19 |    |
| Average (R)              |                 | 8.24 | 8.31 | 8.15 |    |    |

Source SEm ± CD (P≤0.05) CV %
G 0.04 0.11 2.39
B 0.04 NS
G×B 0.07 NS
R 0.04 0.11
G×R 0.07 NS
B×R 0.07 NS
G×B×R 0.11 NS

Each observation is a mean ± SD of three replicate experiments (n = 3); NS=Non significant at 5% level of significance.

It can be noticed that the overall acceptability scores of bottle gourd halwa were significantly (p≤ 0.05) affected by the variables such as steam pressure and scraper speed related to SSHE. However, batch size variation had not shown any significant difference on overall acceptability of the final product. Similar findings obtained in the finished products were similar to those reported by Patel et al. (2006).

It was observed that the treatment combination G2B3S2 led to the product having the highest overall acceptability score of 8.40. Based on the above findings, the optimum conditions for preparation of bottle gourd halwa in the SSHE were utilizing 4 kg batch size, steam pressure of 1.0 kg/cm², and scraper speed of 30 rpm.

Cost Analysis of Bottle Gourd Halwa Prepared in SSHE

Cost analysis of the bottle gourd halwa prepared in SSHE is shown in Table 5. The cost analysis was based on the optimum operating conditions (G2B3S2) of SSHE arrived at in the study. The cost analysis was based on 365 days of working in a year, 8 hours of the working/day and six batches of the product prepared per day.

Thus, cost of bottle gourd halwa/kg = 601.42/4 = ₹ 150.35
Raw materials cost/kg product = 467.30/4 = ₹ 116.82
Processing cost/kg product = 134.12/4 = ₹ 33.53

Conclusion

The steam pressure used during operation of SSHE had a significant (p≤ 0.05) influence on the color and appearance of the bottle gourd halwa; the scraper speed of SSHE markedly influenced the body and texture of the product. The overall acceptability of the bottle gourd halwa was markedly influenced by both steam pressure and scraper speed during operation of SSHE. The optimum operating conditions for preparation of bottle gourd halwa in the SSHE were employing steam pressure of 1.0 kg/cm² and scraper speed of 30 rpm when loading with 4 kg batch size. The estimated cost of bottle gourd halwa prepared in a mechanized manner adopting the optimum operating conditions was ₹ 150.35. The raw materials cost and the operating cost was to the tune of 77.7 percent and 22.3 percent of the total cost, respectively.

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Table 5: Cost of mechanized production of bottle gourd halwa in SSHE

| Sr. No. | Material                        | Rate (Rs.) | Quantity | Total cost ( ) |
|---------|---------------------------------|------------|----------|----------------|
| 1.      | Cost of SMP                     | 265/kg     | 0.80 kg  | 212.00         |
| 2.      | Cost of bottle gourd            | 15/kg      | 4.50 kg  | 67.50          |
| 3.      | Cost of sugar                   | 42/kg      | 1.20 kg  | 50.40          |
| 4.      | Cost of ghee                    | 480/kg     | 0.28 kg  | 134.40         |
| 5.      | Cost of additives               | –          | –        | 3.00           |

Total materials cost (A) 467.30

Operating cost (₹)

| Sr. No. | Material                          | Rate (Rs./quantity) | Quantity | Total cost ( ) |
|---------|-----------------------------------|---------------------|----------|----------------|
| 6.      | Thermal energy (LPG fuel)         | 43.27/kg            | 0.30 kg  | 12.98          |
| 7.      | Electrical energy                 | 7.0/kWh             | 0.257 kWh| 1.79           |
| 8.      | Labour cost                       | Rs. 310/person/day  | 2 persons| 103.33         |
| 9.      | Interest on the cost of the SSHE  | 12% equipment cost  | –        | 6.38           |
|         | (Cost of equipment: 11,5,000)     |                     |          |                |
| 10.     | Depreciation                      | 10% equipment cost  | –        | 5.32           |
| 11.     | Repair and Maintenance            | 5% equipment cost   | –        | 2.66           |
| 12.     | Cleaning chemicals                | –                   | –        | 1.66           |

Total operating cost (B) 134.12

Total cost (A+B) 601.42

References
Anonymous (2017), www.nddb.org/information/stats/milkprodindia. Cited on August 11, 2017.

Dodeja, A.K. and Deep, A. (2012). Mechanized manufacture of danedarkhoa using three stage SSHE. Indian Journal of Dairy Science, 65(4): 274-284.

Dodeja, A.K. (2006). Mechanization in khoa making. In Development in traditional dairy products. Lecture compendium of Centre of Advanced Studies course held at National Dairy Research Institute, Karnal, December, 10-30, 2006. pp.171-176.

Gupta, S.A. (1976). Sensory evaluation in food industry. Indian Dairyman.28(8):293-295.

Modha, H.M., Patel, N.M., Patel, H.G., Patel, K.N. (2015). Process standardization for the manufacture of thabdipeda. Journal of Food Science and Technology, 52(6):3283-3290.

Pal, D. And Raju, PN. (2010). Traditional Indian dairy products with functional attributes: status and scope. Indian Food Industry, 29(1):13-21.

Punjrath, J.S., Veeranjanyalu, B., Mathunni, M.L., Samal, S.K., Aneja, R.P. (1990). Inclined scraped surface heat exchanger for continuous khoa-making. Indian J. Dairy Sci., 43(2): 225-230.

Rajorhia, G.S., Pal, D., Garg, F.C., Patel, R.S. (1991). Evaluation of the quality of khoa prepared from different mechanized systems. Indian Journal of Dairy Science, 44(2):181-187.

Steel, G.D. and Torrie, J.H. (1980). Principles and procedures of statistics-A biometrical approach (2nd ed.). McGraw Hill, New York. pp. 137-167.

Velpula, S., Bhadania, A.G., Pinto, S.V., Aravind, T., Umapathy, K.S. (2018). Sensory and chemical quality changes during storage of bottle gourd halwa. International Journal of Current Microbiology and Applied Sciences, 7(2):3302-3310.

Patel, J.S., Bhadania, A.G. Boghra, V.R. (2006). Chemical composition and sensory evaluation of sandesh manufactured in scraped surface heat exchanger (SSHE). Asian Journal of Dairy and Food Research, 25(1):28-33.