# Performance Evaluation of an Automated Traveling Baking and Roasting Oven.

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## ABSTRACT

The performance evaluation of an automated traveling baking and roasting oven is presented. The oven consists of a 300mm x 300mm traveling tray, a 4500mm chain, and a 17 teeth sprocket to drive the chain. Heating is provided by two 30-Watt heaters installed in a baking/roasting area of 0.18m$^2$. Two delay timers are installed to control the movement of the tray and the heating chamber while a thermostat regulates the heaters temperatures. A 70g meat pie sample was baked at 200$^o$C, 250$^o$C, and 300$^o$C oven temperatures for 40 minutes. The meat pie sample was inspected every 5 minutes interval to determine the time for the bread roll to be fully baked. The result of the inspection tests carried out on the samples showed that it took the 15 minutes for a 70g meat pie sample to be baked. It also revealed that the best baking temperature is 250$^o$C.

(Keywords: baking, food, heating chamber, oven, mobile cooking technology)

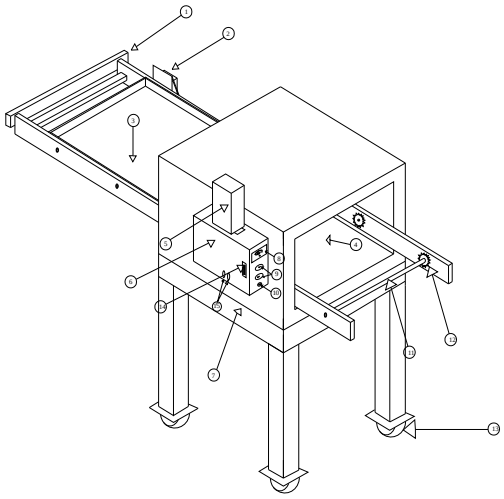
## INTRODUCTION

Long before recorded history, early man obtained his food by hunting wild game animals, fishing, and collecting edible seeds and roots of plants. With advancements in technology, man has also advanced his methods of gathering and processing his foods [1], [2]. While some foods are eaten raw, others need to be processed. Processing of food involves a series of activities embarked upon to ensure the conversion of food from its raw state to a form that is edible and more appealing for human consumption [3]. Food processing methods include cooking (boiling), frying, roasting, baking, etc. These methods involve the application of heat from different sources such as burning wood, coal, gas cooker, electric cooker [4]. A clean environment is needed for food processing so as to encourage production of hygienic food, prevent food contamination, and food poisoning.

Among the food processing methods, baking has gained wide application for the processing of fast foods like bread, sauces, cakes, pies, etc. Baking is a method of cooking by heat in an enclosed space. The enclosed air is heated to a required temperature and the hot air cooks the food [4]. An oven is used to cook by dry heat at temperature between 100$^o$C and 200$^o$C, usually in an enclosure. Common types of oven include anthill oven, kerosene-tin oven, cupboard oven, electric oven, gas oven [1], [4].

In an electric oven, heating elements are installed at the sides of the oven and a thermostat controls the temperature [1]. The mode of heat transfer is mainly by radiation from the heaters and partly by convection of hot air trapped within the oven compartment. The radiant heat is absorbed in a very thin surface layer of solid foods, whose interior then heats slowly by conduction [5]. Advantages of baking/roasting in an oven include development of a good flavor in food, saving of time and energy because more foods can be cooked at a time, food contamination and poisoning is minimized [6]. Modern ovens are often made with some added conveniences and safety measures. Chief among these are food-probe temperature control, programmable time-temperature schedules, etc. [1], [2].

The automated traveling baking/roasting oven for baking was evaluated. The isometric view of the oven is as shown in Figure 1. The major parts of the oven include electric motor, transformer, heating chamber, 300mm by 300mm tray, tray rack, sprocket (17T), 4500mm chain, switch, timer



| ITEM NO | PART NAME |
|---|---|
| 15 | TIMER INDICATOR |
| 14 | ELECTRICAL/CONTROL PANEL CASING |
| 13 | TYRE |
| 12 | SPROCKET |
| 11 | SHAFT |
| 10 | SWITCH |
| 9 | THERMOSTAT/SEMESTA |
| 8 | TEMPEARTURE CONTROLLER |
| 7 | CARRIER |
| 6 | ELECTRICAL/CONTROL PANEL CASING |
| 5 | TRANSFORMER |
| 4 | HEATING CHAMBER |
| 3 | TRAY |
| 2 | ELECTRIC MOTOR |
| 1 | TRAY RACK |

Fig.1: An automated travelling baking/roasting oven.

THE ISOMETRIC VIEW OF AUTOMATED TRAVELLING BAKING/ROASTING OVEN

indicator, thermostat etc. The oven is also fixed with four tires for easy mobility.

There are two thermostats; one to control the upper heater while the other controls the lower heater. The thermostats ensure that the processing is done within a specified temperature. Since the oven is automated, there are two timers to be set (i.e., tray timer and the oven timer). The tray timer is the time (seconds) for the tray to transport the tray to the heating chamber while the oven timer controls the time (in minute) for the oven to fully process the product [2].

## MATERIALS AND METHODS.

The first action is to set the two timers. The tray timer is set for 5 seconds, (i.e., it will take 5 seconds for the tray to get to the heating chamber and another 5 seconds for the tray to fully withdraw from the heating chamber after the product has been fully processed). Then the oven is connected to source of electric supply. The two heaters are switched on to preheat the heating chamber and raise the temperature above that of the environment. The preheating temperature is set to $50^{o}$C.

To evaluate this automated traveling oven, it was used to bake meat pies. A total of 8 pieces of meat pie of a mass 70g each were prepared with flour and other ingredients according to procedures prescribed by Obiageli et al. [6] for baking in a batch.

The two delay timers were thereafter set. The thermostats were set to $200^{o}$C, the tray timer set to 5 seconds, while the heating chamber timer set to 5 minutes.

The meat pie sample was placed on the tray and the oven was switched on. After the set time of 5 minutes, a feedback signal was sent to switch off the heating chamber heaters and the tray was triggered to withdraw the meat pie sample from the heating chamber. The mass of the meat pie sample was measured and recorded.

The same procedure was repeated for heating chamber timer of 10, 15, 20, 25, 30, 35, and 40 minutes, all at a temperature of $200^{o}$C.

The entire processes was also repeated at the oven temperatures of $250^{o}$C and $300^{o}$C, in turn. The results of the experiments were thereafter tabulated.

## RESULTS AND DISCUSSION

The mass of the meat pie at various time under varying oven temperatures are as shown in Table 1. Starting with an initial mass of 70g, it was observed that the mass of the sample reduces with an increase in oven temperature from 200°C to 300°C. The mass also reduces as the time the sample spent in the oven increases.

For example, at the baking time of 5 minutes, the mass of the samples were 68.8g, 64g, and 63g at the baking temperature of 200°C, 250°C, and 300°C, respectively, while the mass has reduced to 55g, 50.6g, and 49.5g, respectively, at the same baking temperatures. This agrees with the work of Ogunleye and Awogbemi [7] that the mass of a sample decreases as the temperature and time increases.

Figure 2 further shows that the baking was most effective at the baking temperature of 300°C and least effective at the baking temperature of 200°C as reflected by the mass of the meat pie sample at these temperatures at equal interval of time.

The free moisture in the various meat pie sample decreases as both the baking time and temperature increases as shown in Table 2 and Figure. 3. This implies that baking as a form of drying is another method of removing moisture from a sample and can be said to be synonymous with drying. Both Table 3 and Figure 4 revealed that the drying rate increased with increase in baking time and temperature, that is, the sample dry faster with increase in temperature.

**Table 1:** Mass of Meat Pie Samples ($M_r$) at Various Baking Times and Temperatures.

| Baking Time, t (mins) | Free Moisture Content, $M_f$ | | |
|---|---|---|---|
| | 200°C | 250°C | 300°C |
| 0 | 0.5 | 0.5 | 0.5 |
| 5 | 0.304951 | 0.354388 | 0.445669 |
| 10 | 0.237734 | 0.236192 | 0.248787 |
| 15 | 0.185333 | 0.157416 | 0.138792 |
| 20 | 0.144482 | 0.104914 | 0.077453 |
| 25 | 0.112635 | 0.069923 | 0.043223 |
| 30 | 0.087808 | 0.046602 | 0.024121 |
| 35 | 0.068453 | 0.031059 | 0.013461 |
| 40 | 0.053365 | 0.0207 | 0.007512 |

**Table 2:** Free Moisture Content of Meat Pie Sample at Various Baking Times and Temperatures.

| Baking Time, t(mins) | Mass of sample $M_r$ (g) at various temperatures | | |
|---|---|---|---|
| | 200°C | 250°C | 300°C |
| 0 | 70 | 70 | 70 |
| 5 | 68.8 | 64 | 63 |
| 10 | 67.5 | 62.5 | 61 |
| 15 | 66 | 60.7 | 58.6 |
| 20 | 64 | 56.2 | 55.8 |
| 25 | 62.2 | 55.5 | 53 |
| 30 | 58.5 | 52.1 | 50 |
| 35 | 55 | 50.6 | 49.5 |
| 40 | 53.1 | 49.5 | 48.2 |

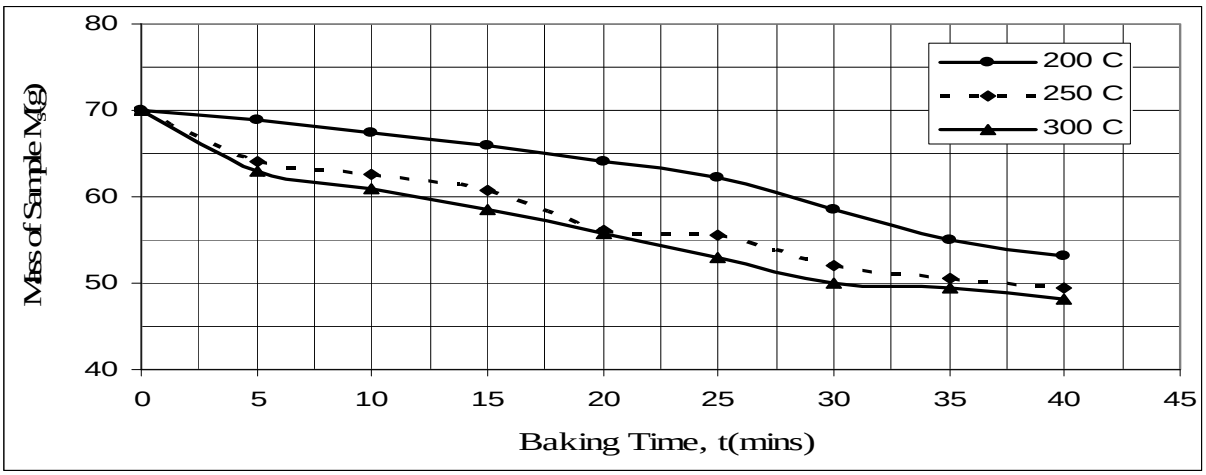



**Figure 2:** The Graph of Mass of Meat Pie Samples (g) against Baking Time (mins) at Various Baking Temperatures (°C).

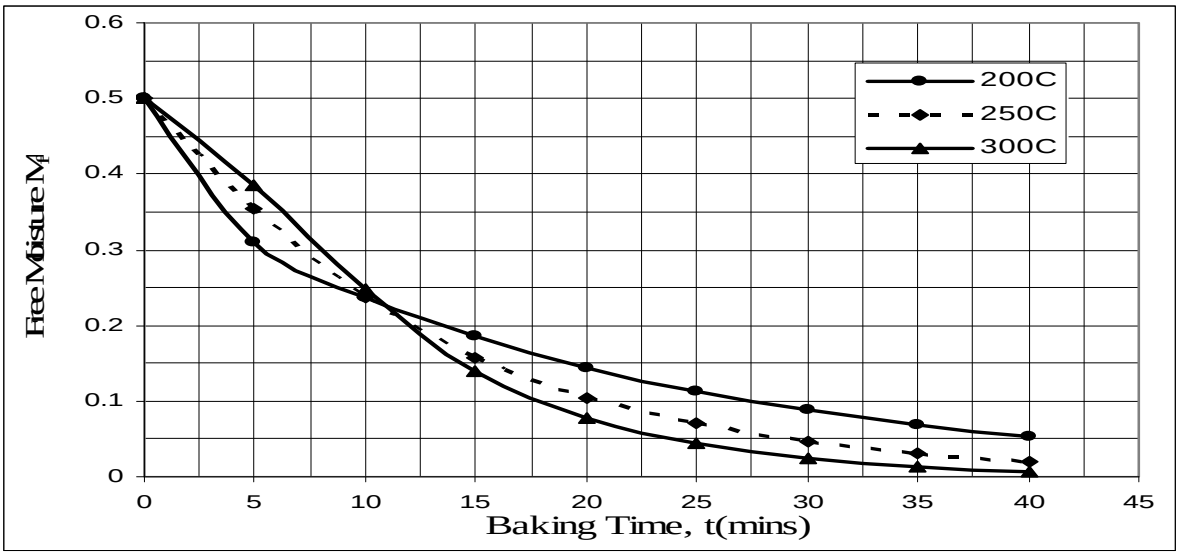



**Figure 3:** The Graph of Free Moisture Content ($M_f$) against Baking Time (mins.) at Various Baking Temperatures.

**Table 3:** Drying Rate ($D_r$) at Various Baking Temperatures.

| 200°C | | 250°C | | 300°C | |
|---|---|---|---|---|---|
| **Drying Rate, $D_r$** | **Free Moisture, $M_f$** | **Drying Rate, $D_r$** | **Free Moisture, $M_f$** | **Drying Rate, $D_r$** | **Free Moisture, $M_f$** |
| 0.0035 | 0.304951 | 0.0027 | 0.354388 | 0.0024 | 0.445669 |
| 0.0046 | 0.237734 | 0.0033 | 0.236192 | 0.003 | 0.248787 |
| 0.0067 | 0.185333 | 0.0048 | 0.157416 | 0.0046 | 0.138792 |
| 0.0076 | 0.144482 | 0.0071 | 0.104914 | 0.0084 | 0.077453 |
| 0.0082 | 0.112635 | 0.01 | 0.069923 | 0.012 | 0.043223 |
| 0.01 | 0.087808 | 0.0125 | 0.046602 | 0.0159 | 0.024121 |
| 0.0123 | 0.068453 | 0.0133 | 0.031059 | 0.0176 | 0.013461 |
| 0.0133 | 0.053365 | 0.0146 | 0.0207 | 0.0198 | 0.007512 |

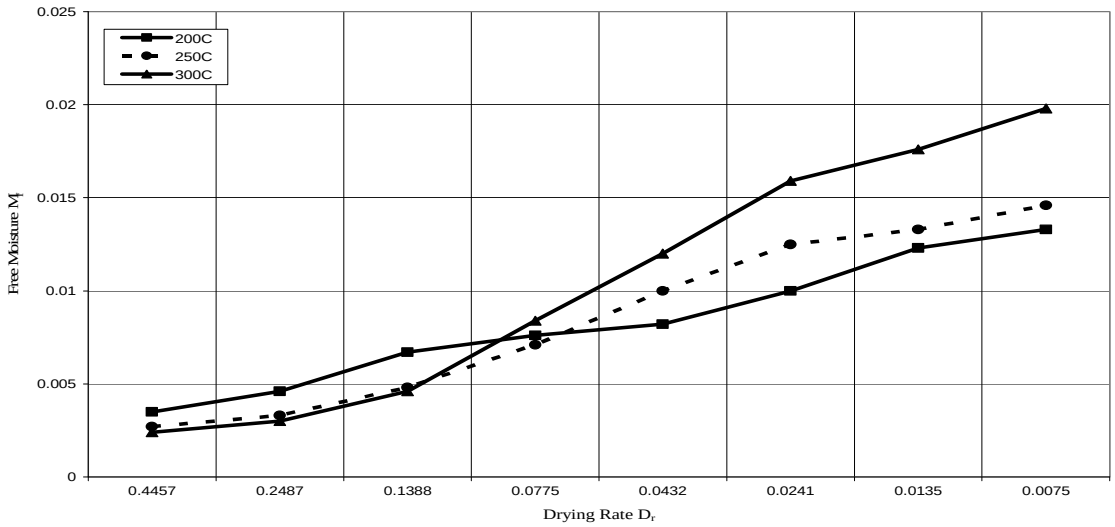



**Figure 4:** The Graph of Free Moisture Content ($M_f$) against Drying Rate ($D_r$).

## CONCLUSION

It can be concluded that the oven operated well without any risk of hazard or injury to the operator and other users. The machine has no special features so can be operated by any adult with little training with little or no supervision. The machine is a good starting point for any small scale fast food shop operators as it can successfully process bread, cake, pastries, pie, meat, etc.

The rate of baking is fastest at 300$^{o}$C and slowest at 200$^{o}$C, which shows that the higher temperature the faster the rate of baking. This agrees with the work of Ogunleye and Awogbemi [7] that temperature is a major factor in processing and preservation of food and other perishable products and that increase in temperature triggers high moisture loss.

However, for this machine, the ideal condition for baking is 15 minutes at an oven temperature of 250$^{o}$C. The baking time can be reduced if the temperature is increased but the temperature must never be increased beyond 300$^{o}$C.

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Go ahead and bake, broil and roast in this countertop appliance.Ä  That is less of an issue in the compact toaster oven, which makes it easy to get food close to the heat, assuming the appliance offers is a good range of rack positions. Ruspino says the short distance the energy has to travel between the element and the food means not much of it will be lost in the air, which is a poor conductor (and another reason larger ovens can be harder to preheat and regulate). With the countertop appliance, itâ€™s easier to keep an eye on the food, too, before it gets too dark.Â  The toaster oven can also be ideal for roasted sides, Bishop says, especially if space in your regular oven is tight, a.k.a. the Thanksgiving conundrum. But donâ€™t discount it for all-in-one dinners either. Absorber Unit; the oven in this case is the absorber, it is made of common bricks with alternative screens (glass, Perspex and aluminum sheets) used to determine the efficiency, temperature and baking time for the ovens. Aluminum sheet is painted with black paint to enhance absorption of the solar radiation; this enhances heat generation due to black body radiation and glass/Perspex heat-up due to green house effect. The baking tins used were also painted black and the ovenâ€™s interior was packed with few materials to help conserve heat generated. 3. methodology and description of the system. D... Our rigorous oven tests cover every ovenâ€™s grilling, roasting and baking capabilities. To test these aspects, we cook a full roast dinner including a chicken, potatoes and apple crumble. We use the grill to see how evenly it toasts a full tray of bread, we bake batches of fairy cakes and a rich fruit cake. We look at how hot the oven door gets when the oven is in use, how well our cakes rise, if our potatoes crisp up, and if cooking on multiple shelves at the same time affects the results.Â  To do this, we use a thermocouple (a sensor for measuring temperature) and place inside the centre of a hot oven at a range of different temperatures. We record the lowest and highest recorded temperatures and calculate an average based on this. EVALUATION OF LOW COST ELECTRIC BAKING OVEN 1 Adegbola A.A., 2Adogbeji O.V, 2Abiodun O.I and S. Olaoluwa2 1 Department of Mechanical Engineering,Ladoke Akintola University of Technology, Ogbomoso,Nigeria. 2 Department of Mechanical Engineering,Moshood Abiola Polytechnic, Abeokuta,Nigeria. ABSTRACT The paper reports on the design and construction of a domestic electric basic oven. The aim of this research work is to improve on the already existing electric baking oven through the incorporation of a blower and interlock switch. The joining techniques and handling of the equipment for optimum usage was explained in details. The AUTOCAD design shows the pictorial views, lines and dimensions for its mass production purposes.