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COMPARATIVE STUDY OF FOODS COOKED USING SOLAR BOX & BUTANE GAS COOKER

Mudawia, H.A., Ahmed, S. A

a. University of Khartoum, Dep. of Food Science & Technology.

b. University of Ahfad for women, School of Family Science.

ABSTRACT

The main objective of this study was to determine the effect of the source of heat for cooking (either solar energy or butane gas) on the chemical composition, minerals profile and organolyptic quality of some food products. The types of foods investigated in this study were okra, rice and meat (burger). The source of the solar energy was a solar box cooker which was mounted and technically prepared as to utilize the maximum possible amount of solar energy. The cooker was found useful at distinct positions according to the mode of employment, with each position having its own set-up. The four positions examined during this study were parking position, food loading position, cooking position and occasional opening position. Each foodstuff was prepared by the most appropriate method known to be specific to that type of food. When using the solar box cooker, the cooking time depends on amount of water (as part of the recipe), preheating of cooker and whether the pot is covered or not. Results showed that, except for burger the protein content using butane gas was more than that scored when using solar box cooker. Cooking with butane gas resulted in higher oil content than using the solar box cooker. Using solar box, the ash and moisture contents were found to be more than butane gas method. Concerning the minerals content after cooking of the three tested food products, it was found that the sodium content using the solar box was more compared to butane gas method except for burger. The magnesium content was higher using the solar box compared to the butane gas. The contents of potassium, calcium and phosphorus were more in products cooked by butane gas than those cooked by the solar box cooker. For sensory evaluation, the assessor's observations revealed that cooking by solar box was more acceptable except for the color.

Keywords: Solar box cooker, butane gas, cooking time, set-up of cooker positions.

Introduction

Cooking in boiling water or by steam pressure are common household practices of food processing. Apart from making food palatable and safe, cooking inactivates practically all the anti-nutritional factors that are heat labile (EIA, 2001).

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It is postulated that now is the time to encourage the establish-ment of sustainable, self supporting solar thermal manufacturing business in sub-Saharan Africa, with emphasis on solar cookers. The motivation is multi-fold. The need for thermal energy is mani-fested in the energy balance of any African country, where over 75% of the energy units consumed is obtained from firewood and charcoal mostly for cooking purposes.

Climatic conditions in the Sudan are good for solar utilization. The end product is cost effective, whilst the manufacturing techno-logy required is accessible to developing industrial capabilities. Serious environmental and health issues can also be positively tackled by wide scale dissemination of solar cookers (EIA, 2001).

Wood and charcoal account for the bulk of cooking energy. Charcoal is becoming more and more important because it is easier to transport than wood to urban centers and because it produces less fume when cooking than wood. The problem is that charcoal-ing usually done locally with very low efficiency – of only 13% on weight basis –. That means 1 kg of wood leads to 0.13 kg of charcoal. With improved techniques 20% efficiency can be reached Under laboratory conditions, 0.31 kg of charcoal is possible. The actual 13% efficiency, expressed the other way round, means that conversion from wood to charcoal needs 7-8 kg of wood as pri-mary energy to produce 1 kg of charcoal. This loss is only partly compensated by the higher energy density of charcoal, which is about double that of wood (UNEP, 2002).

But there are also climate aspects of charcoaling. Low efficiency of conversion means increased carbon emissions into the atmos-phere. Carbon is emitted in the form of CO_2 and CH_4 (methane). Of these methane is of particular importance as it has a high Global

Warming Potential (GWP), which is about 21 times that of CO_2 calculated over a period of 100 years (UNEP, 2002).

Objectives of the study:

1. To study the effect of source of heat for cooking (solar or gas) on chemical composition and mineral profile of different foods.
2. To examine the effect of source of heat (solar or gas) in organolyptic properties of different food products.

MATERIALS AND METHODS

Materials:

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The materials used in this study were rice, meat and okra. They were brought from local market at Khartoum and kept well in poly-ethylene bags at 4^{o} C for further use.

Methods:

Preparation of the Cooker:

Before preparation of the food, the cooker must be prepared as follows:

It is useful to define distinct positions of the cooker according to the mode of employment, with each position having its own set-up combination.

The Parking Position:

In this position:

- Glass cover is closed. Handle is locked.
- Mirror is closed.
- Mirror and glass cover bolted together.

Latch is in the "down" position, with the butter fly nuts tightened.

Food Loading Position:

From the parking position, the following actions were carried out in sequence.

- The mirror was kept bolted to the glass frame.
- The front handle was kept unlocked.
- The butter fly nuts were kept loose on each side of the cooker.
- Using the handle, the cover assembly was gently lifted (mirror and glass together).
- While in the open position, both butter flies were tightened firmly, the cover assembly now stays in the open position.

Cooking Position:

- This position was from the last action in the loading position.

- The butter fly nuts were unscrewed.

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- The cover assembly was brought down and closed.

- The handle on the clamps on the out side of the holding body

  was locked.

- The bolts on both sides of the mirror were disengaged.

- The mirror was turned up to receive the solar radiation and reflect it onto the cooker window, the whole cooker was turned round to get proper alignment.

- The mirror was locked in position by tightening the butter flies onto the latch.

While cooking occasional sun tracking was carried out (every half an hour) by turning the cooker round (about a vertical axis) and tilting the mirror, the shadow of the cooker and the reflected radiations from the mirror. Alignment is optimized when the cooker casts a shadow directly in line with its body, and the reflected radiations from the mirror falls entirely inside the cooker, whenever alignment is achieved.

Occasional Opening Position:

Once the food is loaded and cooking commences, it is advisable not to open the glass window until the food is cooked. If the glass window must be opened to carry out some cooking requisites, like stirring, adding ingredients or simply checking if the food is cooked, this should be done quickly and for a very short period of time.

Food Preparations:

Okra (Mulah), burger and rice were prepared according to the Sudanese traditional foods preparation methods using butane gas and solar box cooker. When using the later the cooking time depends on amount of water, preheating of the cooker and weather the pot covered or not.

Proximate Analysis:

The determination of moisture content, crude protein, fat, and ash content were carried out according to AOAC (1984). The carbohydrates were calculated by difference:

Carbohydrates = 100 – (Moisture% + crude protein% + fat% + ash%)

Minerals were extracted from the samples by dry ashing method. The amount of Fe, Ca and Cu were determined using atomic absorption spectroscopy (Perkin – Elmer 2380). Ammonium vandate was used to determine Phosphorous along with ammonium molybdate method. Sodium and Potassium contents were determined by flame photometer (CORNIGEEL) according to AOAC (1984).

Sensory Evaluation of Cooked Products:

One sample of foods (okra, burger and rice) cooked by butane gas and other sample of the same type of foods cooked by solar energy were subjected to sensory evaluation by 15 panelists. The panelists were asked to evaluate each sample for colour, flavour, texture, taste and overall acceptability using five points scale.

Statistical Analysis:

All results were assessed by Analysis of Variance (ANOVA) as shown by Sendecor and Cochran (1987) and by Duncan's Multiple Range Test (Duncans, 1950) using SAS software.

RESULTS AND DISCUSSIONS

Chemical Composition:

The proximate chemical composition of some foods (okra, rice and burger) cooked by butane gas and solar energy is shown in Tables 3.1a and 3.1b.

Moisture Content:

Table 3.1 shows the moisture content of okra, rice and burger cooked by solar energy and butane gas, the values were as follows: okra (3.42%, 2.83%), rice (6.34%, 5.24%) and burger (4.17%, 3.73%) respectively. The okra, rice and burger cooked by solar energy had more moisture content than that cooked by butane gas and this may be due to the fact that cooking by butane gas causes more water evaporation from foods due to the high temperature used while solar cooking results in low water losses due to cooker design which suggest to cover the pot tightly by special type of glass so that any evaporated water drops will return back to pot after condensation.

Protein Content:

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As shown in Table 3.1 there was slight difference between solar and butane gas in protein content of okra (3.36%, 3.58%). The reason for the decrease of protein content of okra cooked by solar energy may be due to the fact that cooking by solar energy usually takes long time and this affects the protein coagulations and leads to decrease in the quality and quantity of protein. The rice cooked by butane gas had significantly higher protein content than that cooked by solar energy (4.46%, 6.51%). The burger cooked by solar energy was significantly high in protein than that cooked by butane gas (27.66%, 25.73%). It seems that the high tem-perature of butane gas has affected negatively the meat protein, while the slow heating of solar energy had more positive effect in meat protein.

Fat Content:

Table 3.1 shows the fat content of okra, rice and burger cooked by solar energy were as follows: 9.83%, 1.11%, and 52.70%, respectively. And that cooked by butane gas were as follows: 15.3%, 2.70% and 57.8%, respectively. Okra, rice and burger cooked by butane gas have higher oil content than that cooked by solar energy, this may be due to the fact that oil (fat) is affected by the length of cooking time than elevation of temperature.

Ash Content:

As showed in Table 3.1 the ash content of okra cooked by solar energy and butane gas were (15.80%,12.17%) that of rice (7.14%, 6.13%) and burger (2.45%, 1.69%) respectively. The cooking by solar energy resulted in higher ash content than cooking by butane gas, this may lead to say that the ash was not affected by the long time and low temperature of cooking.

Carbohydrate Content:

Table 3.1 showed that the carbohydrate content of okra, rice and burger cooked by solar energy and butane gas were: okra (67.58%, 66.12%), rice (80.95%, 79.42%) and burger (13.02%, 11.08%). The carbohydrate value was obtained by difference, so the values of the other parameters measured in this study had influenced the value of carbohy-drate. Generally comparing the carbohydrate values of foods used in this study revealed that foods cooked by solar energy had higher carbohydrate values than that cooked by butane gas.

Minerals Composition:

Sodium Content:

As shown in Table 3.2 the sodium content in okra, rice and burger cooked by solar energy were 3.99, 2.10 and 885 % respectively and that cooked by butane gas were3.89, 1.95 and 897 %

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respectively. The okra had no significant difference (between solar and butane gas cooking) while the burger had highly significant difference and rice had significant difference. This result may be due to the assumption that the long time of cooking was better for sodium and that the types of food tested were not highly affected by the amount of heat subjected to.

Potassium Content:

As shown in Table 3.2 the potassium content in okra, rice and burger cooked by solar energy were 4.10, 0.29 and 0.25 % and in that cooked by butane gas were 4.15, 0.28 and 0.40 % respectively. The okra, rice and burger had significant difference in potassium and this may be due to the fact that potassium content was affected by long time and less temperature of cooking

Magnesium Content:

As illustrated in Table 3.2 the magnesium content in okra, rice and burger cooked by solar energy were 0.35, 0.20, 0.98 %, respectively and that cooked be butane gas were 0.30, 0.20, 0.10 %, respectively. The okra and burger had significant difference in magnesium and insignificant difference was noticed to rice this may be due to the fact that magnesium was affected by high temperature more than long time and this appears clearly in okra because cooking took more time.

Calcium Content:

As mentioned in Table 3.2 the calcium content in okra, rice and burger cooked by solar energy were 0.70, 0.20, 0.40 %, respectively and in that cooked by butane gas were 1.25, 0.20, 0.50 %, respectively. The okra had significant difference in calcium content and insignificant difference in burger and rice were noticed and this result may be due to that calcium was affected by the length of time for cooking.

Phosphorus Content:

From Table 3.2 the phosphorus content in okra, rice and burger cooked by solar energy were 5.81, 0.41, 0.21 %, respectively and in that cooked by butane gas were 5.85, 0.53, 0.24 %, respectively. The okra, rice and burger showed no significant difference and this result may be due to the fact that phosphorus content was not affected by the way of cooking because the results are nearly equal.

Sensory Evaluation:

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Sensory evaluation of okra:

According to Table 3.3 the colour and flavour had highly significant difference while the texture and taste had significant difference and finally the overall acceptability had no significant difference. This result may mean that the colour of foods cooked by solar energy is less acceptable than other attributes, and the overall acceptability is approximately the same.

Sensory evaluation of rice:

As shown in Table 3.4 The colour, falvour, texture, taste and overall- acceptability had insignificant difference, this result indicates that the rice cooked by solar energy was comparable to that cooked by butane gas, bearing in mind the low costs of cooking by solar energy.

Sensory evaluation of burger:

As shown in Table 3.5 the colour, falvour, texture, taste and overall-

acceptability had insignificant difference, this result means that the burger can be economically cooked by solar energy and had the same quality of expensive cooking by butane gas.

Table 3.1: Proximate composition of foods cooked by butane gas

and solar energy

Sample	Moisture %		Protein %		Fat %		Ash %		Carbohydrate%	
	Solar	Gas	Solar	Gas	Solar	Gas	Solar	Gas	Solar	Gas
Okra	3.42^{a}	2.83^{b}	3.36^{a}	3.58^{b}	9.83^{b}	15.3^{a}	15.81^{b}	12.17^{a}	67.58^{a}	66.12a
Rice	6.34^{a}	5.24^{b}	4.46^{a}	6.51^{b}	1.11^{b}	2.70^{a}	7.14^{a}	6.13^{a}	80.95^{a}	79.42^{b}
Burger	4.17^{a}	3.73^{b}	27.7^{b}	25.7^{a}	52.7^{a}	57.8^{a}	2.45^{a}	1.69^{b}	13.02^{a}	11.08^{b}

Means with different superscript letter in the same row were significantly

Different at 5% level.

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Table 3.2: Minerals composition of foods cooked by solar energy and butane gas.

Sample	Na %		K %		Mg %		Ca %		P %	
	Solar	Gas	Solar	Gas	Solar	Gas	Solar	Gas	Solar	Gas
Okra	3.99[a]	3.89[b]	4.10[a]	4.15[a]	0.35[a]	0.30[a]	0.70[b]	1.25[a]	5.81[a]	5.85[a]
Rice	2.10[a]	1.95[a]	0.29[a]	0.28[a]	0.20[a]	0.20[a]	0.20[a]	0.20[a]	0.41[a]	0.53[a]
Burger	885.2[b]	897.5[a]	0.25[a]	0.40[b]	0.98[a]	0.10[b]	0.40[a]	0.50[a]	0.21[a]	0.24[a]

Means with different superscript letter in the same row were significantly different at 5% level.

Na = Sodium, K = Potassium, Mg = Magnesium, Ca = Calcium, P = Phosphor.

Table 3.3: Sensory evaluation of okra

	Colour	Flavour	Texture	Taste	Overall Acceptability
Solar E.	2.93[a]	4.27[b]	3.87[a]	4.00[a]	3.60[a]
Butane gas	4.07[b]	3.00[a]	3.47[a]	3.47[a]	3.73[a]

Means with different superscript letter in the same row were significantly different at 5% level.

Table 3.4: Sensory evaluation of rice

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	Colour	Flavour	Texture	Taste	Overall Acceptability
Solar Energy	3.73[a]	3.93[a]	3.00[a]	3.33[b]	3.67[a]
Butane gas	2.93[a]	3.47[a]	3.87[a]	3.93[a]	3.60[a]

Means with different superscript letter in the same row were significantly different at 5% level

Table 3.5: Sensory evaluation of burger

	Colour	Flavour	Texture	Taste	Overall acceptability
Solar Energy	3.20[a]	3.73[a]	3.53[a]	3.80[a]	3.67[a]
Butane gas	3.13[a]	3.47[a]	3.53[a]	3.47[a]	3.33[a]

Means with different superscript letter in the same row were significantly different at 5% level.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions:

The thermal feasibility of the used Solar Box Cooker (SBC) was estab-lished. The performance of SBC was good when diverse applications were needed like intermittent removal of the pot, untracking and openings ……..etc.

Comparing the results of the chemical analysis of foods cooked by solar box cooker and by butane gas, there were really no significant difference between the two sources of heat for cooking. The results of sensory evaluation were also to great extent similar. This is a merit for solar cooking, the costs will be significantly decreased when solar box cookers are used for cooking instead of butane gas especially in rural area

Recommendations:

1. Intensive and diverse research programmes are needed to attain the ultimate goal of improving the solar cookers.
2. To delegate specialist-teams to various societies where solar box cookers are in use for exchanging experience in designing, commissioning and operating of SBC.
3. To lucrative market potential.
4. To encourage the manufacture of such solar units for its positive environmental, economical and health issues effects.

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