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Temperature effects on cooked food in the tropics: A case study of local soups in Abraka, Delta State, Nigeria

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This study examined the effects of temperature on cooked food in Abraka, Delta State, Nigeria. It utilized the survey research design. Primary data about cooked food conditions between hours of reheating were generated from women in the area using copies of checklist. Temperature data were collected for a period of one year from Department of Geography and Regional Planning, Delta State University, Abraka. The data were analyzed using analysis of variance (ANOVA) and Pearson's product moment correlation (PPMC). Results indicate that, incidents of soup souring were related to temperature at $p < 0.05$, although the relationship was direct ($r = 0.72$), revealing that as temperature increases soup sours or as temperature reduces soup taste was sustained longer. Again, melon, banga, and owo soups went sour within 6 h of previous heating as temperature reaches 31°C, while, vegetable, okra, and ogbono soups stayed beyond 6 h at 31°C. The ANOVA revealed that, there was a significant difference in soup sour incidence at $p < 0.05$ ($F = 274$) at different seasons (December, January, and February [DJF], May, June, and July [MAM], June July and August [JJA], September, October, and November [SON]) of the year thereby emphasizing the effects of weather on soup behavior after cooking. Based on these findings and dangers that soured soup can cause to human health and the loss of money, there should be proper kitchen ventilation in the absence of refrigerator and/or power supply. Choice of soup to cook should also be made with utmost consideration of prevailing air temperature in the tropics where air temperature is generally high.

Key words: Tropics, local-soup, sour, weather, cooked-food.

INTRODUCTION

Man's survival on earth depends largely, on the quality of food and water available to him for consumption (Dolan et al., 2010). Food and water are basic materials required by man for energy and growth. Food is also required for building up of immune system, which helps the body fight against diseases that may try to attack the human body from time to time (Baxter, 2008). However, food can become a source of poison, when proper cautions were

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not taken, before, during and after cooking, due to bacteria activities (Schmutz and Hoyle, 2011).

Generally, there are bacteria everywhere (water, air, and soil) (Dolan et al., 2010; Omaye, 2004; Kotsonis and Burdock, 2008). Therefore, allowing cooked food to stay out of cold environments (>4.5°C) or in warm-hot environment (4.5 to 60.5°C) for a long time may lead to bacterial contamination (USDA, 2011a, b; USFDA, 2009). Such bacteria include *Escherichia coli, Staphylococcus aureus*, and *Salmonella enteritidis* (Schmutz and Hoyle, 2011). Nevertheless, all raw food and vegetable have various levels of bacteria infestation (USFDA, 2010) which are killed or reduced during cooking (USDA, 2011a). Conversely, if the cooked food is not properly preserved and in time, some bacteria that did not die during cooking or those reintroduced during scooping or air infiltration, will be incubated by temperature, and consequently, begins to grow in numbers that are potentially harmful to human health (Schmutz and Hoyle, 2011). A good environment for bacteria to grow is one typical of 4.5 to 60.5°C temperature (Hutt et al., 2007; Jones, 1995; Kotsonis and Burdock, 2008) and it takes about 20 min for bacteria to double in number in such environment. Based on this, USDA (2011b) advised that food must not be left unconsumed after 2 h of cooking or removal from freezers, and if temperature of that environment is up to 32°C, cooked food must be consumed within an hour from cooking or re-heating period.

In the developed world, these above precautions are practicable, not only because of difference in climate characteristics, but also because of stable power supply, which allows for refrigerating cooked food consistently. However, a sharp contrast exists in Nigeria (a developing country), where power supply is very poor or in some cases non-existent. Furthermore, alternative sources of power are very expensive to acquire, since technological advancement is low. Furthermore, the cost of refrigerating sets makes them beyond the reach of many Nigerians. As a result of these, cooked food is mostly left for long hours at the mercy of temperature and other environmental factors of the tropical climate where Nigeria is positioned, thereby leading to contamination of food and consequently food wastage. Because of poverty, some locals still consume such soured foods and end up having some medical complications (Ozabor and Obaro, 2016; Ostertag et al., 2002).

In Abraka, the Benin Electric Distribution Company (BEDC) supply power on an average of an hour per day, thereby making refrigerating of food after cooking impossible. Local temperature is also high (ranging between 23 and 32°C), thus making reheating of food after cooking to be the only means of its preservation. As a result of economic activities engaged in by locals, food is left for up to 6 to 7 h without reheating, as such bacteria are allowed to incubate and multiply. The implication of this is that soups go soured and in most cases are poured away, while in some other cases are still consumed, since some locals are very poor (Efe, 2006). The consequences of these include, triggering some health conditions and exacerbating poverty situation in the area, since the already poor has to spend more money to replace food that had already been cooked. Ironically, to the best of the knowledge of the researchers, no known work exist regarding the subject matter especially in the tropics. This work thus examined effects of temperature on different local soups in Abraka, Delta State, Nigeria.

MATERIALS AND METHODS

Description of the study area

Abraka is an area in Delta State, Nigeria. To the east, the area is bordered by Ukwani Local Government Area, at the west by Edo State, at the north and south by Ethiope River and Ughelli North, respectively. It is situated on latitudes 5° 46' and 5° 48' north of the equator and longitudes 6° 05' and 6° 08' east of the Greenwich meridian. The area extends over 168.4 km^2 (Olomo and Ajibola, 2006). Abraka is located within the tropical environment, based on the classification of Koppen (1918) and Strahler (1965). Monthly temperature ranges between 23 and 32°C, while monthly rainfall ranges between 25.4 and 457 mm (Efe, 2006). The major economic activities of the locals include farming, transportation, trading, service, etc. These activities signify that people will have to leave their homes in the morning to come back in the evening or at night. This coupled with the poor power supply situation in the area implies that, cooked food is left at the mercy of prevailing temperatures, which are hot enough to allow for bacteria incubation, which could affect soup and food tastes in the area.

Study design and sampling technique

The study adopted the survey research design which involved the use of questionnaire in the area (Nwagbara et al., 2017). Copies of check lists were administered to women in the area to generate information about soup conditions after cooking. To be able to achieve proper sample for the study, the total population of registered residential buildings were generated from the archive of Ministry of Lands, Survey, and Urban Development, Oria, Abraka. After which, the Taro Yamane formula was applied to the total registered residential buildings (7643) and a sample size of 380 were derived using alpha 0.05 levels. However, for the purpose of efficient distribution of the check list to respondents, the systematic sampling technique was used to select 1 in every 3 streets in the area. After which 2 copies of the check lists were randomly distributed to households in the area. Furthermore, daily temperature data were obtained from the Department of Geography and Regional Planning, Delta State University, Abraka and for a period of one year (June 1, 2016 to May 31, 2017). The need for this was to help the researchers find out the relationship between outdoor and indoor temperatures. Also, a thermometer was placed in the kitchens of the houses to which checklists were administered. This was done to find out the relationship between outdoor and indoor temperatures and from there find out the relationship between the incidences of soup sour in the various houses.

Analysis of variance (ANOVA) was used to find out the statistical difference between soup tastes both at seasonal and daily intervals. Again, the Pearson's Product Moment correlation (PPMC) was used to determine the statistical relationship between temperature

Table 1. Frequently cooked soups and their ingredients in Abraka.

Soup type	Ingredients
Owo	Cassava flakes, red oil, beef or fish or both, potash, seasoning cubes, water, pepper, salt, crayfish, prawn.
Ogbono	Red oil, beef or fish or both, seasoning cubes, water, pepper, salt, crayfish, prawn, onion, *Irvingia*.
Egusi	Red oil, beef or fish or both, seasoning cubes, water, pepper, salt, crayfish, prawn, onion, melon seeds.
Vegetable	Red oil, beef or fish or both, seasoning cubes, water, pepper, salt, crayfish, prawn, onion, pumpkin leaf, water leaf and *Celosia argentea*
Okra	Red oil (optional), beef or fish or both, seasoning cubes, water, pepper, salt, crayfish, prawn, onion, *Abelmoschus esculentus*
Tomatoes	Red oil or ground nut oil, beef, chicken or fish or both, seasoning cubes, water (optional), curry, pepper, salt, crayfish, prawn, onion, and tomatoes
Banga	Palm fruits, beef, fish (dry of fresh), seasoning cubes, water, curry, pepper, salt, crayfish, prawn, onion

and soup sour incidences.

The basic soups that are cooked at least twice a week by a household in Abraka were determined by a focused group discussion and informal experience of the researchers and they include the following soups: owo, ogbono, egusi, vegetable, okra, tomato and banga. The ingredients used for the soups are listed in Table 1.

RESULTS AND DISCUSSION

In Table 2, egusi soup has the highest cases of soup sour, with 5212 cases. The next to that is owo soup (2231) and then banga soup (1432). However, tomato soup recorded the lowest cases of soup sour in the area. The variation in soured soup cases, center on the variation in preparation techniques, which reduces the activities of bacteria in the soup after preparation. Within the temperature limit for cooked food to get spoilt (4.5 to 60.5°C) as identified by USDA (2011a), only vegetable, okra and tomato soups were able to last up to 6 h or beyond without going bad or changing taste (Table 3). This also reveals that these soups are able to resist high temperature more than other local soups such as egusi, owo, and banga in tropical environments such as Abraka.

Table 4 shows that there is a strong correlation between outdoor and indoor temperatures at $p < 0.05$. Nevertheless, in Table 5, there was a strong relationship ($r = 0.72$) between temperature and cases of soup sour, thus revealing that as temperature increases, soup sours, and conversely as temperature reduces, soup taste is sustained. This finding is also consistent with that of Schmutz and Hoyle (2011) and USDA (2011b), who identified that the rates at which foods go bad after preparation is related to temperature fluctuations.

However, temperature was only able to explain 51.84% of soup sour cases, while leaving the remaining 48.16% possibly to poor cooking techniques, contaminated ingredients, etc. The correlation model was also significant at $P<0.05$, implying that, soup sour cases are significantly related to temperature in Abraka.

Furthermore, the seasonal characterisation of soup sour cases is shown in Table 6. Here, May, June, and July (MAM), is the season with the highest soup sour cases (2649), the next to that, is September, October, and November (SON) season with 2633 cases. June July and August (JJA) recorded the lowest cases of soup sour (1621). It is expedient to state that, these seasonal distributions are not accidental. For example, temperature in Abraka is usually low during JJA which also coincides with the peak of rainy season in the area. Therefore, the heavy rains have a moderating effect on temperature and consequently on the soup sour cases in the area.

Similarly, although December, January, and February (DJF) belong to the dry period, the harmattan winds that blow into the area during the period have a lowering effect on temperature, as such temperature has reduced effect on soup at this time as compared to other periods of the year such as MAM and SON where convective heating exacerbate temperature conditions, which in turn results in high soup sour cases.

Nonetheless, the effects of temperature is established in Table 7, where the ANOVA analysis indicated that there is significant seasonal variation in soup sour cases at $P < 0.05$ in the area.

As shown in Table 8, within the day soup sour cases were significantly different at $p < 0.05$. However, between 7 am and 12 noon, the highest amount (4475) of soup sour cases are recorded, while the lowest is recorded between 8pm and 5am. Reasons advanced for this variation is that in the tropical environments, there exists a sharp or rather steep change in temperature between 6 am and 12 noon and this quickly creates room for bacteria incubation, resulting in the high amounts of soup sour in that period of the day.

Table 2. Reported cases of soup sour incidence.

Soup type	Sour taste incidence
Owo	2231
Ogbono	1067
Egusi	5212
Vegetable	823
Okra	842
Tomato	231
Banga	1432

Table 3. Duration and temperature effect on the different local soups.

Soup type	Temperature range (±)	Average duration (h)
Owo	4.5-32	4
Ogbono	4.5-32	±6
Egusi	4.5-32	≤4
Vegetable	4.5-32	>6
Okra	4.5-32	>6
Tomato	4.5-32	>6
Banga	4.5-32	5

Table 4. Relationship between outdoor and indoor temperatures.

Sample size	Indoor and outdoor temperature (Pearson's)	P value (0.05)
365	0.842	0.00

Table 5. Relationship between temperature and local soups.

Sample size	Soup sour and temperature (Pearson's)	P value (0.05)
365	0.721	0.00

Again, the effects of time of day temperature is shown in Table 9, where the ANOVA analysis indicated that there is significant daily time variation in soup sour cases at $P < 0.05$ in the area.

CONCLUSION AND RECOMMENDATIONS

This study identified the effects of temperature on incidences of soup sour in Abraka, Delta State, Nigeria. Investigations revealed that, egusi soup is the most susceptible to temperature as compared to the other local soups investigated. On a time scale of 1 to 6 h under 4.5 to 32°C, egusi soup mostly went sour in less than 4 h, while okra and tomato soups were able to retain original taste after 6 h of previous heating. Furthermore, soup sour cases were strongly correlated with temperature. This, by extension, established that there is variation in the seasonal occurrence of soup sour, as most cases of soup sour were recorded in the dry season.

However, what is not established in the current study is a laboratory analysis which should tell what types of bacteria and chemical components are involved in the soured soups.

This is a limitation which this study has not handled of which is being suggested for further investigation. Nevertheless, whenever a soup sours, money is lost. This is not a small measure by exacerbating existing poverty conditions in the study area in particular and developing countries of tropics in general if nothing is done to avert this problem.

From the current study, the following recommendations

Table 6. Seasonal variation in soup sour events.

Season	Subset for alpha = 0.05			
	N	1	2	3
JJA	92	1621.4520	-	-
DJF	91	-	2115.9434	-
SON	92	-	-	2633.1635
MAM	90	-	-	2649.8890
Sig.	-	1.000	1.000	0.884

Table 7. Significance of seasonal variation in soup sour events.

Sum of variance	Sum of squares	Df	Mean square	F	Sig.
Between groups	655679.205	3	218559.735	274.001	0.000
Within groups	1272558.696	361	3525.093	-	-
Total	1928237.901	364	-	-	-

Table 8. Daily time variation in soup sour events.

Time of the day	Subset for alpha = 0.05			
	N	1	2	3
8 pm - 5 am	365	1801.5252	-	-
4 pm - 6 pm	365	-	2741.2954	-
7 am - 12 noon	365	-	-	4475.1794
Sig.	-	1.000	1.000	0.884

Table 9. Significance daily time variation in soup sour events.

Sum of variance	Sum of squares	df	Mean square	F	Sig.
Between groups	1276667.420	2	638333.710	126.537	0.000
Within groups	5508740.936	1092	5044.635	-	-
Total	6785408.356	1094	-	-	-

could be made:

(i) There should be proper kitchen ventilation in the absence of refrigerator and/or power supply.
(ii) Choice of soup to cook should be made with utmost consideration of prevailing air temperature in the area and other areas in the tropics since air temperatures are generally high.
(iii) For private consumption, there is need to reduce the quantity of soup cooked per time.
(iv) There is need to wash food ingredients properly before cooking, so as to reduce the bacterial load that may be inherent of such ingredients themselves which may quicken souring with increasing temperature.
(v) Proper public orientation should be initiated by Delta State government using electronic media to sensitize the locals on the effects of temperature on soups.
(vi) The use of food thermometers by all who cook is recommended as it will help them identify the internal food temperature of food especially during reheating.
(vii) Finally, improvement on power supply in Abraka is highly recommended. With an improved power supply, the residents would be able to utilize their refrigerating sets which have already become cupboards and homes for pests.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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