

# Critical control points of complementary food preparation and handling in eastern Nigeria

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**Objective** To investigate microbial contamination and critical control points (CCPs) in the preparation and handling of complementary foods in 120 households in Imo state, Nigeria.

**Methods** The Hazard Analysis Critical Control Point (HACCP) approach was used to investigate processes and procedures that contributed to microbial contamination, growth and survival, and to identify points where controls could be applied to prevent or eliminate these microbiological hazards or reduce them to acceptable levels. Food samples were collected and tested microbiologically at different stages of preparation and handling.

**Findings** During cooking, all foods attained temperatures capable of destroying vegetative forms of food-borne pathogens. However, the risk of contamination increased by storage of food at ambient temperature, by using insufficiently high temperatures to reheat the food, and by adding contaminated ingredients such as dried ground crayfish and soybean powder at stages where no further heat treatment was applied. The purchasing of contaminated raw foodstuffs and ingredients, particularly raw akamu, from vendors in open markets is also a CCP.

**Conclusion** Although an unsafe environment poses many hazards for children's food, the hygienic quality of prepared food can be assured if basic food safety principles are observed. When many factors contribute to food contamination, identification of CCPs becomes particularly important and can facilitate appropriate targeting of resources and prevention efforts.

**Keywords** Diarrhea, Infantile/etiology; Infant food/microbiology; Food contamination/analysis; Water microbiology; Food handling; Food hygiene; Risk assessment; Task performance and analysis; Nigeria (*source: MeSH*).

**Mots clés** Diarrhée, infantile/étiologie; Aliments pour nourrisson/microbiologie; Contamination alimentaire/analyse; Microbiologie eau; Traitement aliments; Hygiène alimentaire; Evaluation risque; Analyse performance; Nigéria (*source: INSERM*).

**Palabras clave** Diarrea, infantil/etiología; Alimentos infantiles/microbiología; Contaminación de alimentos/análisis; Microbiología del agua; Manipulación de alimentos; Higiene alimentaria; Medición del riesgo; Análisis del desempeño de tareas; Nigeria (*fuentes: BIREME*).

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## Introduction

Measures of child health are useful indicators of the health of a nation, particularly for Nigeria where children constitute about 45% of the total popula-

tion (1). The country's infant mortality rate of 114 per 1000 live births is among the highest in sub-Saharan Africa and mortality among children under five years of age is as high as 300 per 1000 live births in some parts of the country (2). Epidemiological evidence shows that diarrhoea is a major problem, with an estimated one-in-six children under the age of five years experiencing at least one episode every fortnight (1). Children aged 4–24 months are at the greatest risk of developing diarrhoea from contaminated food and water. Normally, breast milk is the main source of nourishment for children within their first months of life. The dependence on breast milk reduces their exposure to food-borne pathogens, and the anti-infective properties of breast milk also afford some protection. Between 4 and 6 months of age, however, complementary foods are given, and children are thus exposed to food-borne pathogens (3). For example, a study of 454 children in eastern Nigeria (4) showed that the incidence of diarrhoea

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was highest among children aged between 6 and 12 months — the age range which coincides with the usual weaning period in the region. The development of sustainable strategies for controlling diarrhoea among children in the region, and in the country as a whole, would thus constitute a significant advance in public health.

### Prevention of diarrhoea

Sustainable preventive strategies include a selection of proven interventions targeted either at the pathogens that cause diarrhoea or at their routes of transmission (5). In the 1980s, the World Health Organization (WHO) reviewed potential strategies for controlling diarrhoeal diseases and evaluated 18 interventions. The interventions were classified into three categories according to their effectiveness and feasibility: interventions that are highly effective and that have strong evidence of feasibility; interventions of uncertain effectiveness and feasibility, which require further research; and interventions that are ineffective or of limited feasibility (6). Seven interventions were identified as highly effective: promoting breast feeding; improving weaning practices (including improving the hygiene of complementary foods); immunization against rotavirus; immunization against cholera (in special situations); immunization against measles; improving the water supply and sanitation; and promoting personal and domestic hygiene. Of these, promotion of food hygiene has received the least attention (3), even though it is accepted that unhygienically prepared complementary foods are prone to contamination with diarrhoeal pathogens, and up to 70% of all cases of diarrhoea in children may be attributable to food contamination (7, 8).

### Hazard Analysis Critical Control Point strategy

In a comprehensive review of studies assessing the contamination of complementary foods, Motarjemi et al. (7) stressed the need to apply the Hazard Analysis Critical Control Point (HACCP) strategy. This strategy identifies hazards associated with different stages of food preparation and handling, assesses the relative risks, and identifies points where control measures would be effective. Therefore, as part of a wider effort to develop a hygiene-promotion intervention for preventing childhood diarrhoea, we used the HACCP strategy to study diarrhoeal diseases among children in 120 households in Imo state, Nigeria.

## Methods

### Selection of participants

Children having more than three separate episodes of diarrhoea in the three months preceding the study were classified as having frequent diarrhoea (9, 10). Diarrhoea was defined as passage of three or more loose, watery, or bloody stools within a 24-hour

period (11). Although a hazard is defined as the presence of biological, chemical, or physical agents in food that may cause the food to be unsafe for human consumption (12), this study considered only microbiological hazards. A critical control point (CCP) is a point, step, or procedure at which a significant hazard occurs in food preparation and handling, and at which control can be applied to prevent, eliminate, or reduce the hazard to an acceptable level (12).

### Sampling method

The multistage sampling technique (13) was used to select the study sample. A household was defined as individuals who live in the same house and who normally eat at least one main meal together in a day. We compiled a register of children 4–24 months old who qualified for inclusion based on these criteria, using records from primary health care centres, voluntary village health workers, and private medical facilities. An optimum sample size of 601 was calculated using Epi-Info version 6.04 (14), from which 120 children and their households were selected for study, using the systematic random sampling technique.

### Study areas

Using a current geopolitical map, the state was divided into three zones: Owerri, Okigwe, and Orlu. Two local government areas, one urban and one rural, were randomly selected from each zone. A total of 14 communities or wards were randomly selected from a list within each sample local government area. To select the sample households, every fifth child out of the 601 children in the sample frame was chosen, to a total of 120 children, and hazard analyses of complementary foods were undertaken in their households.

### Observation of food preparation and environmental conditions

HACCP evaluation of complementary foods in households was preceded by a community mobilization exercise that involved contact with the appropriate primary health care centres and households in the study communities. As part of this exercise, detailed information about the objectives and methods of the study were provided to household members, who were given the option of participating in the study. The mobilization process concluded with a pilot study of five households that were not included in the main study. Because of the effectiveness of the mobilization exercise, people in every household contacted for the main study agreed to participate.

In liaison with staff of the appropriate primary health care centre, we visited the home of each selected child and observed the preparation and handling of complementary foods. Sociodemographic and environmental health data were obtained by means of a short questionnaire in an interview with the parent or caregiver responsible for preparing and

handling the child's food. The educational level of either parent (whichever had the higher level) or of the caregiver was recorded. The usual ways of preparing, serving, and storing food by the mother or caregiver were noted in detail, and they were asked to explain each step in the process. Based on information obtained on-site, a flow diagram of each process was prepared to provide a clear, simple, and complete description of all steps in the process. In addition, a random sample of four markets that served parts of the study communities were visited to observe the hygiene practices of vendors.

### Collection of samples

Samples of the children's foods were collected aseptically, before and after cooking, and after storage at room temperature (for an average storage time of six hours). Raw food samples were obtained from vendors in local markets. The samples were put in plastic sterile containers with tight-fitting lids. Hot food samples from households were cooled immediately in an insulated plastic box containing ice-blocks and were kept there until transported to the laboratory. Sterile digital thermocouples were used to measure food temperature at three points: immediately after cooking, after storage at room temperature for an average of six hours, and immediately after reheating. In total 360 samples were collected and analysed. Each food or water sample collected was recorded in the field notebook and labelled at the point of collection.

### Analysis of samples

Standard methods were used to test food (15) and water samples (16). Depending on the time of arrival at the laboratory, the samples were either analysed immediately, or kept in a refrigerator till the following day. To test for the presence of faecal coliforms, *Escherichia coli*, or *Enterococcus faecalis* in food, a 25 g portion of the sample (or the whole sample if it was < 25 g) was diluted 1:10 in sterile 0.1% buffered peptone water, homogenized using a Waring blender, and serially diluted as required. Water samples from taps, boreholes, streams, and springs were also collected and tested. Faecal coliforms were detected using the membrane filtration technique, after incubating the samples at 44 °C for 24 hours. To detect *Enterococcus faecalis*, samples were incubated on azide medium at 37 °C for 24–48 hours and counted.

### Determination of critical control points

To determine whether a step or procedure was a CCP, we considered whether control could be applied at that point, and whether a loss of control could result in a potential hazard. For example, storage is a CCP if the storage time is not controlled and if food is served without reheating. Equally, reheating is a CCP if temperatures are not controlled. The use of contaminated ingredients is a CCP if they are added at stages where no heat treatment, or other

processes capable of destroying vegetative pathogens, are applied. Purchasing foodstuffs and ingredients from vendors is also a CCP if the foods are contaminated with food-borne pathogens, or are consumed without further processing or proper heat treatment.

## Results

### Characteristics of the study population

The mean age of the 120 children was 15 months. The characteristics of the 120 study households are shown in Table 1. The mean number of people in each household was 7, ranging from 3 to 15. A majority (65%;  $n = 78$ ) of the 120 children in the households studied were girls. There was no significant difference between mean age of girls (15.65 months) and that of boys (14.17 months). Households in urban settings were more likely to have facilities for the refrigerated storage of perishable and leftover foods than those in the rural settings ( $\chi^2 = 25$ ; degrees of freedom (df) = 1;  $P < 0.0001$ ), due to the wider availability of electricity in urban centres. Similarly, households in which the parent/caregiver was educated to post-secondary school level were more likely to have refrigeration facilities than those where the parent/caregiver had a lower level of educational attainment ( $\chi^2 = 29.2$ ; df = 3;  $P < 0.0001$ ). Common cooking fuels were firewood, bottled gas, and kerosene.

People in the small number of households ( $n = 5$ ; 4%) with no standard sewage disposal systems defecated in nearby bushes and surroundings. Children's faeces were observed in 20 (17%) of the study premises and four of these were households with no standard sewage disposal facilities. Hand-washing with soap during preparation and handling of children's foods was observed in only five of the study households.

### Temperature of foods

The mean temperatures of cooked, stored, and reheated foods were 89 °C, 39 °C, and 53 °C, respectively. Although cooking temperatures reached levels capable of destroying many vegetative forms of food-borne pathogens, a marked concentration of organisms persisted in the food after cooking (Table 2). These may represent the group of heat-stable enterotoxigenic strains that have often been implicated in diarrhoea (17). Table 3 presents a summary of the hazards, CCPs, control measures, and monitoring requirements associated with the preparation and handling of the foods analysed.

### Drinking-water quality

Water samples were analysed to provide an indication of the level of contamination of drinking water. According to WHO guidelines, chlorinated water should contain no coliforms (18). However, 84% of the tap water samples did not meet this standard and

33% of the samples from boreholes also failed to meet the respective recommended standard (18). All stream samples showed contamination with faecal coliforms and *Enterococcus faecalis*. A quarter of spring water samples were contaminated (Table 4).

Table 1. Characteristics of the 120 study households

Parameters	No. observed (%)
<b>Gender of children</b>	
Female	78 (65)
Male	42 (35)
<b>Educational level of parent/caregiver</b>	
No schooling	20 (16)
Primary school	46 (38)
Secondary school	27 (23)
Post-secondary school	27 (23)
<b>Refrigerator</b>	
Available	45 (38)
Not available	75 (62)
<b>Radio</b>	
Yes	85 (71)
No	35 (29)
<b>Method of sewage disposal</b>	
Pit latrine	70 (58)
Water-carriage system	45 (38)
None	5 (4)
<b>Source of domestic water supply</b>	
Spring	30 (25)
Pipe-borne	29 (24)
Stream	28 (23)
Bore-hole	27 (23)
Rain	6 (5)
<b>Normal cooking fuel</b>	
Firewood	72 (60)
Bottled gas	25 (21)
Kerosene	23 (19)
<b>Unwashed serving utensils observed</b>	
Yes	13 (11)
No	107 (89)
<b>Procedure for checking temperature of children's food prior to feeding</b>	
Taking a little portion with spoon and putting it in the mouth	17 (14)
Taking a little portion with spoon and putting it in the palm of the hand	18 (15)
Dipping a finger in the food	15 (13)
None	70 (58)
<b>Akamu served to children using feeding bottles</b>	
Yes	8 (7)
No	65 (54)
Not served	47 (39)
<b>Children's faeces observed in the premises</b>	
Yes	20 (17)
No	100 (83)
<b>Children fed during household meal times</b>	
Yes	65 (54)
No	55 (46)

## Complementary foods

**Akamu.** This is the most widely used complementary food in eastern Nigeria. It is also known as ogi in western Nigeria, or ugi in parts of East Africa. It is a complex carbohydrate produced by fermentation of maize, millet, or sorghum (guinea corn). Maize is most widely used in the study location. Households either process akamu at home or buy it ready to use from market vendors. Fermentation can be used to improve the hygienic quality of food (19), but inadequate application of the process and faulty practices may negate its benefits (3). The major CCPs are purchasing from unreliable sources, including market vendors; cooking; addition of contaminated ingredients after heat treatment; storage after preparation; and reheating (Table 3 and Fig. 1).

**Jollof rice.** This dish is the second most widely used complementary food in the study communities and is one of the staple diets for adults. It consists of cooked rice mixed with ingredients such as crayfish, palm oil, tomatoes, onions, and seasoning. Meat and other fish are normally added, depending on cost. The major CCPs are cooking, storage, and reheating (Table 3 and Annex Fig. 2 (available on our web site: <http://www.who.int/bulletin>)).

**Moi-moi.** This food is made from black-eyed beans (cowpeas). Sources of potential hazards in its preparation and serving include the use of contaminated water for processing, dirty utensils, and contamination by food handlers. There is also considerable potential for contamination from the use of empty milk cans for steaming and from unwashed leaves used for wrapping the food. However, most of the risks can be eliminated with adequate cooking. For this reason, the key CCPs are cooking, storage, and reheating (Table 3 and Annex Fig. 3 (available on our web site: <http://www.who.int/bulletin>)).

**Agidi.** Agidi is made from dry ground maize that has been cooked to boiling point. It is relatively safe if prepared under hygienic conditions and served immediately after preparation. The CCPs include cooking, storage and reheating (Table 3 and Annex Fig. 4 (available on our web site: <http://www.who.int/bulletin>)). The most important faulty practices include intermittent assessment of manual grinding; using unwashed hands; using dirty utensils; and using potentially contaminated wrapping materials.

**Combinations of complementary foods and storage.** Combinations of different foods increase the risk of rapid bacterial growth during storage. While the combinations may increase palatability and are nutritionally beneficial to children, they typically involve addition of microbiologically sensitive ingredients, such as soybean powder and dry ground crayfish. Soybean powder can be processed at home or bought ready to use from market vendors. Purchasing soybean powder from vendors in markets is an important CCP if the powder is added to foods and served without heat treatment to children (Table 3 and Annex Fig. 5 (available on our web

Table 2. Microbial quality<sup>a</sup> of complementary foods at different stages of preparation and handling

Organism	Akamu <i>n</i> = 73			Jollof rice <i>n</i> = 52			Moi-moi <i>n</i> = 60			Agidi <i>n</i> = 48		
	Before cooking	After cooking	After storage <sup>b</sup>	Before cooking	After cooking	After storage <sup>b</sup>	Before cooking	After cooking	After storage <sup>b</sup>	Before cooking	After cooking	After storage <sup>b</sup>
Faecal coliforms	600	20	850	400	26	550	350	40	340	250	27	450
<i>Escherichia coli</i>	260	10	30	200	0	400	420	9	417	400	6	380
<i>Enterococcus faecalis</i>	670	81	1300	300	32	710	270	22	970	410	15	730

<sup>a</sup> Measured as the number of organisms per gram of complementary food.

<sup>b</sup> Storage for an average of six hours.

site: <http://www.who.int/bulletin>). While on display in markets, all complementary foods are exposed to dust and flies, and are constant handled with unwashed hands and serving spoons.

## Discussion

### HACCP data

Application of the HACCP strategy to the study of complementary foods is based on the premise that potential food hazards and faulty practices can be identified at an early stage in food preparation and handling, and that their identification will lead to measures that prevent or reduce risks to children (20). The HACCP approach determines quickly and relatively cheaply the points in the food preparing/handling/serving processes that are critical to safety, while taking into account local habits and culture (21). Although there are sufficient data on risk factors for diarrhoea in children, the factors that constitute priorities for intervention have yet to be resolved. The HACCP strategy has the potential to make a significant contribution and can facilitate a more pragmatic approach to developing messages that assure effective behaviour change (3).

Using HACCP data to promote complementary food hygiene is of paramount importance in situations of extreme poverty and where adequate surveillance of food-borne diseases may be lacking (22). The data can be used to inform health and social authorities, train public health personnel, and design culturally appropriate hygiene interventions (23). However, as Abdulsalam & Kaferstein observed, the approach has yet to be fully exploited (21). In 1993, the Codex Alimentarius Commission endorsed the HACCP system as the most cost-effective approach for ensuring the safety of food (12).

### Socioeconomic status

The relationship between household socioeconomic characteristics and childhood diarrhoea has been amply demonstrated in the literature (24, 25). For example, using educational level of the parent/caregiver and availability of household amenities as proxies for socioeconomic status, it is apparent that most of the households were relatively poor. In 16% (*n* = 20) of the households, the parents/

caregivers had no school education, and in 38% (*n* = 46) of households they had only attended primary school. This has significant implications for child health in general (26) and for food-hygiene behaviour in particular (27). Education is also related to employment and income (28, 29), which influence access to household amenities and facilities, including those related to food hygiene and environmental health (26).

### Household sewage disposal

In all five households we studied that had no standard sewage disposal facilities the children defecated in and around the premises; in two of the households the children were ill with diarrhoea. Even in homes with adequate sewage disposal facilities (e.g. pit latrines), the facilities were not adapted for children's use. This contributed to indiscriminate defecation in and around the premises, and thus increased the risk of handling excreta by parents and caregivers, and by the children themselves. This behaviour reflected the children's limited knowledge of hygiene, and is an important public health issue, since such children are at greater risk of faecal-oral infections. Households may regard children's faeces as innocuous (30), but evidence suggests that they are as hazardous as those of adults and may contain high concentrations of pathogens (31). Outdoor defecation by children and adults can contaminate water sources and may explain the high levels of pathogens in nearby streams.

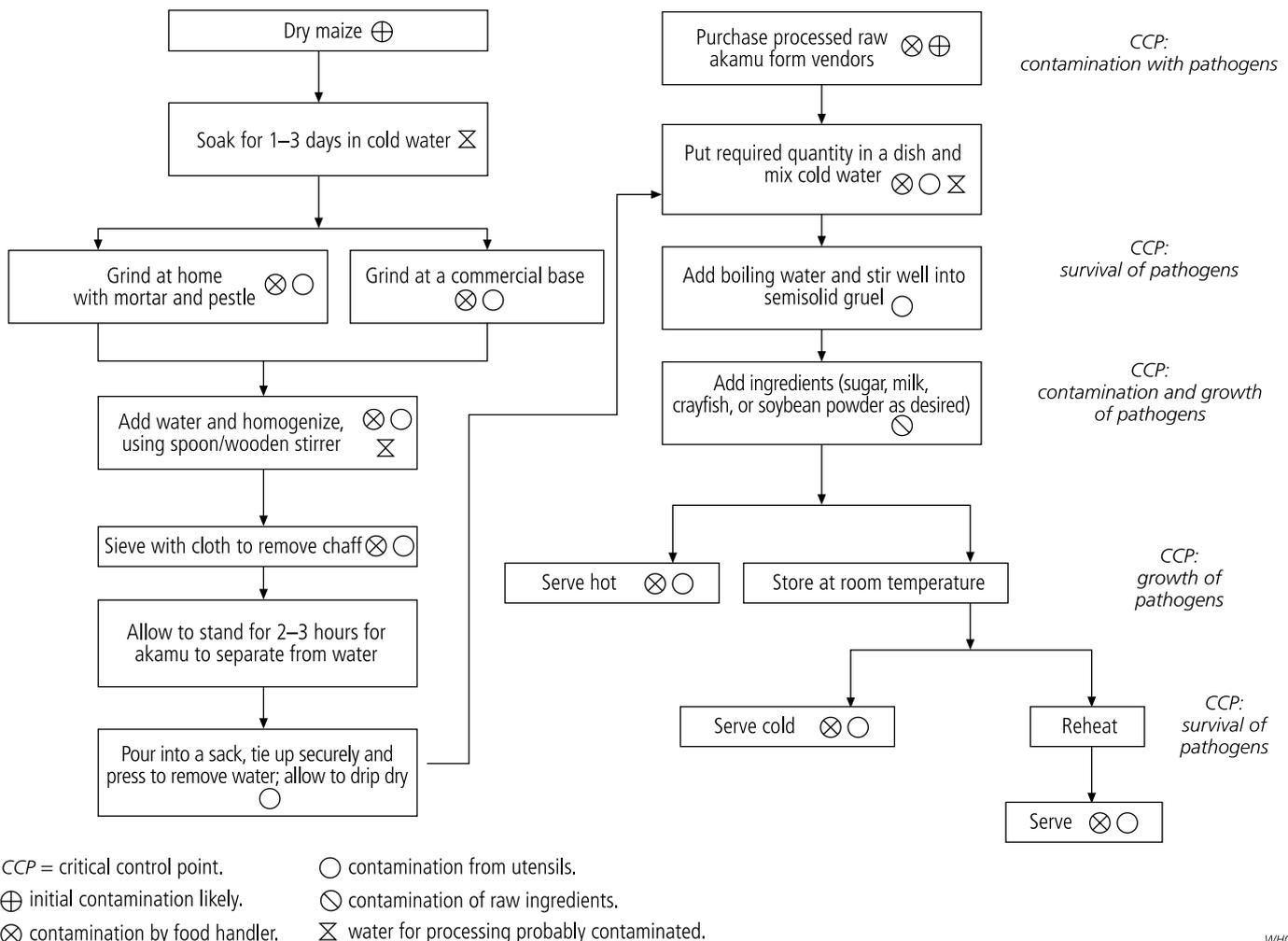
### Water quality

While high counts of faecal coliforms in water usually indicate heavy and recent pollution, their absence does not guarantee that the water is free from faecal contamination, since coliforms die rapidly in water. Of greater public health concern is the level of contamination with *Enterococcus faecalis*, because the latter do not multiply readily in water, they die less rapidly than faecal coliforms, and tend to persist even after chlorination (18). As a result, the presence of *Enterococcus faecalis* in water sources is an indication that the water sources are being polluted by faeces at a distant location (32). Although not investigated in this study, inadequate supply of chemicals owing to lack of financial resources and poor maintenance of

Table 3. Hazards and critical control points of common complementary foods and ingredients

Food	Hazards	Critical control point	Control measures	Monitoring
<b>Akamu</b>	<ul style="list-style-type: none"> <li>enteric pathogens</li> </ul>	<ul style="list-style-type: none"> <li>purchasing raw akamu from unreliable sources, including market vendors</li> <li>cooking</li> <li>addition of contaminated ingredients after heat treatment</li> <li>storage</li> <li>reheating</li> </ul>	<ul style="list-style-type: none"> <li>process at home if possible, or buy from reliable vendors with adequate protection from dust and flies; insist on use of hygienic, good-quality wrapping materials, and on minimal handling by vendor</li> <li>heat thoroughly</li> <li>add ingredients before heat treatment</li> <li>serve to child as soon as prepared, using plate and spoon rather than feeding bottle</li> <li>reheat thoroughly</li> </ul>	<ul style="list-style-type: none"> <li>check appearance of food for spoilage, check hygiene behaviour of vendor with regard to serving utensils and wrapping materials</li> <li>check for indicators of heat treatment during cooking, e.g. colour changes</li> <li>wash hands with soap during food preparation</li> <li>wash cooking facilities and utensils</li> </ul>
<b>Jollof rice</b>	<ul style="list-style-type: none"> <li>enteric pathogens</li> <li>spores of potential pathogens</li> </ul>	<ul style="list-style-type: none"> <li>cooking</li> <li>storage</li> <li>reheating</li> </ul>	<ul style="list-style-type: none"> <li>cook thoroughly</li> <li>serve as soon as prepared</li> <li>reheat thoroughly</li> </ul>	<ul style="list-style-type: none"> <li>ensure cooking is thorough by checking for colour changes, particularly of fish, meat, or other added microbiologically sensitive ingredients</li> <li>reheat thoroughly for a reasonable length of time, and check for indication of heat, e.g. bubbling</li> <li>wash hands with soap during preparation</li> <li>wash cooking facilities and utensils</li> </ul>
<b>Moi-moi</b>	<ul style="list-style-type: none"> <li>enteric pathogens</li> <li>spores of pathogens</li> </ul>	<ul style="list-style-type: none"> <li>cooking</li> <li>storage</li> <li>reheating</li> </ul>	<ul style="list-style-type: none"> <li>prepare at home if possible, or buy from reliable vendors with adequate protection from dust and flies; insist on use of hygienic, good-quality wrapping materials, and on minimal handling by vendor</li> <li>cook thoroughly during preparation at home</li> <li>serve as soon as prepared</li> <li>reheat thoroughly</li> </ul>	<ul style="list-style-type: none"> <li>check appearance of food for spoilage and hygiene quality</li> <li>ensure cooking is thorough by checking for colour changes, particularly of fish, meat, or other added microbiologically sensitive ingredients</li> <li>reheat thoroughly for a reasonable length of time, and check for indication of heat, e.g. bubbling</li> <li>wash hands with soap during preparation</li> <li>wash cooking facilities and utensils</li> </ul>
<b>Agidi</b>	<ul style="list-style-type: none"> <li>enteric pathogens</li> <li>spores of potential pathogens</li> </ul>	<ul style="list-style-type: none"> <li>cooking</li> <li>storage</li> <li>reheating</li> </ul>	<ul style="list-style-type: none"> <li>prepare at home if possible, or buy from reliable vendors with adequate protection from dust and flies; insist on use of hygienic quality wrapping materials.</li> <li>cook thoroughly if prepared at home</li> <li>serve as soon as prepared</li> <li>reheat thoroughly</li> </ul>	<ul style="list-style-type: none"> <li>check appearance of food for spoilage and hygienic quality</li> <li>ensure cooking is thorough by checking for colour changes, particularly of fish, meat, or other added microbiologically sensitive ingredients</li> <li>reheat thoroughly for a reasonable length of time, check for indication of heat, e.g. bubbling</li> <li>wash hands with soap during preparation</li> <li>wash cooking facilities and utensils</li> </ul>
<b>Soybean powder</b>	<ul style="list-style-type: none"> <li>enteric pathogens</li> <li>spores of pathogens</li> </ul>	<ul style="list-style-type: none"> <li>purchasing</li> <li>ready-to-use ground soybean powder from vendors</li> <li>handling during preparation</li> <li>storage</li> </ul>	<ul style="list-style-type: none"> <li>prepare at home if possible, or buy from reliable sources</li> <li>good personal hygiene: proper hand washing with soap, and cleaning of surfaces and utensils</li> <li>separate from raw foods, particularly those that are microbiologically sensitive</li> <li>handle minimally</li> <li>use as soon as prepared</li> </ul>	<ul style="list-style-type: none"> <li>wash hands with soap</li> <li>wash utensils</li> <li>limit storage time</li> </ul>
<b>Ground crayfish</b>	<ul style="list-style-type: none"> <li>enteric pathogens</li> <li>spores of potential pathogens</li> </ul>	<ul style="list-style-type: none"> <li>handling</li> <li>storage</li> </ul>	<ul style="list-style-type: none"> <li>good personal hygiene: proper hand washing with soap, and cleaning of surfaces and utensils</li> <li>separate from raw foods, particularly those that are microbiologically sensitive</li> <li>handle minimally</li> <li>use as soon as prepared</li> </ul>	<ul style="list-style-type: none"> <li>wash hands with soap during preparation</li> <li>wash utensils</li> <li>limit storage time</li> </ul>

Fig. 1. Flow diagram of akamu preparation and handling



equipment are likely to be important determinants of the quality of tap water in many developing countries. It should also be noted that in many of these countries the primary challenge is the lack of water, rather than its quality (33).

All study households in the urban areas admitted that taps often go dry for several weeks and that they rely on water purchased from water vendors when this happens. Although this study did not examine the microbial quality of water sold by vendors, studies in southern Nigeria (34) and in neighbouring Ghana (31) showed very high levels of contamination. In addition, lack of water for operating sewage systems in homes often increased the potential for fly breeding and for handling excreta (35).

### Cooking fuel

Cooking fuel and cooking practices are important in food hygiene since cooking and reheating temperatures are often CCPs. In situations where fuel for cooking is short supply, households may, in a bid to save energy, prepare large quantities of food in advance and then store it until needed. In the absence

of facilities for monitoring food temperature and for properly storing leftover foods, storage and reheating become important CCPs. The potential for contamination and growth of pathogens increases when microbiologically sensitive ingredients are added to stored food, particularly to akamu, and consumed without adequate reheating.

### Food-hygiene behaviour

In a few households ( $n = 13$ ), the plates and spoons used for serving food were not properly washed after previous use, and this may contribute to post-cooking contamination of the food. In the 65 households where children were fed during household meal times, all household members washed their hands (without soap) in one bowl of water before eating. This fairly common practice may contribute to food contamination in a number of ways. For example, pathogens present on hands of infected household members can be transferred to those who subsequently dip their hands in the water, including those feeding children (36). There are also potential health risks associated with methods used by

Table 4. Microbial quality<sup>a</sup> of domestic water supply

Organism	Pipe-borne <i>n</i> = 19		Borehole <i>n</i> = 6		Stream <i>n</i> = 9		Spring <i>n</i> = 8	
	Mean (range)	SD <sup>b</sup>	Mean (range)	SD	Mean (range)	SD (range)	Mean	SD
Faecal coliforms	8.74 (0–30)	8.37	2.50 (0–10)	4.18	12.33 (2–35)	10.78	3.13 (0–10)	4.18
<i>Enterococcus faecalis</i>	31.58 (0–80)	26.51	7.17 (0–20)	7.22	140.00 (12–250)	106.30	6.25 (10–20)	6.94
<b>% of sources contaminated</b>	<b>84</b>	<b>68</b>	<b>33</b>	<b>83</b>	<b>100</b>	<b>100</b>	<b>25</b>	<b>63</b>

<sup>a</sup> Measured as the number of microorganisms per 100 ml sample.

<sup>b</sup> SD = standard deviation.

parents/caregivers to test whether foods are cool enough for children, including dipping a finger (often unwashed) into cooked foods. Fingers are also normally used to feel foodstuffs and ingredients for texture and to ascertain the adequacy of manual grinding, and this also has the potential to contribute to the microbial load of the food.

### Addition of contaminated ingredients to food

In eastern Nigeria and other regions in West Africa it is common practice to add crayfish to most diets. Although the goal is usually to increase palatability, crayfish is also a major source of protein and offers the greatest nutritional benefit to poor families who cannot afford more expensive sources of protein on a regular basis. In the mid-1980s, as part of the efforts to tackle the problem of malnutrition in the region, parents were advised by health workers to add ground crayfish and/or soybean powder to foods given to children. Although no studies have been undertaken to evaluate the impact of this intervention on child nutrition, there is a feeling that this could be a cost-effective way to control protein malnutrition in children (37). However, repeated handling of crayfish and soybean powder during preparation and storage for long periods of time increase the potential for contamination and growth of pathogens. Unfortunately, these important ingredients are often added after heat treatment, thus increasing the potential for contamination.

### Purchasing of foods and ingredients from vendors

Purchasing ready-to-use foods and ingredients from market vendors poses a considerable health risk. The reasons for this are apparent from observational data on hygiene practices in the market. Foods and ingredients are often displayed openly on tables and on the ground in very poor sanitary environments. The prevalence of flies at the markets and the apparent lack of facilities for food protection suggest a high potential for contamination. Foods and ingredients are also subjected to repeated contamina-

tion from the unwashed hands of vendors, and the materials used for wrapping, such as leaves, old newspapers, reusable polythene bags, may also be a source of contamination.

**Raw akamu.** On average, the level of contamination of raw akamu purchased from vendors in the local markets was twice as high as that prepared in households (Table 5). Unfortunately, because of the complex method of processing akamu, most parents/caregivers do not have the time to undertake the task themselves, and most young parents/caregivers even lack the knowledge of how to process it. Parents/caregivers also have competing demands on their time, including having to walk long distances to fetch water and firewood, and being involved in petty trading and other ventures that generate income to help support their families. Most parents/caregivers therefore rely on the relatively inexpensive supplies from the vendors.

**Other studies.** A study conducted by the Food and Agricultural Organization in Thailand in 1991–93 showed that vended foods contributed 88% of the total energy intake for children under six years of age; however, such foods were often heavily contaminated with pathogens that cause diarrhoea (38). Studies across Africa have also highlighted the extent of the problem posed to child health by foods sold on streets and open markets and there is now acceptance that such foods contribute significantly to morbidity and even mortality among children (39). Children may also be exposed to hazards from food and ingredients sold on streets and in open markets if an adult member of the household becomes ill following consumption of food from these sources (8).

An earlier review of the role of food hygiene promotion in preventing childhood diarrhoea in developing countries highlighted the risk of food sold on streets and in open markets, but the authors concluded that the majority of children under five years of age are unlikely to be significantly affected by these food outlets, since their foods are usually prepared and stored at home (8). While this may not be true in some settings, especially many urban trading communities in Nigeria, the benefits of hygiene measures applied during food preparation

and handling in the home may be negated if foods and ingredients purchased from vendors are already contaminated. For example, even though cooking may destroy vegetative pathogens in foodstuffs, it may not eliminate toxins or spores. Furthermore, even though vended foods may not be blamed for a major burden of childhood diarrhoea, a positive association between consumption of vended food and diarrhoea morbidity has been demonstrated in West Africa (31), and this underscores the need for the development and promotion of healthy marketplace initiatives currently supported by WHO (40).

### Storage of cooked foods

Complementary foods observed in the study communities were often cooked to temperatures capable of destroying vegetative pathogens and would therefore pose a minimal hazard to the child if consumed immediately after cooking. However, foods were typically stored either in cupboards or covered pots for an average of six hours, and often overnight. The benefits that should accrue to the few households with refrigerated storage were negated by constant and often prolonged failures in the power supply: in only 8 of the 45 households with a refrigerator was power available at the time of the study visit.

Epidemiological evidence also shows that undue delay between cooking and consumption of food is a major contributing factor to most outbreaks of food-borne diseases (41–44). This situation is particularly critical when foods are consumed without reheating and when reheating temperatures are typically well below levels capable of destroying pathogens. If knowledge of food hygiene is low, the reasons for reheating food may simply be to make it warm and improve palatability, rather than to destroy pathogens.

### Implications of the study

In situations of poverty and adverse environmental conditions, sustainable strategies for preventing diarrhoea associated with contaminated complementary foods may involve developing a protocol that permits the production of safe food in unsafe environments. Though a polluted environment poses many hazards for children's food, the hygienic quality of prepared

Table 5. Microbial quality<sup>a</sup> of foodstuff and ingredients

Organism	Soybean powder	Raw akamu <sup>b</sup>	Ground crayfish
	<i>n</i> = 17	<i>n</i> = 8	<i>n</i> = 60
	Mean (range)	Mean (range)	Mean (range)
Faecal coliforms	200 (5–410)	400 (40–900)	75 (0–31)
<i>Escherichia coli</i>	80 (0–180)	100 (12–380)	120 (5–120)
<i>Enterococcus faecalis</i>	250 (10–450)	600 (75–1100)	93 (6–240)

<sup>a</sup> Measured as the number of organisms per gram of foodstuff and ingredient.

<sup>b</sup> From market vendors.

food can be assured if basic food safety principles are observed (45). When many factors contribute to food contamination, identification of CCPs becomes particularly important and can facilitate appropriate targeting of resources and prevention efforts.

It is important to note that HACCP evaluations are of little value if the results are not used to educate food handlers to improve hygiene practices and to devise other feasible and culturally appropriate measures to promote food safety. It is hoped that this report will contribute not only to advancing current knowledge about CCPs in the preparation and handling of children's foods, but also to the development and implementation of interventions that promote complementary food hygiene in the region studied and in similar settings. ■

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## Résumé

### Points de contrôle critiques dans la préparation et la manipulation des aliments de complément dans l'est du Nigéria

**Objectif** Etudier la contamination microbienne et les points de contrôle critiques (PCC) dans la préparation et la manipulation des aliments de complément dans 120 ménages de l'Etat d'Imo au Nigéria.

**Méthodes** L'approche HACCP (analyse des risques – maîtrise des points critiques) a été utilisée pour rechercher les procédés et modes opératoires qui contribuent à la contamination microbienne ainsi qu'au développement et à la survie des germes, et identifier les

points où des contrôles pourraient être exercés afin de prévenir ou éliminer ces risques microbiologiques ou de les réduire à des niveaux acceptables. Des échantillons d'aliments ont été recueillis et soumis à des analyses microbiologiques à divers stades de leur préparation et de leur manipulation.

**Résultats** Pendant la cuisson, tous les aliments atteignaient une température capable de détruire les formes végétatives des agents pathogènes transmis par

voie alimentaire. Cependant, le risque de contamination augmentait lorsque les aliments étaient conservés à température ambiante, lorsqu'ils étaient réchauffés à une température insuffisante, et lorsque des ingrédients contaminés, par exemple de la poudre d'écrevisse ou de la poudre de soja, étaient ajoutés à un stade où l'aliment n'était plus soumis à un traitement par la chaleur. L'achat de denrées et d'ingrédients crus, en particulier d'*akamu* cru, sur les marchés de plein air constitue également un point de contrôle critique.

**Conclusion** Bien qu'un environnement insalubre comporte de nombreux risques en ce qui concerne les aliments destinés aux enfants, la qualité hygiénique des aliments préparés peut être assurée par le respect de principes de base en matière d'hygiène alimentaire. Lorsque de nombreux facteurs contribuent à la contamination des aliments, l'identification des points de contrôle critiques devient particulièrement importante et peut faciliter le ciblage approprié des ressources et des efforts de prévention.

## Resumen

### Puntos críticos de control en la preparación y manipulación de alimentos complementarios en el este de Nigeria

**Objetivo** Investigar la contaminación microbiana y los puntos críticos de control (PCC) en la preparación y manipulación de alimentos complementarios en 120 hogares del Estado de Imo (Nigeria).

**Métodos** Se empleó el sistema de análisis de peligros en puntos críticos de control (HACCP) para investigar los procesos y procedimientos que favorecían la contaminación microbiana y el crecimiento y la supervivencia de los microbios, así como para identificar los puntos donde podían aplicarse controles a fin de prevenir, eliminar o reducir esos riesgos microbiológicos hasta niveles admisibles. Se sometieron a análisis microbiológico muestras de alimentos recogidas en diferentes etapas de la preparación y manipulación.

**Resultados** Durante la cocción todos los alimentos alcanzaron temperaturas capaces de destruir las formas vegetativas de los patógenos de transmisión alimentaria. Sin embargo, el riesgo de contaminación aumentó

al almacenar los alimentos a temperatura ambiente, cuando se usaron temperaturas insuficientemente altas para recalentar el alimento, y al añadir ingredientes — por ejemplo cangrejo seco molido o soja en polvo — contaminados en etapas tras las cuales no se aplicaba ningún tratamiento térmico. La compra en mercados de alimentos e ingredientes crudos, especialmente de *akamu*, contaminados también constituye un PCC.

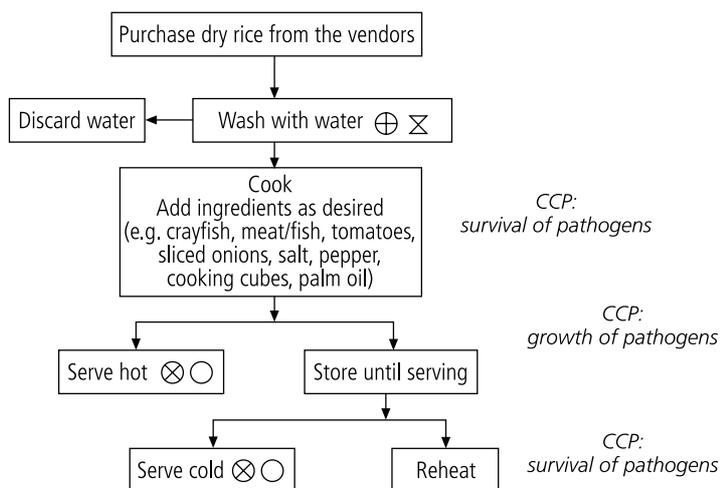
**Conclusión** Aunque un entorno insalubre acarrea muchos peligros para la alimentación de los niños, si se observan los principios básicos de inocuidad de los alimentos es posible asegurar la calidad higiénica de los alimentos preparados. Cuando la contaminación es el resultado de muchos factores, la identificación de los PCC resulta especialmente importante y puede facilitar la adecuada focalización de los recursos y de las actividades de prevención.

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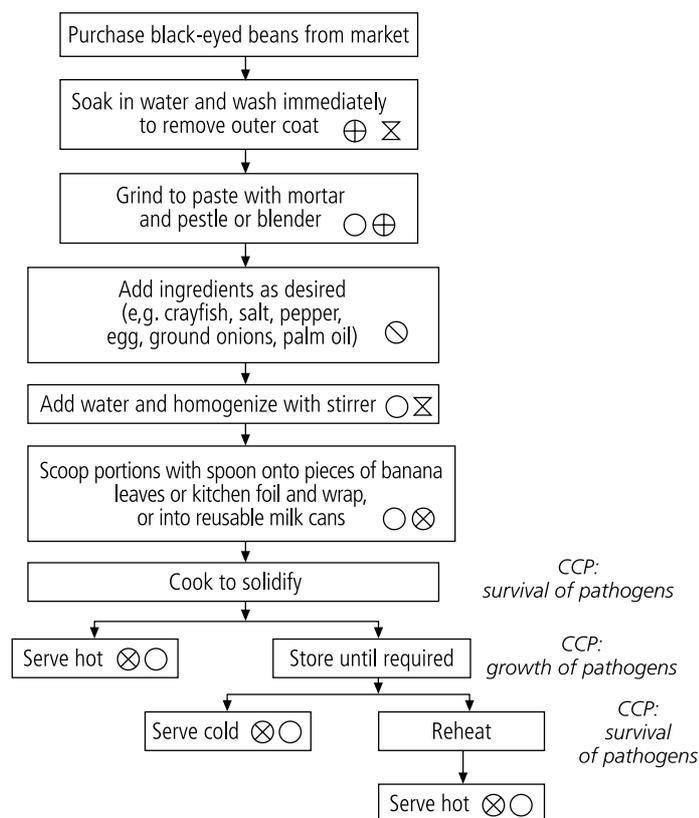
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Annex Fig. 2. Flow diagram of jolloff rice preparation and handling



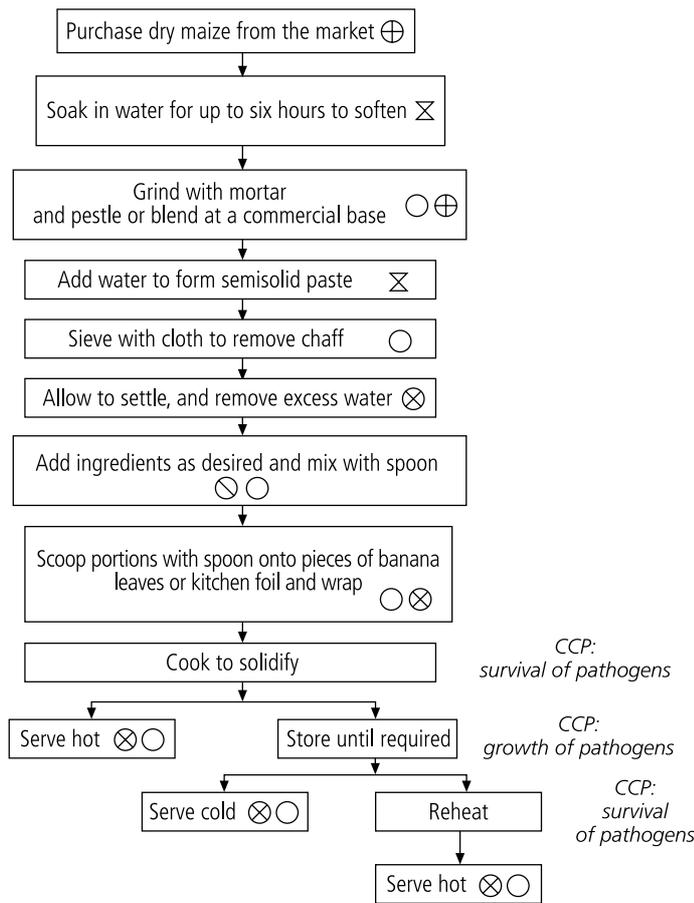
CCP = critical control point.      ○ contamination from utensils.  
 ⊕ initial contamination likely.      ⊗ water for processing probably contaminated.  
 ⊗ contamination by food handler.      WHO 01.53

Annex Fig. 3. Flow diagram of moi-moi preparation and handling



CCP = critical control point.      ○ contamination from utensils.  
 ⊕ initial contamination likely.      ⊙ contamination of raw ingredients.  
 ⊗ contamination by food handler.      ⊗ water for processing probably contaminated.  
 WHO 01.54

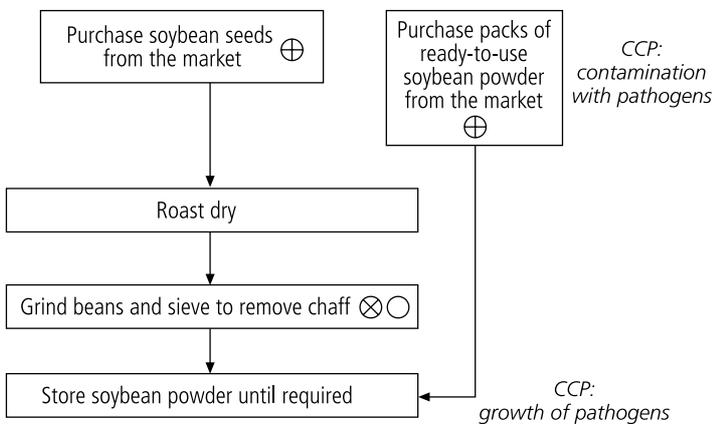
Annex Fig. 4. Flow diagram of agidi preparation and handling



CCP = critical control point.      ○ contamination from utensils.  
 ⊕ initial contamination likely.      ⊙ contamination of raw ingredients.  
 ⊗ contamination by food handler.      ⊗ water for processing probably contaminated.

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Annex Fig. 5. Flow diagram of soybean powder preparation



CCP = critical control point.  
 ⊕ initial contamination likely.  
 ⊗ contamination by food handler.  
 ○ contamination from utensils.

WHO 01.56