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Bacteriological Quality of Weaning Food and Drinking Water Given to Children of Market Women in Nigeria: Implications for Control of Diarrhoea

Christian U. Iroegbu[1*], Henrietta N. Ene-Obong[2], Ada C. Uwaegbute[2], and Uche V. Amazigo[3]

Departments of [1]Microbiology, [2]Home Science and Nutrition, and [3]Zoology, University of Nigeria, Nsukka, Enugu State, Nigeria

ABSTRACT

Bacteriological quality of weaning food and drinking water given to 2 groups of children aged £2 years was evaluated by estimating bacterial cell count. One group consisted of those taken to market and the other of those left at home in the care of older siblings or house-helps. Bacterial counts (geometric mean) ranged from 5.02±1.82 to 8.70±1.0 $\log_{10}$ cfu per g or mL of food, and from 1.15±1.67 to 6.53±0.81 $\log_{10}$ cfu per g or 100 mL of water. Analysis of variance showed no significant difference in counts between types of food and between meals (breakfast and lunch). Bacterial contamination increased significantly with storage time, and was, in all circumstances except the water samples, significantly higher in foods given to children left at home. Reheated leftover foods also had significantly higher bacterial load than the freshly-cooked food. Coliform count varied significantly with source of drinking water. Poor hygiene standard (inferred from bacterial contamination) was generally observed among mothers weaning £2-year-old children, while they were engaged in trading activities in the market, thus exposing their children to high risk of diarrhoea. Hygiene was significantly poorer in weaning of children left at home in the care of older siblings or house-helps. This implies that, in spite of their trading activities in the market, mothers still take better care of their babies than the older siblings or house-helps who may be inexperienced. These mothers may need education on childcare and food hygiene to suit to their trading activities, for example, during their monthly meetings. There is also a need to establish ORT (oral rehydration therapy) corners in the markets as part of the municipal services. This can be used not only for efficient and quick management of diarrhoea in the market but also for reinforcing hygiene education.

Key words: Bacterial contamination; Infant food; Weaning; Child care; Diarrhoea, Infantile; Water supply; Water pollution

INTRODUCTION

Food handling is an important factor in food safety. This includes the safety practices among those preparing and/or serving food as well as mode and duration of food storage. Stanton and Clemens showed a positive association between frequency of hand-washing prior to food preparation and incidence of diarrhoea among consumer children, frequency of hand-washing being indicative of the level of hygiene practice (1). Black *et al.* reported increase in contamination of food at the household level with temperature and duration of storage (2). Henry *et al.* observed an increase in coliform count when there was a delay of more than 4 hours between preparation and consumption of weaning food (3). There are 2 main practices in food handling which increase the risk of food-borne diseases. First is preparation of

Correspondence and reprint requests should be addressed to: Dr. Christian U. Iroegbu
Department of Microbiology, University of Nigeria
Nsukka, Enugu State, Nigeria
Fax: 042-770644
Email: MISUNN@aol.com

food several hours before consumption and storage at temperatures that favour growth of pathogens and/or formation of bacterial toxins. Second is insufficient cooking or reheating of preserved food (4). Microbial contamination of food invariably makes the weaning period most hazardous, particularly with respect to diarrhoeal diseases. Rowland *et al*. discovered that traditional gruels used in Gambia to supplement breastmilk were often contaminated with potentially pathogenic micro-organisms, and such supplements were important factors in weaning-related diarrhoea (5).

The risk of food contamination presumably increases with mothers engaging in occupations that limit the time available for safe preparation of weaning food. Such mothers would resort to the time-saving measures, such as preparing baby's food and storing for a relatively long time or delegating caretakers or other siblings to prepare food without supervision. Women working in markets of eastern Nigeria are very good examples of this class of mothers. Some would leave their children at home with other siblings aged 7-13 years or with house-helps while engaging themselves in trading activities in the market. Others would prefer to take their children to the market, with food already prepared at home or from vendors in the market.

Microbial contamination is an indicator of the degree of safe handling of food which is a vehicle for transmission of enteric pathogens (4). Therefore, we evaluated the bacteriological quality of food and water given to children aged £2 years as an assessment of hygiene practice in child-rearing among mothers while engaging in trading activities in the market.

METHODS AND MATERIALS

Sample

The present study is part of a wider study with 663 mothers to determine the nutritional status of children of women working in 7 urban markets–6 in Enugu and one in Nsukka, Enugu State, Nigeria. Of these mothers, 157 left their children at home, and 506 took their children to market. All mothers were pooled together, and irrespective of the above categorization, every third mother in the list was requested to provide food samples for bacteriological examination. Thus, randomly, 148 mothers who took their children to market and 73 who left their children at home were requested. A total of 184 mothers consented–116 among those who took their children to market and 68 among those who did not. Nine of those requested declined consent. Four of the mothers with children in the market and 2 who left children at home objected for cultural taboo of giving away a child's food to a stranger. The other 3 with children at home left instruction that strangers should not be allowed for fear of their children being kidnapped. Twenty-eight of the mothers requested neither refused nor consented but remained evasive throughout the study. Day of collection of samples was not given out to avoid deliberate improvement of hygiene.

Collection of food and water samples

All food and water samples were collected once (except for those revisited) in sterile disposable containers (Sterilin). Each sample was properly identified with a code number, name of the subject, meal (breakfast or lunch, no supper food collected), type of food, and time lag between cooking/heating and feeding (if known). For water, only the source was requested. Where more than one type of food was given to a child simultaneously, both were mixed as they would be eaten, and the result reported along with 'other foods.' Further information was sought from the child's mother or caretaker on whether the food was freshly cooked or leftover from the previous day's dinner. Samples were sent to the laboratory within 4 hours of collection in a cold box containing ice-blocks. Table 1 shows the distribution of samples collected. Thirty mothers were re-visited–15 serving freshly-cooked food and 15 serving

Table 1. Characteristics of food and water samples collected for analyses

Identification of sample	Mothers who took child to market (n=116)	Mothers who did not take child to market (n=68)
Meal sampled		
Breakfast	40	28
Lunch	76	40
Total	**116**	**68**
Type of food sampled		
Agidi	12	2
Beans	14	3
Foo-foo/soup	12	12
Moin-moin	5	1
Pap	19	11
Okpa	5	4
Rice	25	14
Yam	10	6
Others	14	15
Total	**116**	**68**
Time from preparation to serving (in hours)		
<1	18	17
1-3	12	11
>3	17	18
Not determined	69	22
Total	**116**	**68**
Source of sampled drinking water		
Tap	31	11
Tanker	21	10
Stream	3	2
Total	**55**	**23**

reheated food–from whom samples were collected and examined immediately.

Enumeration of bacteria

Approximately 0.2 g of each food sample was weighed in a sterile Bijou bottle on a Mettler H8 balance. The sample was crushed with sterile glass rod, blended in 2 mL of sterile saline and serially diluted. Duplicate plates of trypticase soy agar (TSA) were inoculated with 0.2 mL of each dilution, and the inoculum spread over the agar surface with a sterile (bent) glass rod. After 24 hours of incubation at 37 °C, the plates were examined and colonies counted.

Coliform count for water samples was done by membrane filtration technique on Eosin Methylene blue agar (EMB-A). Water sample (100 mL) was filtered through a 0.45 mm membrane filter (Millipore) after which the filter was aseptically removed with sterile forceps and placed on EMB-A. Heavily-contaminated samples were repeated after 10^1-10^3-fold dilution with sterile saline. Presumptive coliform colonies with or without metallic sheen on EMB-A were selected at random and verified in lactose broth (6) for gas production.

Statistical analysis

Analysis of variance (ANOVA), Fisher's Least Significant Difference (F-LSD) and Student's *t*-test statistics (7) were used for comparing the geometric means of bacterial counts.

RESULTS

The 184 food samples examined consisted of 18 food types categorized into 9 groups (Table 2), and 78 water samples were from 3 main sources (Table 3). Altogether, bacterial counts (geometric means) ranged from 5.02±1.82 to 8.70±1.0 $\log_{10}$ cfu per g or mL of food (Table 2). Statistical analysis (ANOVA) showed no significant difference in counts between types of food ($F_{cal.}$=0.94, $p<0.05$) or between foods served as breakfast or lunch (Table 4; $p<0.05$). In both the study groups, bacterial load increased significantly with increase in storage time, i.e. interval between preparation and consumption (Table 5; $F_{cal.}$=23.15; $p<0.01$). The contamination was also higher in the foods served to children left at home ($F_{cal.}$=4.63; $p<0.05$). Table 6 shows the bacterial counts (geometric means) obtained from freshly-cooked, overnight reheated foods, and foods bought from vendors. Reheated leftover foods had significantly higher counts than freshly-cooked or foods bought from vendors ($F_{cal.}$=39.12; $p<0.01$). Again, significantly higher contamination was observed in overnight reheated or other foods served to children left at home ($F_{cal.}$=6.31; $p<0.05$). This is confirmed by Student's *t*-test for comparison of the geometric mean count of freshly-cooked food and overnight reheated food collected immediately after preparation or reheating (Table 7). The reheated leftover had significantly higher bacterial load than the freshly-cooked foods ($F_{cal.}$=10.05; $p<0.01$). Bacterial counts in water samples ranged from 1.15±1.67 to 6.53±0.81 $\log_{10}$ cfu per g or 100 mL. The

Table 2. Bacterial contamination (geometric mean count, GMC) in relation to type of food

Type of food	Source of food sample			
	Mothers who took child to market (n=116)		Mothers who did not take child to market (n=68)	
	Frequency (%)	GMC±SD ($\log_{10}$ cfu/g or mL)	Frequency (%)	GMC±SD ($\log_{10}$ cfu/g or mL)
Agidi	12 (10.3)	6.31±2.3	2 (2.9)	5.94±2.73
Beans	14 (12.1)	6.87±1.72	3 (4.4)	8.70±1.00
Foo-foo/soup	12 (10.3)	8.25±0.95	12 (17.6)	7.41±1.00
Moin-moin	5 (4.3)	7.45±0.08	1 (1.5)	6.67±0.00
Pap	19 (16.4)	5.28±1.93	11 (16.2)	6.20±2.42
Okpa	5 (4.3)	7.56±1.16	4 (5.9)	7.52±1.38
Rice	25 (21.6)	6.97±1.49	14 (20.6)	6.49±2.14
Yam	10 (8.6)	5.38±2.14	6 (8.8)	7.70±1.68
Others	14 (12.1)	5.02±1.82	15 (22.1)	7.64±2.22

Table 3. Bacterial coliform contamination (GMC, cfu/100 mL) according to source of drinking-water sample

Source of sampled drinking water	Subjects consuming water			
	Children taken to market		Children not taken to market	
	Frequency (%)	GMC±SD ($\log_{10}$ cfu/g or mL)	Frequency (%)	GMC±SD ($\log_{10}$ cfu/100 mL)
Tap	31/55 (56.4)	1.50±1.27	11/23 (47.8)	1.15±1.67
Tanker	21/55 (38.2)	3.90±1.12	10/23 (42.5)	3.19±1.31
Stream	3/55 (5.5)	6.53±0.80	2/23 (8.7)	5.51±1.10

Table 4. Bacterial contamination (GMC, cfu/g/mL) in relation to meal sample

Meal sample from	Source of food			
	Mothers who took child to market (n=116)		Mothers who did not take child to market (n=68)	
	Frequency (%)	GMC±SD (log_{10} cfu/g or mL)	Frequency (%)	GMC±SD (log_{10} cfu/g or mL)
Breakfast	40 (34.5)	3.95±2.03	28 (41.2)	6.23±2.00
Lunch	76 (65.5)	7.19±1.49	40 (58.86)	7.40±2.35
Supper	ND	ND	ND	ND

ND = Not determined

Table 5. Bacterial contamination (GMC, cfu/g/mL) in relation to duration of storage

Time interval between food preparation and serving (in hours)	Source of food sample			
	Mothers who took child to market (n=116)		Mothers who did not take child to market (n=68)	
	Frequency (%)	GMC±SD (log_{10} cfu/g or mL)	Frequency (%)	GMC±SD (log_{10} cfu/g or mL)
<1	18 (15.5)	4.39±1.51	17 (25.0)	5.16±2.26
1-3	12 (10.3)	5.93±2.74	11 (16.1)	7.53±2.16
>3	17 (14.7)	7.73±2.19	18 (26.5)	8.05±1.77
Not determined	69(59.5)	–	22 (32.4)	–

Table 6. Bacterial contamination (GMC) distributed according to state of food

State of food	Source of food			
	Mothers who took child to market (n=116)		Mothers who did not take child to market (n=68)	
	Frequency (%)	GMC±SD (log_{10} cfu/100 mL)	Frequency (%)	GMC±SD (log_{10} cfu/g or mL)
Freshly-cooked	34 (29.3)	4.90±2.05	34 (50.0)	5.21±2.25
Leftover (overnight)	16 (13.8)	8.39±1.42	17 (25.0)	9.19±0.80
Bought from vendor	59 (50.9)	6.66±2.45	15 (22.1)	6.55±1.60
Not determined	7 (6.0)	–	2 (2.9)	–

Table 7. Comparison of bacterial count (GMC, cfu/g/mL) in freshly-cooked food and reheated leftover immediately after preparation

State of food	Frequency (%)	Geometric mean count, GMC (log_{10} cfu/g or mL)	Standard deviation, SD
Freshly-cooked	15 (50)	1.68	±0.96
Reheated leftover	15 (50)	6.47	±1.59

coliform counts varied significantly with source of water (Table 3; F_{cal}.=47.10; $p<0.01$), the highest load being in stream water, followed by tanker water, and the least in tap water. However, there was no significant difference in the counts in water collected from the two groups of children (F_{cal}.=0.74; $p>0.05$).

DISCUSSION

Factors of food hygiene include handling, preparation, and storage practices, and these are generally evaluated from the level of bacterial contamination (8). In this work, bacterial count was adopted as a measure of hygiene standard of food and water given to £2 year-old children while their mothers were engaged in trading activities in the market.

Overall, the foods given to the 2 groups of study children were highly contaminated, and this probably increases the risk of diarrhoea (3,5). In a parallel study, Ene-Obong *et al*. (9) observed high prevalence of diarrhoea among these children of market women. Like other reported investigations in developing countries (3,5,10-12), this contamination may be linked to food hygiene practices. In this study, the level of contamination does not depend on the type of food, rather it depends largely on preparation and storage. Thus, counts in foods left overnight and reheated were significantly higher than in foods bought from vendors, and the counts in these foods were significantly higher than in freshly-cooked foods. Bacterial counts also increased with the duration of storage. A few food items sold by vendors were prepared in the previous night before the market day,

but most are cooked early in the morning of the market day. Therefore, these and the foods categorized as freshly-cooked had longer time lapse between cooking and serving (or sample collection).

The greater contamination found in the food fed to the children left at home in the care of other siblings or house-helps indicates even poorer hygiene practices among this group in the absence of the mothers. This implies that, in spite of their trading activities in the market, mothers still take better care of their babies (if they take the babies along to the market) than older siblings or house-helps who may be inexperienced. To worsen the hygiene situation, mothers who left their children at home relied more heavily on reheated foods or foods prepared and stored to be given much later by the caretaker–the 2 conditions that are known to favour bacterial multiplication (3). Lack of time for food preparation seems to be the major factor influencing the decision of market women to adopt food-preparation practices that can be detrimental to child health. This is not to overlook the element of poverty constraining some mothers to economize on fuel, time, and food. Thus, they take to insufficient reheating, preparation of large quantities at a time, and subsequent storage of the remainder, most often at ambient temperature. Storage at ambient temperatures creates an even greater risk, because such temperatures are more favourable to multiplication of micro-organisms, and in some cases, production of toxins.

Availability of safe water may be central to satisfactory practice of food hygiene. All water sources in this study were contaminated by coliforms, precisely *Escherichia coli*, to a level higher than the "<10 coliform per 100 mL maximum" allowed by WHO for small community supplies (13). *E. coli* in drinking water suggests recent faecal contamination, thus further increasing the risk of ingesting the pathogen in untreated water (14). *E. coli* contamination of tap water may arise from the use of containers already contaminated from other sources, since these containers are used for whatever water is available. Higher contamination in stream water and water from commercial tankers is expected. First, tanker drivers often collect water from streams where they do not have to pay. The streams on their part are often contaminated by run-off water flowing over ground where human defaecation has occurred.

From the point of view of food hygiene, a laudable advice to mothers in general may be to give their children only freshly-cooked food and to boil all drinking water. This simple piece of advice is difficult to implement when mothers, such as market women, are considerably constrained in their time (5) besides the preparation of food for the children; and when, as a result of poverty, they may not afford the cost of fuel. The results of this study definitely suggest a need for education on childcare and food hygiene to this category of mothers. For this to be attended by the target group, it must be arranged to suit their trading activities; for example, during their monthly general meetings, since these mothers may not be persuaded to suspend their trading activities on other occasions. There is also a need to establish ORT (oral rehydration therapy) corners in the markets as part of the municipal services. These can be used not only for efficient and quick management of diarrhoea in the markets but also for reinforcing hygiene education.

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