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Full Length Research Paper

Assessment of Food security in boarding schools using the HACCP system in Zaria, Nigeria.

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A systematic evaluation of food safety was carried out in five boarding schools in Zaria, Kaduna State. The analysis consisted of investigating hazards associated with microbial contamination and critical control points (CCPs) in the preparation and handling of foods in the schools. Food and water samples as well as swabs of food contact surfaces were collected in addition to animal droppings found in or near the food preparation areas and transported to the laboratory for further investigations. Enterotoxin production by *Bacillus cereus* and *Escherichia coli* strains was performed on New Zealand white rabbits using the ileal loop technique. All the foods (akamu, eba, tuwo and vegetable soup) attained cooking temperatures of 60 – 100^{o}C capable of destroying vegetative forms of food borne pathogens. However, a concentration of 3 - 5log$_{10}$ cells of *B. cereus*, 2 - 3log$_{10}$ cells *Staphylococcus aureus* and 1-2log$_{10}$ coliforms were isolated per 100 g/ml of some of the cooked foods. The water samples for drinking, cooking and washing dishes were contaminated with coliforms below 2 log$_{10}$ cells/ml. The food and water samples were found to have counts within acceptable limits but the isolation of enterotoxigenic strains of *B. cereus* and *Escherichia coli*, hazards such as inadequate (5 - 10 min) time/temperature exposure of foods (akamu, tuwo, eba), high level initial contamination associated with raw foods, food ingredients, food contact surfaces, food handlers and inadequate cleaning of food utensils call for concern. Critical control points are frying and steaming of akara and moimoi respectively, manipulation of foods after cooking, and holding of cooked foods. The improvement of the personal hygiene of the handlers and the environment using hazard analysis critical control point (HACCP) could help in ensuring safety of foods served in the boarding schools.

Key words: Hazards, contamination, HACCP, CCP, boarding school, enterotoxin production, food safety.

INTRODUCTION

From 1973-1999, a little over 600 food borne disease outbreaks in American schools were reported to the Centre for Disease Control (2001). They resulted in nearly 50,000 illnesses and more than 1500 hospitalizations (Daniels et al., 2000; Daniels, 2002). The figures are worrisome given that food borne illnesses are grossly underreported, mainly because symptoms such as diarrhea and abdominal cramps mirror those of common stomach viruses (McCabe-Sellers and Beattie, 2004; Flanigan, 2006). Practices identified as contributing to outbreaks in schools include improper refrigeration, prolonged handling and inadequate reheating of cooked food and contamination of food by food handlers who worked while ill or had poor personal hygiene (Panisello et al., 2000; Daniels, 2002; Hedberg et al., 2006).

Efforts must be made to adhere strictly to hygiene measures by following good hygiene practices and stringently implementing hazard analysis critical control point (HACCP) along the whole food chain (Powell et al., 2002) According to Oranusi et al. (2003) the HACCP strategy identifies hazards associated with different stages of food preparation and handling, assesses the relative risk and identifies points where control measures would be effective in order to ensure that the final product is safe for the consumer. This systematic approach has been described as the most effective means of controlling food borne diseases (Ropkins and Beck, 2002). As such it has been

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made mandatory in American school food services. However, the rate of implementation in American schools is approximately 20 - 30% (Henroid and Sneeds, 2004). Barriers to HACCP implementation within schools include lack of funds and/or time as well as employee motivation and confidence (Youn and Sneed, 2003; Roberto et al., 2006).

Epidemiological data on food borne disease outbreaks in Nigerian boarding schools is not available but poor storage practices coupled with poor personal hygiene and lack of knowledge in food safety practices which is inherent with food handlers in boarding schools are causes for concern. With the above facts in mind the current study aims at evaluating the hazards associated with food handling practices in schools in Zaria Local Govern-ment Area with boarding facilities using the HACCP system.

MATERIALS AND METHODS

Selection and description of schools surveyed

All the five schools in Zaria Local Government Area (ZLGA) with boarding facilities were selected for this study. Permission was sought and obtained from school principals before commencement of the work.

School 1: School for Arabic Studies and Islamic Education located in Gaskiya District

The school has about 350 student boarders. Food was prepared in a kitchen made of zinc. Part of the kitchen is used as store for damaged and non-functional kitchen equipments and firewood. The school has no functional dining hall, thus meals are served and eaten in the open. Water for cooking, washing dishes and drinking was obtained from tap in a dirty environment and stored in tanks. Animals (cows, chickens and goats) roamed freely in the food preparation area, and their droppings were found near the food preparation area. Basins for holding student food were used by cooks in washing clothes while cooking and eating utensils were inadequately washed before use.

School 2: Barewa College located in Gaskiya District

The school has about 1500 student boarders. Food was prepared in a temporarily built kitchen with zinc roof and no wall. Cooking was done using fire wood as fuel. The dining hall has no seats thus meals are served and eaten in the open. Water for cooking, washing dishes and drinking was from a tap and was stored in a rusted old tank. Water for cooking was obtained from this tank by dipping buckets directly into the tank. Utensils were inadequately washed before use.

School 3: Alhudahuda College located in Zaria walled city

The school has 400 boarders. Food was prepared in a temporarily built kitchen with zinc roof and no wall. Meals were served in a poorly kept dining hall without seats, thus meals are eaten outside the dining hall in the open or taken to the hostels. Water for cooking, washing dishes and drinking was obtained from a tap in a dirty environment. Animals (cows, sheep, goats and chickens) roamed the environment freely. Utensils were not properly washed before use.

School 4: St. Bartholomew's School located in Wusasa District

The school has 350 boarding students. Food was prepared in a kitchen attached to the dining hall. Fire wood is used for cooking. Water for cooking, washing dishes and drinking was from a bore-hole and was stored in covered metal drums and plastic containers. Water is fetched from the drum by dipping a bucket directly into the drum. Utensils were not adequately washed before use. Meals were served and eaten in the dining hall.

School 5: Science Secondary School, Kufena, located in Wusasa District

This school has 1,300 boarders. Food was prepared in a kitchen using fire wood. Water for cooking, washing dishes and drinking was from open wells and a bore hole. Water was sometimes stored in rusted tanks. Utensils were not adequately washed before use. Meals were served and eaten in the dining hall or hostels since seats were not enough.

In all the schools except school 4, akamu and akara or moimoi were served as breakfast, eba, rice and beans were prepared as lunch. Tuwo (corn meal) served with vegetable soup was prepared for supper. In school 4, akamu and akara/moimoi, tea and bread, and porridge were prepared and served as breakfast. Eba and soybean/groundnut soup, beans, yam and rice served with stew were prepared for lunch. Tuwo, lafu (cassava flour meal) and eba served with soya bean/groundnut soup were prepared for diner. In all the schools food was often left open for 30 min to 1h before serving to students.

Hazard analyses

Each school was visited for six consecutive days during which studies of methods of food preparation, and schematic drawings of each food preparation from beginning to end was made as descrybed by Bryan et al. (1992). The environment and food preparation area were studied. Potential sources of contamination, likelihood of microbial survival, destruction and multiplication were also noted. The preparation temperature, time and pH were measured and indicated at appropriate steps of preparation.

Temperatures of the interior of foods were taken immediately after cooking, during holding and before consumption. This was carried out by inserting a thermocouple (Atkins Technical with needle type sensor, USA) into the central region of the food being measured. Time was recorded using a wrist watch while pH was measured using a Crimson micro pH meter (model 2000, USA). Food samples were taken at the beginning, during and after cooking and during holding for analysis. Ingredients were sometimes sampled. Samples of drinking water; water used for food preparation and for washing was collected.

Swabs of areas that could serve as sources of food contamination such as the hands and finger nails of food handlers, food contact surfaces (food utensils and equipments and food spread areas) were taken by rubbing sterile swabs over areas touched by food. If the surface was dry, the swab was first moistened in sterile 0.1% peptone water (Oxoid). Evaluation was also made of hygienic practices and habits that could serve as means of food contamination e.g., food handlers not washing hands after using the toilet, picking their noses or keeping long finger nails. Samples were tested for total aerobic mesophilic and coliform counts, *Bacillus cereus* and *Staphylococcus aureus* counts, and the presence of *Escherichia coli*.

Sampling procedures

Samples of foods were collected into sterile specimen containers with metal spoons used by the cooks for dishing food. Samples of water were collected with bowls used by the cooks and poured into sterile specimen bottles with screw caps as described by Nwanze et al. (2006). Swabs of food contact surfaces were transported in sterile specimen containers containing sterile 0.1% peptone water. Samples of animal droppings were taken from the floor with sterile spatula into sterile specimen containers. Samples were then taken to the laboratory for analysis.

Microbiological evaluation

10 g or 10 ml of food samples were homogenized with 90 ml of 0.1% peptone water in screw capped flasks by means of horizontal and vertical agitation for a few minutes. Serial dilutions of 10^{-2} for cooked foods (such as akara, moimoi, akamu, tuwo and soup) and 10^{-3}-10^{-4} for raw foods (such as milled beans, maize flour, and vegetables) were prepared for enumeration. Aliquots of 0.2 ml of the serial dilutions of the food samples were spread on duplicate plates using a sterile glass spreader. This technique was used for the enumeration of total aerobic viable count, coliform, *Bacillus* and *Staphylococcus* counts on nutrient agar (Difco), eosin methylene blue (EMB) and Baird-Parker agar (Oxoid) supplemented with tellurite and egg yolk emulsion, respectively. All cultures were incubated at 37ºC for 24 h except for the coliforms which were incubated at 37 and 44ºC for 24 h (Machado et al., 2005; Fujita et al., 2005). Animal droppings and swab samples were inoculated directly onto plating media as well as into selective broths for enrichment. One hundred milliliters of water samples for drinking and washing was filtered through 0.45 μm pore size membrane filters. The filters were aseptically placed using a sterile pair of forceps on EMB and nutrient agar plates (Oxoid) for coliform and total aerobic viable counts. Incubation was for 24 h at 44 and 37ºC respectively. Media used were prepared according to the manufacture's instructions.

Characterization of isolates

Various isolates on nutrient agar slants (Oxoid) were purified and characterized after Gram staining. Confirmation of coliform organisms was by inoculating typical organisms into lactose broth with Durham tubes and incubating at 37 and 44^{o}C for 24 h in the absence of gas production (Oranusi et al., 2004). The presence of gas constituted a presumptive test and was streaked out on EMB agar incubated at 37^{o}C for 24 h. Typical colonies on EMB plates appearing bluish black with greenish metallic sheen are characteristic of *E. coli*. Isolates were stored on nutrient agar slants at 4^{o}C for further confirmatory tests which include IMViC test, carbohydrate utilize-tion, gelatin liquefaction, nitrate reduction, urease production and motility. Large, flat, irregular, wrinkled or smooth ground-glass colo-nies 4 - 6 mm in diameter were counted as *Bacillus* spp. Confirma-tion was based on gelatin liquefaction, citrate utilization, starch hydrolysis, and fermentation of sugar as described by Yusuf et al. (1992). Confirmation of typical colonies of *S. aureus* on Baird-Par-ker agar was on the basis of the results of catalase, coagulase, phosphate reduction, and carbohydrate utilization (Umoh et al., 1999).

Ligated rabbit ileal loop test for screening enterotoxigenic *B. cereus* and *E. coli*

Enterotoxin production for *B. cereus* was carried out in brain heart infusion broth (Oxoid) with 0.1% (w/v) glucose supplement (BHIG) while toxin production for *E. coli* was in trypticase soy broth (Difco) as described by Spira and Geopfert (1972) and Turnbul and Kramer (1983). Stock cultures on nutrient agar slants were subcultured into BHIG and trypticase soy broth, incubated at 37 C for 8 h and 20 h for *B. cereus* and *E. coli* respectively and on a shaker at 200 rpm, with the addition of 0.1N NaOH at intervals.

The ligated rabbit ileal loop test was conducted following the procedures of Portnoy et al. (1976) using New Zealand white rabbits. Results were interpreted as described by Portnoy et al. (1976) and Yusuf et al. (1992).

Statistical analysis

The values obtained for total aerobic, staphylococcal, coliform and *Bacillus* counts were subjected to analysis of variance (ANOVA) and Duncan's multiple range tests (Snedecor and Cochran, 1987).

RESULTS

Foods prepared in the different schools attained temperatures of boiling or near boiling of 60 – 100^{o}C and were consumed within 30 min to 1 h after preparation, thus no serious time-temperature abuse was recorded. There was no left over foods thus reheating of foods before consumption was not recorded.

Table 1 shows the mean microbial counts of breakfast meals prepared by the five different schools. The results reveal that akamu prepared in St. Bartholomew's school had a significantly higher total aerobic plate count (TAPC) than all the other schools. In addition, it also had a higher *B. cereus* count than all other schools. The results also reveal that in general milled maize had higher TAPC, *B. cereus* and *S. aureus* than the finished product (akamu). The milled beans from the School for Arabic Studies had the highest TAPC, *B. cereus*, *S. aureus* and coliform counts. However, the finished product produced in Science Secondary School had the lowest TAPC and *B. cereus* counts.

Table 2 depicts the mean microbial counts of raw materials and finished porridge in the five schools. According to the results Alhudahuda College had a mean TAPC for tuwo which was comparable to that of Barewa College and Science Secondary School but significantly higher than that of School for Arabic Studies and St. Bartholomew's. The *B. cereus* count of tuwo from Alhudahuda College was comparable to that of Barewa College but significantly higher than the remaining schools. The *S. aureus* count of tuwo from Science Secondary School was highest followed by Alhudahuda, St. Bartholomew's and Barewa College respectively. The microbial count of the raw maize flour was generally higher than that of the finished products. The TAPC of gari used to make eba in Barewa and Alhudahuda Colleges were similar but significantly higher than the remaining schools. The *B. cereus* count of gari was highest in Barewa College followed by Science Secondary School. The eba produced in the School for Arabic Studies had the highest plate count. It also had a significantly higher *B. cereus* count than all other schools.

Table 1. Mean microbial counts (log_{10} $cfug^{-1}$) of breakfast meals prepared by five schools in Zaria, Nigeria.

Organism	School	Milled Maize	Akamu	Temp (°C) [Time (min)]*	Milled Beans	Akara	Temp (°C) [Time (min)]*
TAPC	1	6.04± 2.7	4.23± 1.1[b]	60(30)	7.00 ± 3.1	5.40 ± 2.1	35(45)
	2	6.00 ± 2.7	4.94± 1.2[b]	60(30)	6.18 ± 2.1	5.70 ± 1.8	34(45)
	3	6.59 ± 3.7	4.20 ± 1.2[b]	38(90)	NA	5.40 ± 1.0	AMB(NT)
	4	5.94 ± 2.8	5.88 ± 3.1[a]	62(<30)	5.99 ± 1.5	4.08 ± 1.1	70(<30)
	5	5.90 ± 2.8	4.28 ± 1.9[b]	60(30)	6.04 ± 2.1	3.18 ± 0.1	36(45)
B. Cereus	1	5.91 ± 3.1	5.04 ± 2.2	60(30)	6.51 ± 2.7	4.06 ± 1.0	35(45)
	2	5.75 ± 2.6	4.87 ± 1.6	60(30)	5.95 ± 5.0	5.63 ± 1.8	34(45)
	3	6.62 ± 3.8	4.67 ± 1.7	38(90)	NA	6.20 ± 2.2	AMB(NT)
	4	6.11 ± 3.0	5.38 ± 2.5	62(<30)	5.92 ± 1.4	4.04 ± 0.6	70 (<30)
	5	5.88 ± 2.9	4.26 ± 1.9	60(30)	5.81 ± 2.2	3.72 ± 0.5	36(45)
S. aureus	1	4.79 ± 0.7	ND	60(30)	5.89 ± 1.8	4.00 ± 0.2	35(45)
	2	4.95 ±1.8	3.78 ± 1.2	60(30)	4.78 ± 0.9	ND	34(45)
	3	5.26 ± 2.2	3.18 ± 0.8	38(90)	NA	ND	AMB(NT)
	4	4.30 ± 0.0	ND	62(<30)	4.90 ± 1.5	ND	70 (<30)
	5	4.85 ± 0.0	ND	60(30)	5.15 ± 1.8	ND	36(45)
Coliform	1	4.48 ± 1.1	ND	60(30)	3.72 ± 1.0	2.18 ± 0.5	35(45)
	2	ND	ND	60(30)	3.56 ± 0.7	ND	34(45)
	3	4.88 ± 0.9	ND	38(90)	NA	1.80 ± 0.9	AMB(NT)
	4	ND	ND	62(<30)	2.61 ± 0.7	ND	70(<30)
	5	ND	ND	60(30)	2.48 ± 0.8	ND	36(45)

ND= Organism not detected; ± = Standard deviations; NT = Not tested; * = Temperature of internal portion (approximate center) of finished food and holding time before consumption ; NA = Not analyzed ; TAPC= Total aerobic plate count; AMB = Ambient temperature 0f 28^{U} C; a, b, c = Means within column with the same letter for same count are not significantly different ($p>0.05$)

Table 3 represents the results of the ileal loop test. Approximately 13(46.4%) of the *B. cereus* and 5(20.8%) of *E. coli* were mildly toxigenic. No severe reaction was recorded for both *B. cereus* and *E. coli* isolates, however, 5(17.19%) of the *B. cereus* and 2(8.3%) of the *E. coli* were moderately toxigenic.

DISCUSSION

This HACCP study revealed that factors such as improperly washed utensils and equipment, poor hygiene, dirty environment and the presence of animals in the cooking environment contributed to the contamination of foods prepared in the boarding schools. The major hazards associated with foods prepared in the schools studied were the inadequate (5 - 10 min) time/temperature exposure of foods (akamu, tuwo, eba), extensive handling of foods by cooks after preparation, leaving cooked foods open till served to students and the presence of toxigenic strains of *B. cereus* and *E. coli*. The cooking temperatures of foods examined in this study reached levels capable of destroying many vegetative forms of foodborne pathogens. However, a concentration of organisms ranging from 2-5log_{10} cfu/g survived in the foods after cooking. This may represent the group of heat resistant spore formers and/or post process contaminants (Inabo et al., 2000; Ehiri et al., 2001).

The total aerobic plate count of 2.87-5.88 log_{10} cfu/g recorded for cooked foods from all the schools could be attributed to survival of spores which could have come initially from the raw foods and food ingredients or by reduction of but not total elimination of large number of vegetative cells that contaminated the raw foods and food ingredients (Obuekwe and Ogbimi, 1989). Post process contamination could also have contributed to TAPC. The significantly higher TAPC of tuwo from Alhudahuda College could be attributed to initially higher level of contamination of the raw maize flour, contamination from water used to cool the fingers when wiping off tuwo from the stirrer and contamination from the food handler (Cappaelli and Mata, 1975; Yusufu et al., 1992). The higher level of TAPC for gari from Alhudahuda and Barewa Colleges could be linked to processing and handling practices (Bryan, 1988).

The isolation of *B. cereus* from all the cooked food samples is of concern. This could be explained by the ubiquitous distribution of this organism and its ability to form endospores (Mckillip, 2000) . The presence of *B. cereus* in tuwo could be attributed to the methods of processing the grains (drying on inadequately clean floors

Table 2. Mean microbial counts $\log_{10}$ cfu^{-g} of raw materials before and after preparation of stiff porridge in the five schools.

Organism	School	Maize flour	Tuwo	Temp (°C) [Time(min)]*	Gari	Eba	Temp (°C) [Time(min)]*
TAPC	1	4.28 ± 2.0	4.23 ± 2.0^{b}	60(30)	2.58 ± 1.2^{b}	4.00 ± 1.0	60(30)
	2	4.84 ± 2.8	4.61 ± 2.5^{ab}	68(30)	4.49 ± 1.4^{a}	3.61 ± 1.6	71(<30)
	3	5.20 ± 3.4	5.04 ± 3.2^{a}	62(30)	4.72 ±1.9^{a}	ND	NT(30)
	4	4.15 ± 2.2	4.28 ± 2.2^{b}	50(36)	2.71 ± 0.6^{b}	ND	60(30)
	5	4.64 ± 2.3	4.45 ± 2.3^{ab}	50(35)	3.00 ± 0.6^{b}	2.87 ± 1.3	70 (<30)
B.cereus	1	4.86 ± 3.0	4.90 ± 3.1^{ab}	60(30)	2.30 ± 1.6	4.41 ± 1.5^{a}	60 (30)
	2	4.59 ± 2.1	4.52 ± 2.2^{b}	68(30)	2.40 ± 0.4	2.26 ± 0.7^{b}	71(<30)
	3	4.46 ± 3.6	5.36 ± 3.6^{a}	62(30)	3.87 ± 1.1	1.70 ± 0.7^{b}	NT(30)
	4	3.95 ± 2.1	3.97 ± 2.0^{b}	50(35)	2.66 ± 1.1	3.59 ± 1.7^{b}	60(30)
	5	5.26 ± 3.4	4.62 ±2.4^{b}	50(30)	2.85 ± 1.3	3.15 ± 1.9^{b}	70(<30)
S. aureus	1	ND	ND	60(30)	ND	2.34 ± 0.2	60(30)
	2	ND	3.18 ± 0.0	68(30)	4.26 ± 1.0	4.11 ± 2.1	71(<30)
	3	4.54 ± 1.7	3.36 ± 0.5	62(30)	ND	ND	NT(30)
	4	3.49 ± 1.2	3.30 ± 0.0	50(35)	ND	ND	60(30)
	5	4.40 ± 0.0	3.40 ± 0.8	50(30)	ND	1.11 ± 0.3	70(<30)
Coliform	1	ND	2.70 ± 0.0	60(30)	ND	ND	60(30)
	2	ND	ND	68(30)	ND	ND	71(<30)
	3	3.04 ± 0.4	ND	62(30)	ND	ND	NT(30)
	4	ND	ND	50(35)	ND	ND	60(30)
	5	2.97 ± 0.2	ND	50(30)	ND	ND	70(<30)

ND = Organism not detected; NT = Not tested; a, b, ab = means within column with the same latter for same counts are not significantly different (P>0.05); ± = Standard deviation; * = Temperature of internal (approximate center) of finished food and holding time before consumption; TAPC = total aerobic plate count.

Table 3. Enterotoxigenicity of *B. cereus* and *E. coli* using Ileal loop test. Number of isolates tested (n)/number (%) of total.

Reaction	*B. cereus* (n = 28)	*E. coli* (n = 24)
Mild reaction	13(46.4)	5(20.8)
Moderate reaction	5(17.9)	2(8.3)
Severe reaction	-	-
Total	18(60.7)	7(29.1)

n =No of isolates tested; - =No reaction

and machine milling) (Blakey and Priest, 1980). The limited time/temperature exposure of 5 - 10 min during tuwo preparation is equally insufficient to destroy *B. cereus* spores. The significantly higher *B. cereus* count of 5.3 $\log_{10}$/g recorded for tuwo in Alhudahuda College, and 4.4 $\log_{10}$/g recorded for eba in the School for Arabic Studies could be attributed to initial high level contamina-tion of flour before tuwo preparation and post process contamination after eba preparation, considering the fact that the count of the eba was higher than counts of the garri before heat treatment.

The International Commission on Microbiological Specification for Food (ICMSF) suggested the acceptable limit for *B. cereus* in food as 3 $\log_{10}$cells/g, with 4$\log_{10}$/g as tolerable and above 6log10/g as above the acceptable limit. Based on this the observed results are acceptable.

S. aureus isolation from tuwo, eba and akamu could be ascribed to post process contamination. The fact that *S. aureus* was not detected in the raw foods but was found only in the finished tuwo (Barewa College) and eba (Sch-ool for Arabic Studies and Science Secondary School) confirms the fact that these organisms were introduced post processing. The contamination could have come from improper personal hygiene of the cooks or from dirty cooking utensils (Vivek et al., 1995) . However, the values were within acceptable limits stated by ICMSF (1994).

The isolation of coliform organisms from tuwo (School for Arabic Studies) and akara (School for Arabic Studies and Alhudahuda College) is attributed to post process contamination. This is confirmed by the fact that the organisms were detected in finished products and not in raw food samples. The presence of coliforms could have been from improperly cleaned utensils, persons handling the food, and animals (along with their faecal droppings) present in the environment (Ehiri et al*.,* 2001).

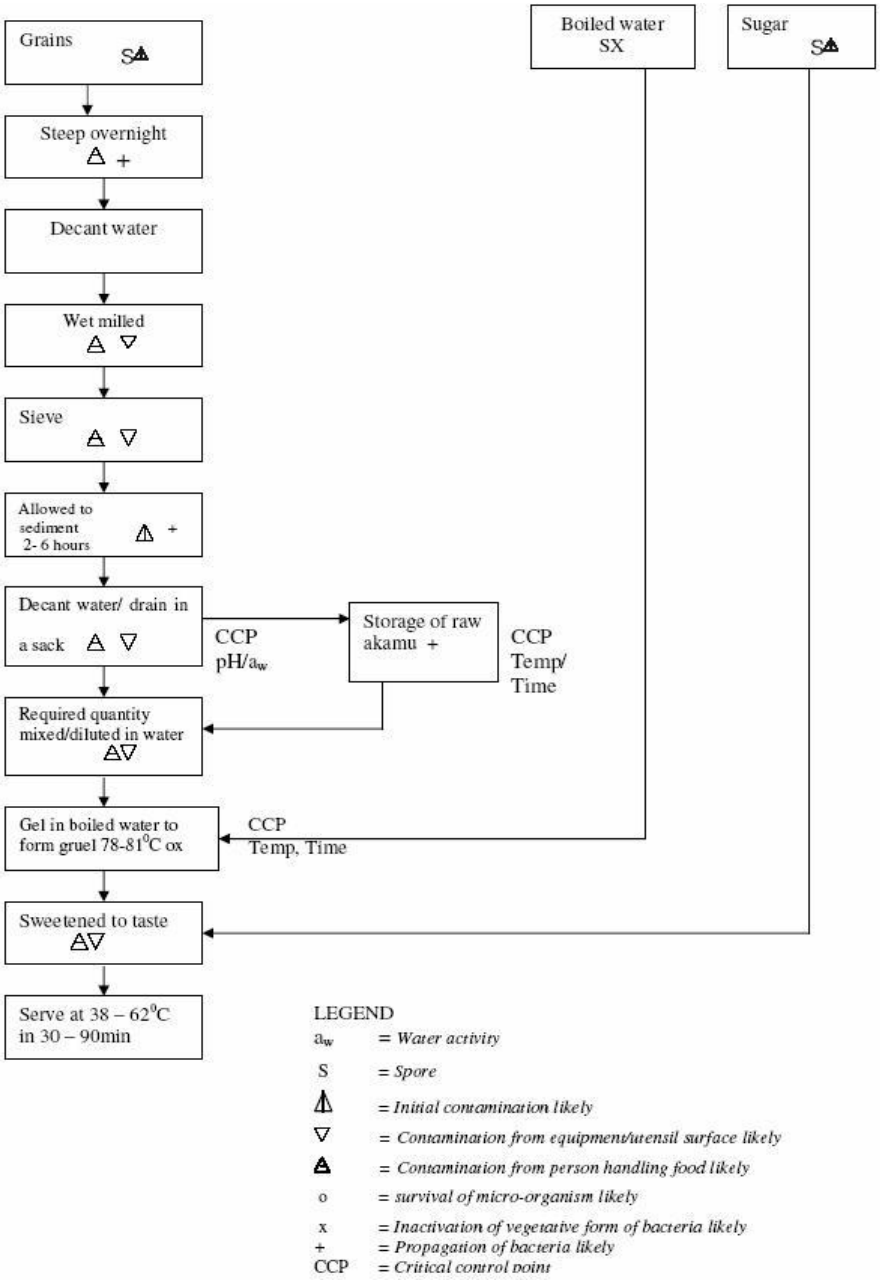

Figure 1. Flow diagram of akara and moimoi preparation and handling in the various schools.

The contamination of the entire well water samples of this study with coliform organisms and the presence of *E. coli* in some water samples should be of concern. The contamination of well water with coliforms could be accredited to the fact that the wells are open and subject to contamination from run offs and from vessels used to collect the water which are often placed on the ground prior to being dipped into the well (Adesiyan et al., 1983; Bryan et al., 1992). Contamination of well and tap water could also be from water storage vessels and from persons collecting the water. Poor tap treatment could also be a contributing factor with coliform organisms (Alabi and Adesiyan, 1985; Ehiri et al., 2001).

Toxin production using ileal loop test showed that the *B. cereus* and *E. coli* isolates were mild and moderate enterotoxin producers. Although the counts of these organisms were within acceptable and tolerable limits, the fact still remains that the foods are consumed by a large number of institutionalized adolescents, some of whom are under emotional and psychological stress due to studies and absence from family members. Stress is known to compromise the immune system. Immuno-com-

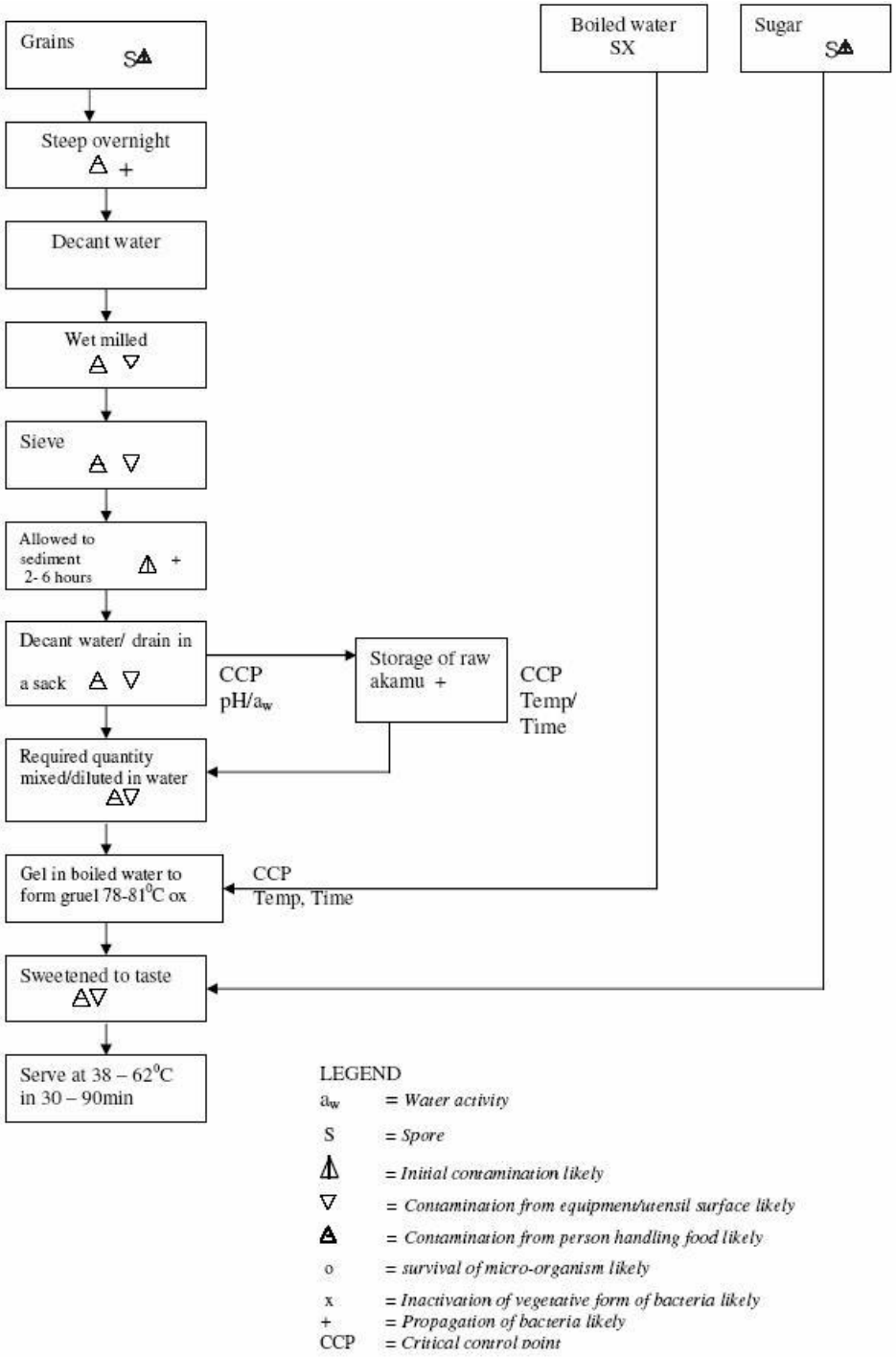

Figure 2. Flow diagram of akamu preparation and handling in the various schools.

promised individuals are at risk of food and water borne infections even at low doses of enterotoxigenic strains of microorganisms (Nataro et al., 1998).

Three critical control points were observed for the preparation of akara and moimoi as well as for akamu. In the case of akara the temperature should be high enough and maintained long enough to kill all microorganisms present. The moimoi should also be well steamed while the holding temperature for both should be for a period of time within which the temperature is 45^{o}C and above, in order to prevent multiplication of microbes. The decanting of water in the akamu reduces pH and a_w both of which

reduce microbial growth. In addition, the time/temperature during preparation should also be high and long enough to kill microorganisms (Figures 1 and 2).

In conclusion, food handlers could be important reservoirs for pathogenic bacteria. Increased time/temperature exposure of foods and strict control of mishandling of product during preparation and dispensing is highly recommended for prevention of contamination. In addition, the HACCP system should also be introduced and enforce in Nigerian school foodservices.

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