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Microbiological Analyses of Commonly Used Local Complementary Foods in North Western Nigeria

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Studies on microbiological concentration of commonly used local complementary foods in three states of North Western Nigeria were carried out. Total aerobic count in complementary foods from Kaduna state was greater than the 10^4 permissible limits. Unacceptable levels of *Salmonella* and *Shigella* were detected in some of the samples. Results also indicated the predominance of *Staphylococcus* sp. and fungi and molds, which showed that the levels of contamination of some of the samples are very high when compared to International Standards. Attention needs to be paid to the specific behaviours surrounding feeding and any constraints to care as important interventions in order to improve feeding practices in Northern Western Nigeria.

Key words: Nigeria, North West, malnutrition, complementary foods, microbiological analyses

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INTRODUCTION

Complementary feeding period is the time when malnutrition starts in many infants contributing significantly to the high prevalence of malnutrition in children under 5 years of age (Daelmans and Saadeh, 2003) and the deficits acquired at this age are difficult to compensate for later in childhood (Martorell *et al*., 1994). Illness due to contaminated foods is one of the most widespread health problems in the contemporary world which plays a major role in the occurrence of diarrheal diseases and transmission of this infection occurs by direct contact, which is highly favored by the habits and customs of the people, improper storage and handling of cooked food is equally responsible for food-borne illnesses (Sheth and Dwivedi, 2006). Improving complementary feeding is of highest priority for infant and young children because of its crucial role in preventing mortality and enhancing children development (Lutter and Dewey, 2003).

In Nigeria, 42% of children are stunted, 10% wasted and 25% underweight (NFCNS, 2004). The data available on the regional prevalence of diarrhoea, undernutrition and under 5 mortality in Nigeria showed a strong interaction among these factors, with each of them far more prevalent in the northern than in the southern part of Nigeria (UNICEF, 2001). Exclusive breastfeeding helps to ward off the risk of illness, but the early introduction of other liquids and solids, often prepared in insufficiently hygienic conditions increases the likelihood of infection, resulting in potentially life-threatening conditions such as diarrhoea (UNICEF, 2001). It is hypothesized that the household level nutritional practices could be responsible for the high level of malnutrition in Northern Nigeria. This magnitude of malnutrition deserve urgent attention knowing the consequences of malnutrition as it affects survival and health, education and the economy of the nation (NFCNS, 2004).

The present study was conducted to assess the level of microbial load in commonly used local complementary foods in North Western Nigeria.

MATERIALS AND METHODS

Sample collection: This study was carried out in North Western Nigeria during the year 2005 using the Multiple Indicator Cluster Surveys (MICS) zones and Nigeria Demographic and Health Survey (NDHS) 1990 zones, which was based on agro-ecological zones of the country (UNICEF, 2001). Three States (Kaduna, Kebbi and Niger States) based on Principal Food Crop grown in the Northwest zone were randomly selected for the study. Representative food samples were collected from mothers with children more than 6 but less than 24 months in a mother/child pair while in the absence of the biological mother, the person considered as the child's caretaker (Father, Aunt, Grandmother) was eligible. Food samples were transported in coolers (4°C) to the laboratory for microbiological analyses.

Microbiological analyses: All microbiological analyses were carried out based on procedures recommended in the International Commission on Microbiological Specification for Foods (ICMSF, 1996). An appropriate serial dilution of all the commonly used local complementary food samples was carried out and 0.1 mL of the selected dilution was spread on triplicate plates using sterile glass spreader. This technique was used for the enumeration of total aerobic count, *E. coli* counts, *Staphylococcal* counts, *Salmonella* and *Shigella* counts and fungi and molds counts on Nutrient Agar, Eosin Methylene Agar, *Salmonella* and *Shigella* Agar and Sabourand Glucose Agar. Media used were prepared according to the manufacturers instructions.

Analysis of data: Analysis of data was done using the Microsoft Excel data analysis package for windows. Frequencies for various responses for the commonly used local complementary foods were generated. Results for the microbiological analyses were expressed as mean±standard deviation. The difference between groups of each parameter was determined using the t-test and statistical significance were claimed at $p<0.05$ (95% confidence limit).

RESULTS

Local complementary foods in Kaduna state: Total aerobic count of organisms in KDPS ($285.33\pm12.86\times10^5$cfu g^{-1}) was significantly ($p<0.05$) higher while KDGP had the lowest count ($2.30\pm1.15\times10^5$ cfu g^{-1}). KDMP recorded highest ($p<0.05$) *E. coli* count of $129.33\pm20.13\times10^4$ cfu g^{-1} while lowest count of $2.00\pm0.41\times10^4$ cfu g^{-1} was in KDLP. *Staphylococcal* count was significantly ($p<0.05$) highest in KDFN ($77.50\pm0.71\times10^3$ cfu g^{-1}) and lowest in KDPS ($2.00\pm1.00\times10^3$ cfu g^{-1}). KDFN recorded highest ($p<0.05$) *Salmonella* and *Shigella* count of $194.50\pm22.73\times10^3$ cfu g^{-1} followed by KDMP which had $85.00\pm4.50\times10^3$ cfu g^{-1} and KDPS with $66.67\pm6.01\times10^3$ cfu g^{-1}. The fungi and mould count results showed that KDMP had the highest count of $386.67\pm106.16\times10^4$ cfu g^{-1} followed by KDPS and KDFN which gave counts of $173.33\pm4.16\times10^4$ cfu g^{-1} and

100.33±12.01×10^4 cfu g^{-1}, respectively. The lowest counts were recorded in KDGP (9.33±2.52×10^4 cfu g^{-1}) and KDLP (9.50±0.19×10^4 cfu g^{-1}) (Table 1).

Local complementary foods in kebbi state: The highest total aerobic count of organism was in KBFN (24.33±6.11×10^5 cfu g^{-1}) which was significantly different from KBDM (12.33±0.58×10^5 cfu g^{-1}). *E. coli* count were also recorded in KBFN (32.50±3.54×10^4 cfu g^{-1}) and KBDM (3.00±1.41×10^4 cfu g^{-1}) which are significantly different ($p<0.05$). Significantly ($p<0.05$) higher *Staphylococcal* counts was recorded in KBDM (17.67±4.04×10^3 cfu g^{-1}) while KBGP had the lowest counts of 2.00±0.00×10^3 cfu g^{-1}. For *Salmonella* and *Shigella* count KBGP recorded the highest (480.10±40.50×10^3 cfu g^{-1}) followed by KBFN and KBMP which both recorded the lowest counts (Table 2). Fungi and Mold counts of organism in local complementary foods in Kebbi state was significantly ($p<0.05$) higher in KBMP with 239.33±52.54×10^4 cfu g^{-1} compared to the other samples from the state.

Local complementary foods in Niger state: Results in Table 3 showed the mean count of organisms in commonly used complementary foods in Niger state. Total aerobic count of organism in NGTW (27.00±9.54×10^5 cfu g^{-1}) was higher significantly ($p<0.05$) compared to NGFN (1.50±0.71×10^5 cfu g^{-1}) and NGMG (10.67±4.04×10^5 cfu g^{-1}). *E. coli* counts in NGFN (90.33±22.68×10^4 cfu g^{-1}) was also significantly ($p<0.05$) higher than NGRG (2.33±0.31×10^4 cfu g^{-1}). *Staphylococcal* count showed that NGRG with 2.67±0.00×10^3 cfu g^{-1} counts was significantly ($p<0.05$) lower than that obtained in NGFN and NGTW. The highest count of *Salmonella* and *Shigella* was in NGFN with 63.67±11.06×10^3 cfu g^{-1} compared to NGTW which had 3.33±1.15×10^3 cfu g^{-1}. Significantly ($p<0.05$) higher fungi and mould count were in NGFN and NGTW which had 47.67±4.04×10^4 cfu g^{-1} and 43.50±2.12×10^4 cfu g^{-1}, respectively than NGRG with 13.00±8.66×10^4 cfu g^{-1}. NGMG did not showed any growth for *E. coli*, *Staphylococcal*, *Salmonella* and *Shigella* and Fungi and Mold (Table 3).

Most probable number of organism (MPN): For those used in Kaduna state, KDFN had highest number of organism (430 MPN g^{-1}) while KDLP recorded the lowest (7 MPN g^{-1}). KBDM commonly used in Kebbi state had >1600 MPN g^{-1} of sample and the lowest number was in KBLP with 25 MPN g^{-1}. Niger state samples showed that NGTW had the highest (24 MPN g^{-1}) followed by NGRG (17 MPN g^{-1}) and NGFN (15 MPN g^{-1}) while NGMG had <2 MPN g^{-1} (Table 4).

Table 1: Mean count of organisms in commonly used local complementary foods in Kaduna state (cfu g^{-1})

Complementary foods	Total aerobic count×10^5	*E. coli* count×10^4	Staphylococcal count×10^3	*Salmonella* and *Shigella*×10^3	Fungi and Mold count×10^4
KDFN	11.00±1.41^b	9.67±5.51^c	77.50±0.71^a	194.50±82.73^a	100.33±12.01^c
KDGP	2.30±1.15^c	NG	15.00±9.90^b	NG	9.33±2.52^d
KDLP	NG	2.00±0.41^d	8.00±4.24^b	NG	9.50±0.19^d
KDMP	21.67±9.50^b	129.33±20.13^a	14.00±5.29^b	85.00±49.50^{ab}	386.67±106.16^a
KDPS	285.33±12.86^a	43.00±4.24^b	2.00±1.00^c	66.67±10.01^b	173.33±4.16^b

Values are means±SD of triplicate determinations, Values in the same column with different superscripts are significant ($p<0.05$). NG = No Growth, KDFN = Fura nono, KDGP = Guinea corn pap, KDLP = Millet pap, KDMP = Maize pap and KDPS = Maize Porriage (pate)

Table 2: Mean count of organisms in commonly used local complementary foods in Kebbi state (cfu g^{-1})

Complementary foods	Total Aerobic count×10^5	*E. coli* count×10^4	*Staphylococcal* count×10^3	*Salmonella* and *Shigella*×10^3	Fungi and Mold count×10^4
KBDM	12.33±0.58^b	3.00±1.41^b	17.67±4.04^a	TNTC	95.33±25.42^b
KBFN	24.33±6.11^a	32.5±3.54^a	NG	38.00±4.24^b	84.00±32.91^b
KBGP	NG	NG	2.00±0.00^c	105.50±7.78^a	22.50±0.71^c
KBLP	NG	NG	12.00±0.40^b	NG	76.67±18.72^b
KBMP	NG	NG	NG	31.00±7.55^b	239.33±52.54^a

Values are means±SD of triplicate determinations, TNTC = Too Numerous To Count, Values in the same column with different superscripts are significant ($p<0.05$), NG = No growth, KBPS = Tuwo (Dami), KBFN = Fura nono, KBGP = Guinea corn pap, KBLP = Millet pap and KBMP = Maize pap

Table 3: Mean count of organisms in commonly used local complementary foods in Niger state (cfu g^{-1})

Complementary foods	Total aerobic count×10^5	*E. coli* count×10^4	*Staphylococcal* count×10^3	*Salmonella* and *Shigella*×10^3	Fungi and Mold count×10^4
NGFN	1.50±0.71^c	90.33±22.68^a	57.00±28.28^a	63.67±11.06^a	47.67±4.04^a
NGMG	10.67±4.04^b	NG	NG	NG	NG
NGRG	NG	2.33±0.31^b	2.67±0.00^b	NG	13.00±8.66^b
NGTW	27.00±9.54^a	NG	27.67±4.73^a	3.33±1.15^b	43.50±2.12^a

Values are means±SD of triplicate determinations Values in the same column with different superscripts are significant ($p<0.05$), NGFN = Fura nono, NGMG = Guinea corn/millet pap, NGRG = Rice/groundnut pap, NGTW = Tuwo and NG = No Growth

Table 4: Most probable number of organism (MPN) in commonly Used local complementary foods

State/complementary foods	MPN g^{-1}
Kaduna State	
KDFN	430
KDGP	11
KDLP	7
KDMP	14
KDPS	39
Kebbi State	
KBDM	>1600
KBFN	48
KBGP	430
KBLP	25
KBMP	1600
Niger State	
NGFN	15
NGMG	<2
NGRG	17
NGTW	24

KDFN = Fura nono, KDGP = Guinea corn pap, KDLP = Millet pap, KDMP = Maize pap, KDPS = Maize Porriage (pate), KBPS = Tuwo (Dami), KBFN = Fura nono, KBGP = Guinea corn pap, KBLP = Millet pap, KBMP = Maize pap, NGFN = Fura nono, NGMG = Guinea corn/millet pap, NGRG = Rice/groundnut pap and NGTW = Tuwo

DISCUSSION

Studies have shown that poor drinking water facilities, inadequate sanitary facilities and poor hygiene, particularly during food preparation are the main causes of many infections among the young children (WHO, 1993). And the best way to ensure that food and water are free from contamination is to heat them to a sufficiently high temperature (>70°C) immediately prior to serving. Microbiological analyses are useful ways to assess the safety and quality of food. Aerobic colony count is a count of viable bacteria and it indicates the level of microorganisms in a product. Total aerobic count in complementary foods from Kaduna state was greater than the 10^4 permissible limits (ICMSF, 1996) except for KDLP that had satisfactory level (Table 1). Unsatisfactory levels of aerobic colony counts were detected in KBDM and KBFN (Table 2) while other samples from Kebbi state recorded satisfactory levels. Levels of aerobic colony counts in complementary foods obtained in Niger state (Table 3) were found to be unsatisfactory except for NGRG which was satisfactory when compared to microbiological quality standards (ICMSF, 1996).

Indicator organism refers to the selected surrogate markers and the main objective of using bacteria as indicators is to reflect the hygienic quality of food. *E. coli* is commonly used as surrogate indicator and its presence in food generally indicates direct or indirect fecal contamination. Substantial number of *E. coli* in food suggests a general lack of cleanliness in handling and improper storage (ICMSF, 1996). KDGP recorded satisfactory levels of *E. coli* whereas *Staphylococcus* counts in all food samples from Kaduna state were unsatisfactory (Table 1). Acceptable level of indicator organism *E. coli* and *Staphylococcus*, an *Enterobacteriaceae* counts were detected in NGMG and NGRG (Table 3) while all other samples had unsatisfactory levels of both microorganisms. Unsatisfactory levels of *E. coli* counts also were detected in KBDM and KBFN while other samples from Kebbi state recorded satisfactory levels (Table 2). KBFN and KBMP had satisfactory levels of *Staphylococccus* counts.

The presence of *E. coli* in ready-to-eat foods is undesirable because it indicates poor hygienic conditions which have lead to contamination or inadequate heat treatment (ICMSF, 1996). Ideally *E. coli* should not be detected and as such a level of <3 g^{-1} (the limit of the Most Probable Number test) has been given as the satisfactory criteria for this organism. Levels exceeding 100 g^{-1} are unacceptable and indicate a level of contamination which may have introduced pathogens or that pathogens, if present in the food prior to processing, may have survived. The family *Enterobacteriaceae* includes many bacteria that are found in the human or animal intestinal tract, including human pathogens such as *Salmonella* and *Shigella enterobacteriaceae* are useful indicators of hygiene and of post-processing contamination of heat processed foods (ICMSF, 1996). Their presence in high numbers (>10^4 per gram) in ready-to-eat foods indicates that an unacceptable level of contamination has occurred or there has been under processing like inadequate cooking.

Specific pathogens are bacteria that may cause food poisoning and mechanisms involved may be toxins produced in food or intestinal infection. The symptoms of food poisoning vary from nausea and vomiting caused by *Staphylococcus aureus*, through diarrhoea and dehydration by *Salmonella* sp. and *Campylobacter* sp. to paralysis and death in the rare cases of botulism. The infectious doses vary from less than 10 to more than 10^6 organisms (ICMSF 1996). Unacceptable levels of *Salmonella* and *Shigella* were detected in NGFN and NGTW (Table 3) however, satisfactory levels of *Salmonella*, were recorded in KDGP and KDLP while the rest had unacceptable levels (Table 1). Ready-to-eat foods should be free of *Salmonella* as consumption of food containing this pathogen may result in food borne illness. The presence of this organism indicates poor food preparation and handling practices such as inadequate cooking or cross contamination (ICMSF, 1996).

The presence of fungi in a food product is undesirable (Adegoke, 2004) and have been implicated in food poisoning illness and also known as spoilage microorganisms (Yusuf *et al*., 1992). High levels of fungi and molds were recorded in all the commonly used local complementary foods from all the states studied (Table 1-3) except for NGMG which had satisfactory level.

Results indicates the predominance of *Staphylococcus* sp. and fungi and molds in the

complementary foods commonly used in North Western Nigeria, which indicates that the levels of contamination of foods were very high when compared to International Standards (ICMSF, 1996). There is the need for caregivers in the region to adopt strict hygienic practices (Badau *et al*., 2005). The presence of *Staphylococcus* sp. could be as a result of processors handling (Babajide *et al*., 2006) while presence of coliform is an indication of fecal contamination (Tahir and Oyawole, 1993) and they also reported that microbial quality of tap water supplied to some communities in Nigeria is poor with coliform counts exceeding recommended level. A study of complementary food preparation and handling in Eastern Nigeria also confirmed the presence of enteric pathogens and that the exotoxin of *Staphylococcus* sp. is associated with food poisoning and spores of pathogens with handlers (Ehiri *et al*., 2001). High levels of pathogens such as *Staphylococcus*, *Salmonella* and *Shigella* and *E. coli* are sometimes found in traditional foods after processing under unhygienic conditions (Mbugua and Njenga, 1991; Svanberg, 1991). The coliforms may include strains of *E. coli* which is heat stable form, as the virulence factor of enterotogenic *E. coli* strains which can withstand 100°C for 15 min (Adegoke, 2004).

CONCLUSIONS

Attention needs to be paid to the specific behaviours surrounding feeding like personal and domestic hygiene and any constraints to care and not just to the nutritional aspects of complementary foods as important interventions in order to improve feeding practices in Northern Western Nigeria. The food preparation habits of caregivers should be studied using the Hazard Analysis Critical Control Point system as a methodology.

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