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Incidence of xerophilic/xerotolerant mycobiota, fusaria, and nephrotoxigenic penicillia in some cereal baby foods imported into Uganda

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Abstract: Fifty samples of five cereal baby food products imported into Uganda were investigated for contamination by xerophilic/ xerotolerant fungi, fusaria and nephrotoxigenic penicillia**.** The dilution plate method and three selective isolation media (Dichloran 18 % glycerol agar, DG18; Peptone-pentachloronitrobenzene agar, Peptone-PCNB; and pentachloronitrobenzene rose bengal yeast extract sucrose agar, PRYES) were used for this purpose. On DG18, 9 xerophilic species were isolated, accounting collectively for 6.7% of the total fungi. Of the products investigated, Porridge oats followed by Cerelac and Cornflakes were the most heavily contaminated. Of the species encountered, those of *Eurotium* were frequent while those of *Aspergillus*, *Wallemia* and *Chrysosporium* were infrequent. On Peptone-PCNB, 9 species of *Fusarium* were recorded. Among the products, Cornflakes followed by Cerelac and Weetabix were the most contaminated with *Fusarium*. *F. tricinctum* followed by *F. solani* and *F. verticillioides* were the most common from at least three products. The other 6 species were isolated infrequently from only one product. On PRYES agar, 10 species of *Penicillium* were isolated of which 2 nephrotoxigenic species (*P. citrinum* and *P. viridicatum*), both were heavily contaminating Cerelac product. The former was also found infrequently in Cornflakes, Weetabix and Porridge oats while the latter was found in Heinz mixed cereal. Some other fungi were frequently isolated on DG18 (yeasts, *Cladosporium sphaerospermum*, *Penicillium viridicatum*, *Fusarium verticillioides* and *Aspergillus flavus*), on Peptone-PCNB (*C.sphaerospermum*, yeasts and *A. flavus*), and on PRYES (*A. flavus*, *F. solani*, *F. tricinctum* and *C. sphaerospermum*). Contamination of such baby foods by fungi (especially toxigenic ones) constitutes a health hazard for human consumption. So, these foods and their ingredients must be examined to assess their hygienic quality.

Key words: Xerophiles, nephrotoxigenic penicillia, fusaria, cereal baby foods, Uganda

Introduction

Consumption of high quality, nutritive and safe food is fundamental in promoting public health, safety and social welfare at all levels. To meet these demands, a variety of baby foods rich in carbohydrates and proteins are being produced from cereal and leguminous seeds/grains. The manufacture of such foods involves mixing the cereal flour with other ingredients such as powders of soya beans, dried fish and fruits. Fungi develop on cereal grains either in the field, during harvesting, processing, under different conditions of storage and handling before reaching the consumer (Ciegler 1975, Lacey 1988, Gourama & Bullerman 1995). They render contaminated foods not only unpalatable, but also unsafe for consumption by producing mycotoxins (Munimbazi & Bullerman 1996).

Dried foods possessed low moisture content levels. Spoilage of such foods is due to xerophilic fungi that are capable of rapid growth above 0.77 a_w and of slow growth at 0.75 a_w and below-down to about 0.68 a_w. Taligoola *et al.* (2004) and Pitt and Hocking (2009) stated that the most common causes of spoilage of dried cereals are species of *Eurotium* particularly *E. chevalieri*, *E. repens*, *E. rubrum* and *E. amstelodami*. A variety of yeasts are also common on cereal grains and flour (Kurtzman *et al.* 1970, Aran & Eke 1987, Pitt & Hocking 2009). Also, it was found that fungi particularly *F. verticillioides*, *F. proliferatum*, *F. oxysporum* and *A. flavus* can persist in maize and the molds and their toxins be carried through to maize products such as flour , corn chips and breakfast cereal (Bullerman & Tsai 1994, Zohri *et al.* 1995, Ismail *et al.* 2003, 2008).

Other ingredients such as powders of soya beans, milk, dried fish and fruits were also found to be contaminated with a wide variety of fungal species (Mislivec & Bruce 1977, Sutic *et al.* 1979, Bullerman 1979, Jarchovska *et al.* 1980, Ito & Abu 1985, Pitt *et al.* 1994, Ismail & Saad 1997, Pitt & Hocking 2009). Moreover, Sanchis *et al.* (1982) noted that certain species if humidity reaches a sufficient level would start producing toxic metabolites. Mycotoxins occurring naturally in foods are of significance in terms of food safety, and are produced mainly by species of *Aspergillus*, *Penicillium* and *Fusarium* (Bullerman 1979, 1986, Ismail *et al.* 2003, 2008, and Pitt & Hocking 2009).

In Uganda, more knowledge about fungi contaminating foods is needed. Henceforth, this work was designed to survey the xerophiles along with fusaria and nephrotoxigenic penicillia in baby foods imported to Uganda.

Materials and Methods

Fifty samples from five cereal baby food products imported into Uganda (10 tins or packets each) were randomly bought during the stage of marketing from different shops in Kampala. Each of these baby foods contained at least one or more cereal products (Table 1).

Determination of moisture content

Three sub-samples of 50 g each were taken from each food sample and put in aluminium foil dish. These were dried in an oven at 110 C for 24 hours, and reweighed (Magan & Lacey 1985, Pitt & Hocking 2009). The moisture content of each sample was expressed as the average percentage of the weight loss of the three replicates.

Mycological analysis

Dilutions were prepared by shaking 10 gms of each sample in 90 ml diluents of 0.1 % peptone water (Kurtzman *et al*. 1971). Serial tenfold dilution was prepared and 1ml aliquots were placed in sterile Petri dishes. All food samples were analyzed mycologically on three different isolation media: (1) Dichloran 18% glycerol agar (DG 18) (Hocking & Pitt 1980) which contains glycerol and glucose needed for the growth of xerophilic fungi; (2) Peptone–pentachloronitrobenzene agar medium (Peptone-PCNB) (Nash & Snyder 1962) for *Fusarium* species; and (3) Pentachloronitrobenzene rose Bengal yeast extract sucrose agar (PRYES) for isolation of nephrotoxigenic *Penicillium* species (Frisvad 1983). Plates were set up in replicates of four for each isolation medium for each sample. Cultures were then incubated at room temperature (25 – 27 ◦C) in day and night cycle of light conditions for 10-14 days (for DG 18 medium) and for 7-8 days (for PYRES plates) while under continuous light from a fluorescent tube for 7-8 days in case of Peptone-PCNB medium. The growing fungi were enumerated, isolated and identified. The identification of fungi was mainly on the basis of their macroscopic and microscopic features using the methods and keys described by Raper and Fennell (1965) for *Aspergillus* and its teleomorphs; Booth (1971), Leslie and Summerrell (2006) for species of *Fusarium*; Pitt (1979) for species of *Penicillium*; and Ellis (1971), Domsch *et al.* (1980), Moubasher (1993), and Pitt and Hocking (2009) for other fungi and yeasts.

Statistical analysis: Analysis of variance (ANOVA) was used to analyze data (Steel & Torrie 1980)

Results and Discussion

Each of the five imported baby foods had at least one or more cereal products. Heinz mixed cereal was made of a mixture of corn, oats and malted barley flours; Cornflakes had maize flour; both Cerelac and Weetabix had been made from wheat flour; and Porridge oats from rolled roasted oats.

Moisture content of the samples investigated

As shown in Table (1) Heinz mixed cereal samples had a range of moisture content from 9.8 % ± 0.2 to 10.6 % ± 0.4 with a mean of 10.09 % ± 0. 21. All Cerelac samples were characterized by low levels of moisture content which was ranging from 2.8% ± 0.2 to 3.6% ± 0.1 with a mean of 3.1 % ± 0.22. In Cornflakes samples the moisture content was ranging from 9.0 % ± 0.1 to 9.4 % ± 0.2 with a mean of 9.25 % ± 0.13. Weetabix samples had a range of moisture content from 10.2 % ± 0.2 to 10.8 % ± 0.2 with a mean of 10.62 % ± 0.29. Relatively high moisture contents were detected in Porridge oats (10.4 % ± o.4 to 11.8 % ± 0.1 with a mean of 10.82 ± 0.33). However, all these samples had moisture contents below 14.0%, the recommended level for safe storage of cereal grains and their products (Christensen & Kaufman 1974, Taligoola *et al.* 2004). Among these products, Cerelac had the lowest moisture content and Porridge oats had the highest moisture content and this reflects the low fungal content in the former and the high fungal content in the latter. The high fungal content of Porridge oats may also be due to contamination from the environment during roasting and rolling of such products.

Xerophilic and xerotolerant fungi recovered on dichloran 18 % Glycerol agar (DG 18)

Nine species belonging to 4 genera of xerophilic fungi were recovered from the five food products investigated. All xerophilic species accounted for 6.7 % of the total counts obtained on this medium. However, they were highly dominant, occurring in 54 % of the 50 samples investigated (Table 2). Porridge oats was the most heavily contaminated food with xerophiles followed by Cerelac, Cornflakes and Heinz mixed cereal while the least number of xerophiles was recorded in Weetabix.

Eurotium was the most commonly encountered xerophile (40 % of the samples accounting for 85.22 % of the xerophiles and 5.56 % of the total fungi). It was found mostly contaminating Porridge oats, followed by Cerelac and the least was in Cornflakes, Heinz mixed cereal and Weetabix. Four *Eurotium* species were recovered: *E. rubrum, E. cristatum, E. repens* and *E. chevalieri* occurring in 36 %, 26 %, 26 % and 20 % of the samples, accounting for 42.8 %,12.5 %, 22.73 % and 6.82 % of the xerophiles and 2.8 % 1.48 %, 0.82 % and 0.45 % of the total counts respectively (Table 2). These observations are consistent with other findings, whereby *E. rubrum* and *E. chevalieri* were isolated in moderate frequency from corn snacks (Zohri *et al.*1995) and

Table1. Main cereal and other components, country of origin and percentage moisture content of the baby food products investigated.

Product	**Heinz mixed cereals**	**Cerelac**	**Cornflakes**	**Weetabix**	**Porridge oats**
Main cereal components	Corn flour, oat flour, malted barley flour	Wheat flour, corn oil	Maize flour, malt flavoring	Whole wheat flour, malt extract	Rolled roasted oats
Other ingredients	Dicalcium phosphate, reduced iron, vitamins	Skim milk, sucrose, milk fat, calcium carbonate, disodium phosphate, vitamins, sodium chloride, ferrous fumarate, vanillin	Sugar, salt, niacin, iron, folic acid, thiamine (B_1), riboflavin (B_2), vitamin B_6, vitamin B_{12}	Sugar, salt, niacin, iron, folic acid, thiamine (B_1), riboflavin (B_2)	-
Country of origin	Canada	Kenya	England	England	Kenya
Sample 1	10.0 ± 0.1	3.0 ± 0.3	9.2 ± 0.1	10.4 ± 0.2	11.0 ± 0.5
2	10.0 ± 0.1	3.0 ± 0.1	9.2 ± 0.1	10.6 ± 0.0	10.6 ± 0.0
3	9.8 ± 0.2	3.2 ± 0.2	9.0 ± 0.0	10.8 ± 0.1	11.0 ± 0.5
4	10.0 ± 0.0	3.2 ± 0.2	9.2 ± 0.1	10.6 ± 0.0	10.6 ± 0.1
5	10.0 ± 0.1	3.0 ± 0.0	9.2 ± 0.1	10.2 ± 0.2	11.8 ±0.1
6	10.0 ± 0.4	3.0 ± 0.1	9.4 ± 0.2	10.4 ± 0.2	11.0 ± 0.5
7	10.6 ± 0.4	3.6 ± 0.1	9.2 ± 0.0	11.0 ± 0.5	10.8 ± 0.1
8	10.4 ± 0.2	2.8 ± 0.2	9.3 ± 0.0	10.4 ± 0.5	11.0 ± 0.5
9	10.0 ± 0.0	3.2 ± 0.2	9.2 ± 0.0	10.8 ± 0.1	10.4 ± 0.4
10	10.1 ± 0.0	3.0 ± 0.1	9.4 ± 0.1	10.8 ± 0.2	10.0 ± 0.1
Mean ± SD	10.09 ± 0.21	3.1 ± 0.22	9.25 ± 0.13	10.62 ± 0.29	10.82 ± 0.33

Figures of moisture contents for the individual samples are means of three replicates.

biscuits (Abdel-Sater & Ismail 1993). *E. chevalieri* has been also reported as the commonest spoilage fungus in stored cereal grains (Taligoola *et al.* 2004, Pitt & Hocking 2009). Aran and Eke (1987) found *E. chevalieri* in rare occurrence on wheat and absent in corn, rice and barley. On the other hand, *Eurotium* species were completely absent in milk powder (Ismail & Saad 1997), and on Kishk, a product of wheat and milk (Ismail 1993).

The xerophilic species of *Aspergillus* came second, occurring in 18 % of the samples accounting for 12.88 % of the xerophiles and 0.84 % of the total counts. They were represented by three species: *A. penicillioides*, *A. wentii*, and *A. restrictus*, all of which were infrequently encountered (Table 2). These three species were recovered in high frequency from wheat and barley (Lacey 1988). *A. wentii* was reported in rare occurrence on Kishk, a product of wheat and sour milk (Ismail 1993), on wheat grains (Moubasher *et al.* 1972). *A. wentii* was also reported in high frequencies on wheat, rice, corn and barley (Aran & Eke 1987).

Wallemia sebi and *Chrysosporium farinicola* were also infrequent, occurring in 8 % and 6 % of the samples respectively. *W. sebi* was isolated from Heinz mixed cereal and Porridge oats, while *C. farinicola* from Weetabix and Porridge oats.

Two factor analysis of variance for the common xerophilic fungi found in baby foods on DG-18 medium were tested at 5 % significance level. The analysis revealed no significant difference between the total counts of the different species ($F_{test} = 0.39 < F_{critical} = 0.6915$). Yet, there was a significant difference between fungal total counts of the different food products ($F_{test} = 3.23 > F_{critical} = 0.0742$, df = 4). Hence, there is a significant association between the xerophilic species recovered and the type of food product ($F_{test} = 2.28 > F_{critical} = 0.1389$, df = 4).

Regarding the xerotolerant fungi, 39 species belonging to 21 genera in addition to some unidentified yeasts accounting approximately for 93 % of the total counts were encountered. *Cladosporium, Penicillium, Fusarium* and *Aspergillus* were the most predominant genera.

Yeasts had the highest number of propagules encountered. However, they were isolated from 30 % of the total samples accounting for 48.52 % of the total counts. Three yeast species were isolated namely: *Brettanomyces bruxellensis* from Porridge oats, *Rhodotorula mucilaginosa* from Cornflakes and white-colored yeasts from Cerelac, Cornflakes, and Porridge oats.

Cladosporium was the most commonly encountered genus, occurring in 76 % of the samples accounting for 9.08 % of the total counts. It was recovered from the 5 products with Cornflakes being the most heavily contaminated. *C. sphaerospermum* was the most predominant species occurring in 66 % of the samples of all food products and accounting for 7.42 % of the total counts.

Penicillium was the second most frequent genus, but it had more propagules than *Cladosporium.* It was isolated from 60 % of the samples and found most heavily contaminating samples of Cerelac, followed by Heinz mixed cereal, Cornflakes, and Porridge oats. The least level of contamination with *Penicillium* was recorded in Weetabix. Of the six *Penicillium* species isolated, *P. viridicatum* (a nephrotoxigenic species) was the most common. It was recovered from Cerelac, Heinz mixed cereal, and Porridge oats. The remaining 5 species were less frequently encountered (Table 2).

Fusarium was the third common genus being recovered from 54 % of the samples accounting for 17.45 % of total fungal population. Cornflakes was the highest contaminated product with *Fusarium* species followed by Porridge oats, Cerelac, and Heinz mixed cereal, while the least contaminated product was Weetabix. Of the 5 species of *Fusarium*. *F. verticillioides* was the most common. It was recovered from 32 % of the samples accounting for 1.5 % of the total counts. The remainder of *Fusarium* species were isolated infrequently either in low (*F. tricinctum*) or rare frequency (*F. equiseti, F. poae,* and *F. solani*) (Table 2).

The xerotolerant *Aspergillus* species were also recovered from 54 % of all samples investigated, accounting for 6.11 % of the total fungal counts. *A. flavus* was the most common species (28 % of the samples, 0.41 % of the total counts). It was only isolated from Cerelac and Weetabix. The remaining aspergilli were infrequently encountered with *A. oryzae* in low, *A. niger, A. candidus, A. carbonarius, A. fumigatus, A. ochraceus,* and *A. versicolor* in rare frequency (Table 2).

Fusarium species recovered on peptone-pentachloronitrobenzene agar (Peptone-PCNB).

Nine *Fusarium* species were recovered from the five products investigated. *Fusarium* was isolated in high frequency (80 % of the samples), accounting for 52 % of the total propagules. Cornflakes had the highest contamination level followed by Cerelac, Weetabix, and Porridge oats while the lowest level was registered in Heinz mixed cereal. The finding whereby Cornflakes, a product of corn, was highly contaminated with fusaria was in agreement with earlier reports on corn (El-Kady *et al.* 1982, Abdel Hafez 1984, Logrieco *et al.* 1995, Munimbazi & Bullerman 1996). In contrast, fusaria were absent on Cornsnacks (Zohri *et al.* 1995). The low contamination levels by fusaria in Heinz mixed cereal (a product of barley, wheat and oats) is in agreement with reports of Flannigan (1970) who found fusaria in rare occurrence in oats, barley, and wheat. In contrast, fusaria were completely absent from biscuits, a product of wheat and milk (Abdel-Sater & Ismail 1993), wheat varieties (El-Maghraby

1989), and wheat and barley (Lacey 1988). These variations are expected and might be correlated with methods of food processing, and food additives as well as other environmental and geographical conditions controlling production and storage of cereals.

F. tricinctum was the most commonly encountered species with 48 % frequency. It was isolated from only 3 products (Cornflakes, Weetabix, and Porridge oats). Cornflakes were the most heavily contaminated with this species (94.03 % of the total fungi). This high incidence of *F. tricinctum* on Cornflakes, a product of corn, is consistent with the earlier findings on baby foods (Ismail *et al.* 2008), and corn (Marasas & Smalley 1972).

F. solani was contaminating 26 % of the samples, accounting for 10.97 % of *Fusarium* propagules. It was isolated from all products, except Cornflakes. Cerelac had the highest contamination level. *F. solani* has been recorded earlier among the dominant species isolated from mouldy supermarketed foods (Bullerman 1979), baby foods (Ismail *et al.* 2008). The high occurrence of *F. solani* on Cerelac, a product of wheat and milk, is in contrast to earlier reports where it was absent in other products of wheat and milk such as biscuits (Abdel-Sater & Ismail 1993) and Kishk (Ismail 1993), milk powder (Ismail & Saad 1997), wheat grains (Moubasher *et al.* 1972), and wheat, barley and maize (Assawah & Elarosi 1960, and Onyike & Nelson 1992). While the absence of *F. solani* in Cornflakes is in disagreement with the finding of Logrieco *et al.* (1995) who reported a high frequency of *F. solani* in maize.

F. verticillioides was encountered in low frequency (24 %) accounting for 7.87 % of *Fusarium* and 4.09 % of the total fungi. Three products (Porridge oats, Cerelac, and Heinz mixed cereal) were contaminated of which Cerelac had the highest contamination level, and Heinz mixed cereal registered the least level. The high contamination level of Cerelac, a product of wheat and milk, with this species is in agreement with the finding of Moubasher *et al.* (1972) and Mazen *et al.* (1984) on wheat. On the other hand, the presence of *F. verticillioides* in low numbers in Heinz mixed cereal (a product of corn, oats and barley) is consistent with the findings of Assawah and Elarosi (1960) on barley and maize, Taligoola *et al.* (2004) on rice and Ismail *et al.* (2008) on baby foods. *F. verticillioides* was also reported to be the most common *Fusarium* species isolated on barley grains in Egypt (Abdel-Kader *et al.* 1979). The absence of *F. verticillioides* on Cornflakes is in agreement with the earlier findings on cornsnacks (Zohri *et al.* 1995). It is reported that *F. verticillioides* is an endemic fungus on maize worldwide (Moubasher *et al.* 1972, El-Maghraby 1989, Munimbazi & Bullerman 1996, Pitt & Hocking 1997, and Ismail *et al.* 2003) and is able to produce fumonisins (Pitt & Hocking 1997, Placinta *et al.* 1999).

The remaining 6 species of *Fusarium* were isolated infrequently: *F. udum, F. lateritium,* and *F. proliferatum* (from Heinz mixed cereal, a product of corn, oats, and barley), and *F.equiseti, F. oxysporum* and unidentified species (from Cerelac, a product of wheat and milk) (Table 3). *F. proliferatum* was previously isolated from maize in Italy (Logrieco *et al.* 1995), Nigeria (Onyike and Nelson 1992), Thailand (Pitt *et al.* 1994), Burundi (Munimbazi & Bullerman 1996), and in Uganda (Ismail *et al.* 2003). *F. oxysporum* was reported to be a contaminant of barley grains (Abdel-Kader *et al.* 1979), wheat (Moubasher *et al.* 1972), and milk powder (Ismail & Saad 1997). The occurrence of *F. udum* on Heinz mixed cereal (a product of wheat) is consistent with earlier findings where it was recovered from kishk, a product of wheat and milk (Ismail 1993). Also, *F. lateritium, F. proliferatum* and *F. oxysporum* were reported from baby food products (Ismail *et al.* 2008).

Using Anova test at 5 % significance level, the calculated value of $F_{test} = 1.03 > F_{critical} = 0.4007$ df= 2, indicating that there is a significant difference in the total counts of the different *Fusarium* species recovered from imported baby foods on P-PCNB. Also the Anova test revealed a slight statistically significant difference in the total counts of *Fusarium* species recovered from the different baby food products ($F_{test} = 0.79 > F_{critical} = 0.5656$, df = 4, $P > 0.05$). Hence there is a slight significant association between the type of *Fusarium* species and the type of food (F test = 0.87 > F critical = 0.5572, df = 6, $P > 0.05$) recovered on P-PCNB. This may indicate that the incidence of fungal species depends on the kind of food products.

Apart from *Fusarium*, a total of 19 species belonging to 14 genera in addition to some unidentified yeasts were also recovered on P-PCNB. Of these, *Cladosporium* (2 species, with *C. sphaerospermum* being the most common) was the most dominant. It was isolated from 50 % of the samples accounting for 20.28 % of the total propagules. It was found most heavily contaminating Heinz mixed cereal, then Cerelac, Porridge oats, Weetabix and the least was recorded in Cornflakes. Yeasts and *Aspergillus* (with *A. flavus* being the most common species) were moderately isolated from 44 % and 40 % of the 50 samples investigated, accounting for 7.41 % and 11.67 % of the total fungi respectively (Table 3). *A. flavus, A. niger, C. sphaerospermum* and yeasts were among the most dominant fungi in maize grains (Ismail *et al.* 2003). The remaining 12 species were infrequently encountered, either in low or rare occurrence (Table 3).

Table 2: Incidence of xerophilic and xerotolerant fungi in cereal baby food products investigated on dichloran 18% glycerol agar (DG18)*.

Genera and species	**TC**	**% TC**	**% F**	**OR**	**Source**
Xerophilic fungi	1320	6.54	54	H	1,2,3,4,5
Aspergillus	170	0.84	18	L	1,2,3,4,5
A. penicillioides Spegazzini	30	0.15	8	R	3,5
A. restrictus Smith	20	0.1	6	R	4,5
A. wentii Wehmer	120	0.59	8	R	1,2,4
Chrysosporium farinicola (Burnside) Skou	35	0.17	6	R	4,5
Eurotium	1125	5.56	40	M	1,2,3,5
E. chevalieri Mangin	90	0.45	20	L	1,3,5
E. cristatum (Raper & Fennell) Malloch & Cain	300	1.48	26	M	1,2,3,5
E. repens de Bary	165	0.82	26	M	1,2,3,5
E. rubrum Konig, Spieckermann & Bremer	565	2.80	36	M	1,2,3,5
Wallemia sebi (Fries) von Arx	30	0.15	8	R	1,5
Xerotolerant fungi	18850	93.46	100	H	1,2,3,4,5
Acremonium strictum W. Gams	115	0.57	10	R	1,5
Aspergillus	1235	6.11	54	H	1,2,3,4,5
A. candidus Link	20	0.1	8	R	4,5
A. carbonarius (Bainier) Thom	50	0.24	4	R	2
A. flavus Link	830	0.41	28	M	2,4
A. fumigatus Fresenius	25	0.21	2	R	1
A. niger van Tieghem	175	0.87	12	R	1,2
A. ochraceus Wilhelm	30	0.15	8	R	2,4
A. oryzae (Ahlburg) Cohn	95	0.47	14	L	1,2,3,4,5
A. versicolor (Vuillemin) Tiraboschi	10	0.05	4	R	1,4
Cladosporium	1835	9.08	76	H	1,2,3,4,5
C. cladosporioides (Fresenius) de Vries	325	1.61	24	L	1,3,4,5
C. herbarum (Persoon) Link	10	0.05	4	R	3,4
C. sphaerospermum Penzig	1500	7.42	66	H	1,2,3,4,5
Curvularia protuberate Nelson & Hodges	25	0.12	2	R	2
Colletotrichum gloeosporioides Penzig & Saccardo	55	0.27	6	R	1,2
Eupenicillium sp.	5	0.02	2	R	5
Fusarium	3525	17.45	54	H	1,2,3,4,5
F. equiseti (Corda) Saccardo	225	1.11	12	R	2
F. poae (Peck) Wollenw.	300	1.5	2	R	3
F. solani (Martius) Saccardo	20	0.1	6	R	5
F. tricinctum (Corda) Saccardo	2680	13.26	16	L	3,5
F. verticillioides (Saccardo) Nirenberg	300	1.5	32	M	1,2,3,4,5
Geotrichum candidum Link	20	0.10	2	R	3
Lasiodiplodia theobromae (Pat.) Griffon & Maubl.	10	0.05	2	R	3
Microascus cinereus (Emile-Weil & Gaudin) Curzi	10	0.05	4	R	1
Mucor circinelloides van Tieghem	10	0.05	4	R	1,5
Microdochium nivale (Fries) Samuels & Hallett	5	0.02	2	R	5
Neurospora crassa (Shear & Dodge) v. Arx	5	0.02	2	R	1
Nigrospora oryzae (Berkeley & Broome) Petch	5	0.02	2	R	1
Penicillium	2120	10.50	60	H	1,2,3,4,5
P. camembertii Thom	5	0.20	2	R	5
P. citrinum Thom	50	0.24	10	R	3,4,5
P. corylophilum Dierckx	155	0.77	10	R	3,4
P. islandicum Sopp	10	0.05	4	R	3
P. oxalicum Currie & Thom	220	1.09	18	L	3,4,5
P. viridicatum Westling	1680	8.21	30	M	1,2,5
Phoma sp.	5	0.02	2	R	3
Rhizopus stolonifer (Ehrenberg) Vuillemin	55	0.27	8	R	1

Trichoderma harzianum Rifai	5	0.02	2	R	5
Yeasts	9805	48.52	30	M	2,3,5
Brettanomyces bruxellensis Kuff. & van Laer	65	0.32	6	R	5
Rhodotorula mucilaginosa (Jörgensen) Harrison	520	2.57	2	R	3
Yeasts (white)	9220	45.63	22	L	2,3,5
Total counts	20170	100	100	H	1,2,3,4,5

*TC = Total counts (calculated / g imported baby food product in 50 samples.
% TC = Percentage total counts (calculated per total fungal counts).
% F = percentage frequency (calculated per 50 samples investigated.
OR = occurrence remarks; High (H) = 50 % - 100 %, Moderate (M) = 25 % - 49 %, Low (L) = 13 % - 24 %, Rare (R) = less than 13 %.
Source: 1 = Heinz mixed cereal, 2 = Cerelac, 3 = Cornflakes, 4 = Weetabix, 5 = Porridge oats.

Table 3: Incidence of *Fusarium* species and other fungi in cereal baby food products investigated on Peptone-Pentachloronitrobenzene agar (Peptone-PCNB).

Genera and species	**TC**	**% TC**	**% F**	**OR**	**Source**
***Fusarium* (Total)**	5970	52	80	H	1,2,3,4,5
F. equiseti	25	0.22	2	R	2
F. lateritium	25	0.22	8	R	1
F. proliferatum	25	0.22	6	R	1
F. oxysporum	250	2.18	8	R	2
F. solani	655	5.71	26	M	1,2,4,5
F. tricinctum	4440	38.68	48	M	3,4,5
F. udum	30	0.26	8	R	1
F. verticillioides	470	4.09	24	L	1,2,5
Fusarium sp.	50	0.44	4	R	2
Other fungi	5510	48.00	100	H	1,2,3,4,5
Aspergillus	1340	11.67	40	M	1,2,3,4,5
A. flavus	885	7.71	26	M	2,3,4
A. niger	340	2.96	16	L	2,4,5
A. ochraceus	105	0.91	6	R	2,4
A. penicillioides	10	0.09	4	R	1,4
Chrysosporium farinicola	170	1.48	20	L	3,4,5
Cladosporium	2340	20.38	50	H	1,2,3,4,5
C. cladosporioides	5	0.04	2	R	1
C. sphaerospermum	3335	20.34	50	H	1,2,3,4,5
Cochliobolus lunatus	5	0.04	2	R	1
Eurotium cristatum	5	0.04	2	R	5
Geotrichum candidum	10	0.10	4	R	3
Microdochium nivale	75	0.65	2	R	2
Mucor sp.	5	0.04	2	R	4
Paecilomyces variotii	25	0.22	8	R	4,5
Penicillium	350	3.05	2	R	2
P. expansum	325	2.83	2	R	2
P. verrucosum	25	0.22	2	R	2
Trichoderma harzianum	275	2.40	2	R	2
Scopulariopsis candida	40	0.35	6	R	3
Wallemia sebi	15	0.13	6	R	3,5
Yeasts	850	7.41	44	M	1,2,3,4,5
Rhodotorula mucilaginosa	280	2.44	20	L	1,2,3,4
Yeasts (white)	400	3.18	20	L	1,2,3,4
Yeasts (yellow)	170	1.48	16	L	2,4,5
Other unidentified fungus	5	0.04	2	R	3
Total counts	11480	100	100	H	1,2,3,4,5

* Legends as those in table (2).

Nephrotoxigenic *Penicillium* species and other fungi recovered on Pentachloronitrobenzene Rose-Bengal Yeast Extract Sucrose agar (PRYES)

As shown in Table (4) the imported baby foods were highly contaminated with *Penicillium* species. 10 species were recovered on PRYES medium from 64 % of the samples investigated. Cerelac was the most heavily contaminated with *Penicillium* followed by Heinz mixed cereal, Cornflakes, and Weetabix while the least level of contamination was recorded in Porridge oats. The contamination of Cerelac, whose major component is wheat flour, is in agreement with earlier reports on biscuits and Kishk (wheat products) (Abdel-Sater & Ismail 1993, Ismail 1993). In addition, this finding is consistent with that of Moubasher *et al.* (1972) who isolated penicillia in high frequency from wheat. The high incidence of penicillia in Heinz mixed cereal (a product of corn, oats and barley flours) is consistent with earlier reports from corn and corn kernels (Jimenez *et al.* 1985, and Munimbazi & Bullerman 1996), wheat, barley and corn (Abdel-Hafez 1984, Aran & Eke 1987, Lacey 1988, El-Maghraby 1989).

Only two nephrotoxigenic species, *P. citrinum* and *P. viridicatum* were isolated. *P. citrinum* does not produce the violet brown reverse coloration on PRYES medium (Frisvad 1983). It was found to be the most abundant *Penicillium* species, occurring in 26 % of the samples accounting for 5.45 % of the total counts. The highest contamination level with this species was recorded in Cerelac while few propagules were recorded in Cornflakes, Weetabix, and Porridge oats. However, *P. citrinum* was absent in Heinz mixed cereal. The abundance of *P. citrinum* in Cerelac, a product of wheat and milk powder is consistent with the earlier finding from milk (Ismail & Saad 1997), and wheat (Moubasher *et al.* 1972). This species was absent in Kishk (Ismail 1993), and biscuits (Abdel-Sater & Ismail 1993). The absence of *P. citrinum* on Heinz mixed cereal, a product of wheat, barley and oats, is in agreement with the report of Flannigan (1970). However, *P. citrinum* was infrequent on freshly harvested corn and stored corn kernels (Moubasher *et al.* 1972) and completely absent on bin-stored corn (Sanchis *et al.* 1982).

P. viridicatum was only recovered in low frequency from Heinz mixed cereal and Cerelac, accounting for 40.56 % and 15.10 % of the total propagules respectively. The presence of *P. viridicatum* on Heinz mixed cereal, a product of corn and barley is supported by the earlier findings on barley and corn (El-Maghraby 1989). Similarly, its occurrence on Cerelac, a product of wheat is in agreement with earlier reports on wheat (El-Maghraby 1989). *P. viridicatum* which produces a typical violet brown reverse on PRYES medium is known also to produce ochratoxin A and citrinin mycotoxins (Frisvad 1983). Fortunately, this species was not found on the foodstuff kishk, a product of wheat (Ismail 1993).

The remaining 8 *Penicillium* species were infrequently encountered: *P. corylophilum, P. oxalicum, P. chrysogenum, P. expansum, P. islandicum, P. phoeniceum, P. paxilli* and *P. pubrerulum.* They accounted collectively for 15.47 % of *Penicillium* and 3.13 % of total fungi (Table 4). Other investigators have recovered the following species frequently; *P. corylophilum* on wheat flour (Suarez *et al.* 1981), *P. chrysogenum* on wheat (Mazen *et al.* 1984), *P. islandicum* on kishk (Ismail 1993), biscuits in Egypt (Abdel-Sater & Ismail 1993), and wheat and barley (Lacey 1988). *P. corylophilum* was also recovered from corn (Munimbazi & Bullerman 1996), *P. islandicum* was infrequent on maize in Philipine (Pitt & Hocking 2009). Similar to our findings, *P. expansum* was found less common on cereals (Pitt & Hocking 2009).

In addition to *Penicillium* species, PRYES medium produced 35 species belonging to 21 genera as well as some yeasts and other unidentified molds. Of these, *Aspergillus* (9 species), *Fusarium* (4 species) and *Cladosporium* (3) were the most predominant on the five products (Table 4). *Aspergillus* was obtained from 62 % of the samples, accounting for 21.34 % of the total counts. It was most common on Cerelac, followed by Weetabix, Heinz mixed cereal, Cornflakes and Porridge oats. *A. flavus* was found in 44 % of samples of the 5 products accounting for 14.14 % of the total counts. The remaining eight *Aspergillus* species were of low or rare occurrence (Table 4). *Fusarium* was recovered in 58 % of the samples accounting for 17.59 % of the total counts. However, it constituted a low proportion of the total fungal propagules in the five products. *F. solani* was the most common among fusaria. On the other hand, despite its low frequency, *F. tricinctum* had the highest contamination level (14.18 % of the total counts). *Cladosporium,* with *C. sphaerospermum* being the most common species, was isolated from 50 % of the samples of the five products accounting for 5.98 % of the total propagules. The remaining fungi were infrequently encountered.

Conclusion: The current results revealed that among the nine xerophilic species recorded on the cereal baby food products imported to Uganda, species of *Eurotium* were the most common. Also, of the nine species of *Fusarium*, *F. tricinctum*, and *F. solani* followed by *F. verticillioides* were the most common on 3 or 4 of the products investigated. The presence of two nephrotoxigenic species among the 10 species of *Penicillium* is worthy to mention. The high incidence of *Aspergillus flavus*, Yeasts and

Table 4: Incidence of nephrotoxigenic *Penicillium* species and other fungi in cereal baby food products investigated on pentachloronitrobenzene rosebengal yeast extract sucrose agar (PRYES).

Genera and species	**TC**	**% TC**	**% F**	**OR**	**Source**
***Penicillium* (Total)**	3685	18.50	64	H	1,2,3,4,5
P. citrinum	1085	5.45	26	M	2,3,4,5
P. chrysogenum	40	0.20	2	R	3
P. corylophilum	175	0.86	14	L	2,4,5
P. expansum	5	0.03	2	R	3
P. islandicum	90	0.45	2	R	3
P. paxilli	10	0.05	2	R	4
P. oxalicum	400	2.0	12	R	1,2,4
P. phoeniceum	5	0.03	2	R	5
P. puberulum	20	0.1	6	R	5
P. viridicatum	1855	9.31	18	L	1,2
Other fungi	16230	81.50	100	H	1,2,3,4,5
Aspergillus (Total)	4250	21.34	62	H	1,2,3,4,5
A. candidus	25	0.13	8	R	3,4,5
A. flavus	2815	14.14	44	M	1,2,3,4
A. niger	675	3.38	20	L	1,2,4,5
A. ochraceus	15	0.08	2	R	4
A. oryzae	240	1.21	22	L	1,2,4,5
A. penicillioides	10	0.05	2	R	5
A. tamarii	5	0.03	2	R	3
A. versicolor	460	2.31	8	R	2,3,4
A. wentii	5	0.03	2	R	5
Chrysosporium farinicola	165	0.83	8	R	1,3,5
Cladosporium (Total)	1190	5.98	50	H	1,2,3,4,5
C. cladospoioides	55	0.27	14	L	1,3,4
C. sphaerospermum	1125	5.65	50	H	1,2,3,4,5
C. herbarum	10	0.05	4	R	4
Cochliobolus lunatus	5	0.03	2	R	1
Colletotrichum gloeosporioides	125	0.62	4	R	2
Doratomyces sp.	10	0.05	4	R	1
Eurotium (Total)	275	1.38	18	L	3,5
E. chevalieri	85	0.43	12	R	3,5
E. cristatum	125	0.62	12	R	5
E. repens	65	0,33	2	R	5
Fennellia flavipes	450	2.25	2	R	2
Fusarium (Total)	3505	17.59	58	H	1,2,3,4,5
F. lateritium	275	1.38	10	R	2
F. solani	215	1.07	26	M	1,2,3,4,5
F. tricinctum	2825	14.18	16	L	3,4,5
F. verticillioides	190	0.95	16	L	1,2,3
Geotrichum candidum	45	0.22	8	R	2,3,5
Neurospora crassa	10	0.05	2	R	3
Nigrospora oryzae	20	0.1	8	R	1
Mucor circinelloides	80	0.4	12	R	1,2,3,5
Paecilomyces variotii	5	0.02	2	R	4
Phoma sp.	25	0.13	2	R	2
Rhizopus oryzae	470	2.36	12	R	1,3
Scopulariopsis brevicaulis	5	0.03	2	R	4
Trichoderma harzianum	5	0.03	2	R	4
Thermoascus aurantiacus	5	0.03	2	R	5
Wallemia sebi	15	0.08	4	R	5
Yeasts (Total)	5520	27.71	16	L	2,3,4
Rhodotorula mucilaginosa	1125	5.65	16	L	2,3,4

Yeasts (orange-colored)	60	0.30	4	R	2,4
Yeasts (white-colored)	4335	21.76	12	R	2,3,4
Other unidentified fungi	50	0.25	8	R	3,4,5
Total counts	19915	100	100	H	1,2,3,4,5

* Legends as those in table (2).

Cladosporium sphaerospermum on the three isolation media is a worrisome. Contamination of such foods (especially those for babies) by these toxigenic or potentially pathogenic fungi is a matter of health hazard for humans.

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