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Full Length Research Paper

Moisture contents, mouldiness, insect infestation and acceptability of market samples of dried 'tatase' pepper and tomato in Kano, Nigeria

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Triplicate samples of dried 'tatase' pepper and dried tomato in early and late storage periods were randomly obtained monthly from 2 major markets in Kano and analyzed for moisture contents, mould loads, insect infestation and consumer acceptability and relationships of parameters. Respective mean±SD values of moisture for new and old stocks; 11.05±1.04 and 9.93±2.85% and 9.69±0.98 and 9.74±1.31% were not significantly different at P = 0.05. Moisture contents varied widely, with low correlation coefficients, r = -0.47 and r = -0.14 for moisture contents/mould loads relationships in dried 'tatase' pepper and dried tomato respectively. However, correlation coefficients for log.mould load / acceptability by brightness of colour relationships, r = -0.71 and r = -0.8; and by discoloration, r = +0.71 and r = +0.81 were high and related to mouldiness. Mean±SD of mould loads in new stocks were 2.7±1.9 × 10^3 and 4.3 × 10^3 ± 4.6 × 10^2 cfu/g for pepper and tomato respectively, and showed increases to 3.0±2.3 × 10^4 and 3.4±2.6 × 10^4 cfu/g respectively in old stocks. Insect infestations were common on tomato but rare even on old 'tatase' pepper.

Key words: Dried 'tatase' pepper, dried tomato, new stock, old stock, moisture contents, mould loads, insect infestation, consumer acceptability, correlation coefficient.

INTRODUCTION

'Tatase' pepper (*Capsicum annum* L.) and tomato (*Lycopasicum esculentum* Mill) were some of the most abundantly produced crops in Northern Nigeria annually, especially in Kano. However, Akanbi et al. (2006) described fresh tomato fruits as highly perishable and were often lost to deterioration and wasted during the peak harvesting period. Oyebanji et al. (2008) reported that *Geotrichum candidum, Alternaria altanata, Aspergillus niger, Fusarium chlamydosporium, Mucor* and *Botrytis* species grew in succession on ripe tomato as initiated by damage to fruits within 2 to 9 days as influenced by different storage conditions of ambient ventilated shed, refrigerator and ambient moist jute covered cane box, with 70, 65 and 40% spoilage losses respectively in 20 days of storage. The high perishability of fresh 'tatase' pepper and tomato under ordinary condition in a tropical developing country like Nigeria compelled drying of the crops to extend shelf life. Doymaz (2007) and Sobukola et al. (2007) had also reported that drying was the most common form of food preservation to extend shelf life under ambient storage in packs.

Similarly, Hell et al. (2009) reported that vegetables including okra, hot chilli pepper, tomato, melon seeds, onion and baobab leaves were dried to preserve them for lean periods and decrease their perishability. Sun drying of crops has been particularly relevant in Nigeria, especially in the drier northern states for conservation and reduction of post harvest losses. 'Tatase' pepper and tomato were dried annually in Northern Nigeria including Kano area spreading 'tatase' pepper and tomato on bare floor or ground, perhaps to meet the large scale or commercial drying in the abundance of harvest. Idah and Aderibigbe (2007) reported that such dried crops were exposed to contamination with dirt and risked wetting during rains or flood and needed proper packaging for

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storage. Contaminations of crops with dirt during open air sun drying of tomato reported by Adesina et al. (2010) and were imagined in the drying of 'tatase' pepper and tomato in Kano. Meanwhile, no official monitoring of the dried products (for standard in terms dryness for packaging and storage or mould quality and regulation against risk of mycotoxin contamination) existed for 'unpackaged-unlabelled' products such as dried 'tatase' in Nigeria.

However, Atanda and Akano (1997) reported that dried 'tatase' pepper was widely acceptable to consumers, being affordable and available in the off season. The early period of storage of dried 'tatase' pepper and dried tomato was from February to April annually. This period was when the products were abundant in the markets in good visual quality. They were then bright coloured and seemingly wholesome. The late period of storage was from November to January each year and the products were often discoloured and unappealing, but buyers were then left with no choice in the market. Dried 'tatase' pepper and tomato were used in proportions as condiments in preparation of soup like the fresh forms by soaking in water to rehydrate. Preliminary visits to markets and stores in Kano showed varied visual qualities of 'tatase' pepper and tomato as bright colour or discoloration at different periods of a year. Buyers of dried 'tatase' pepper and dried tomato from markets in Kano were local consumers, traders and dealers from other parts of Nigeria, especially from the south.

Ordinarily, these consumers and traders demanded good quality dried products that were bright looking, not mouldy and not insect infested. Desire for quality in the dried pepper and tomato manifested in the buyers' inspection, selection and rejection tendencies for the discoloured. As well, traders sorted the products to improve the grading for acceptability according to Idah and Aderibigbe (2007). Kano remained a major commercial centre for dried crops including 'tatase' pepper and tomato in Nigeria, with the yearly abundance of production. The drying, packaging and storage had to be adequately done to preserve, conserve and grant consumers satisfaction for their expenses. Ogunkoya et al. (2011) had since reported that demand for high quality dried crops manifest more in international markets, due to existence of monitoring, appreciation of standards, crops' abundance and availability of choice in the market. Due reward for all (traders and consumers of dried 'tatase' pepper and tomatoes) was expected. Parameters of quality and preference of dried pepper and dried tomato were known to include brightness of colour, moisture content, mouldiness and insect infestation according to Idah and Aderibige (2007).

There was the need to document quality status, relevance and relationships of parameters of mould growth and customer appeal concerns of dried 'tatase' pepper and dried tomato in Kano. This study was therefore a market survey, of dried 'tatase' pepper and dried tomato during the early and late storage periods in Kano, which determined the moisture contents, mouldiness, insect infestation quality parameters and consumers' acceptability of samples as well as their relationships.

MATERIALS AND METHODS

Dried 'tatase' pepper and dried tomato samples from Kano markets

Market samples of dried 'tatase' pepper and dried tomato from the City and Yankaba markets in Kano, consisting of respective triplicate bowl measures of the products per month during early storage period of February to April for new stocks and during the late storage periods of November to January for old stocks, were obtained into sterile black polyethylene sampling bags. The market samples of dried 'tatase' pepper and dried tomato were respectively sub-sampled for analysis of moisture contents, mouldiness, insect infestation and consumers' acceptability.

Moisture content determination

Moisture content was determined by the oven drying method according to Atanda and Akano (1997) and AOAC (2000) for 10 g sub-sample of dried 'tatase' pepper or dried tomato, dried to a constant weight at 80°C in 4.5 h. Moisture content was expressed as percentage of moisture loss by weight during drying of a 10 g subsample.

Mouldiness

Mouldiness as mould load of bulked triplicate samples of dried 'tatase' pepper or tomato, each month from a market, was determined by serial dilution pour plate technique as according to Akani and Madumere (2008) for a 10 g sub-sample rinsed in 90 ml Tween 80 incorporated sterile water for 1 ml suspension dispensing in series into 9 ml sterile water in test tubes. Pour in sterile Petri-dishes consisted of 1 ml suspension with sterile cool molten Malt Extract Agar incorporated with 50 ppm of Tetracycline and Chloramphenicol. Plates were incubated at 28°C for 3 days and mould colonies were enumerated in plate with less than 100 colonies. Mould load was expressed as colony forming units per gram of sub-sample (cfu/g). The isolated moulds were identified by macroscopic examination of growth of pure cultures for colour, texture and surface appearance. Microscopic (Yashima Tokyo OS.K No. 800038) examination of mount of pure culture for sporangia, conidial heads, conidia and vegetative mycelium morphology was according to Samson and Reenen-Hoekstra (1988) and Harrigan and McCance (1990).

Percentage acceptability

Acceptability of market samples of dried 'tatase' pepper and dried tomato were determined by consumers' sorting of respective samples into Undiscoloured-Uninfected or Discoloured-Infected-Infested lots and percentages of acceptable component of samples computed by weight of sorted lots. These values were respectively matched with predetermined weight acceptability percentage groups of 0 to 10, 10 to 20, 20 to 30, 30 to 40, 40 to 50, 50 to 60, 60 to 70, 70 to 80, 80 to 100% that corresponds with hedonic scores on a 1 to 9 scale of 1= disliked extremely, 2 = disliked, 3 = disliked

Table 1. Moisture contents of new and old samples of dried 'tatase' pepper and dried tomato from markets in Kano.

Market sample		Moisture content (%)	
Stock	**Period and market**	**Pepper**	**Tomato**
	February at Yankaba market	10.94	8.62
	February at City Market	11.34	8.71
	March at Yankaba Market	9.20	9.82
New	March at City Market	12.10	9.40
	April at Yankaba Market	10.80	11.08
	April at City Market	11.90	10.50
	Mean ± SD	(11.05±1.0)	(9.60±0.98)
	November at Yankaba market	11.07	7.73
	November at City market	10.64	11.20
	December at Yankaba Market	8.41	11.11
Old	December at City Market	13.26	9.80
	January at Yankaba market	5.05	9.02
	January at City market	11.15	9.60
	Mean± SD	(9.93±2.85)	(9.74±1.31)

Values in parenthesis were grand mean ± SD for new and old stocks of dried pepper and dried tomato respectively.

moderately, 4 = disliked slightly, 5.= neither disliked nor liked, 6 = liked slightly, 7 = liked moderately. 8 = liked, 9 = liked extremely; according to Munoz and King (2007) and Olayemi et al. (2011).

Insect infestation

Presence of insect infestation in samples was determined by stereomicroscope (Reichert Austria Nr 259314) aided visual detection of adult, dead or life stages or their absence as in Williams et al. (2002).

Statistics

Mean values of moisture contents of triplicate samples of old and new stocks of dried 'tatase' pepper and tomato from City and Yankaba markets in Kano were respectively computed and grand means for new and old stocks were determined and compared for differences for dried 'tatase' pepper and tomato respectively at P=0.05. Also, mould loads of bulked monthly samples of dried 'tatase' pepper and tomatoes from markets were respectively computed for mean values for new and old stocks and analysed for difference by t-test for null hypothesis. Correlation coefficients with critical correlations of mean moisture contents and logarithms of mould loads; and of logarithms of mould loads and percent acceptability of market samples of dried 'tatase' pepper and tomato were computed respectively from scatter diagrams at P=0.05 and 10 degrees of freedom.

RESULTS AND DISCUSSION

Moisture content

Table 1 shows moisture contents of market samples of dried 'tatase' pepper and tomato in Kano. Moisture contents ranged from 9.2 to 12.10% (new), from 5.05 to 13.26% (old); and from 8.62 to 11.08 (new) and from 7.73 to 11.20% (old) for samples of dried 'tataste' pepper and dried tomato respectively. The widely varied moisture contents of market samples of new dried 'tataste' pepper or dried tomato, showed the varied extents of drying achieved for packaging and storage of the samples, usually in exposure and often in torn polyethylene lined sacks (hessian or jute), all of which determined storability against mouldiness. Safe moisture content of crop was put as the moisture content in equilibrium with relative humidity of 70% at 27°C. While the safe moisture content of dried 'tatase' pepper and that of dried tomato need to be established, Idah and Aderibigbe (2007) reported that 4.2% moisture content, was adequate drying of tomato for storage in polyethylene bags, or hermetic packaging which should not be prone to damage or exposure of dried crop.

Hence, market samples with higher levels of moisture therefore suggest risk of mouldiness and possibly mycotoxin contamination in storage. Findings in this study showed the varied adequacy of drying and storage of 'tatase' pepper and tomato in Kano. Even wider moisture content variation in the range of 24.80% in the wet season and 5.3% in the dry season in Ibadan, as reported by Atanda and Akano (1997) in open storage. Therefore, sensitization needs to continue for the awareness of the need for conscious monitoring during drying and determination of safe moisture content of 'tatase' pepper and tomato for specification of necessary dryness for storage. Mean ± SD of moisture contents of 11.05±1.0% for new and 9.93±2.85% for old; as well as 9.6±0.98% for new and 9.74±1.31% for old stock of dried

Table 2. Mould loads of new and old samples of dried 'tatase' pepper and dried tomato from markets in Kano.

Sample		Mould load (cfu/g)	
Stock	**Period and market**	**Pepper**	**Tomato**
New	February at Yankaba market	3.2×10^3	4.1×10^3
	February at City market	1.8×10^3	5.2×10^3
	March at Yankaba market	5.3×10^3	4.0×10^3
	March at City market	5.5×10^2	4.1×10^3
	April at Yankaba market	4.3×10^3	4.1×10^3
	April at City market	7.6×10^2	4.5×10^3
	Mean±SD	$(2.7 \times 10^3 \pm 1.9 \times 10^3)$	$(4.3 \times 10^3 \pm 4.6 \times 10^2)$
Old	November at Yankaba market	1.3×10^4	4.4×10^4
	November at City market	7.4×10^4	1.1×10^4
	December at Yankaba market	2.0×10^4	2.4×10^4
	December at City market	2.0×10^4	8.1×10^4
	January at Yankaba market	3.6×10^4	1.4×10^4
	January at City market	1.4×10^4	2.9×10^4
	Mean±SD	$(3.0 \times 10^4 \pm 2.3 \times 10^4)$	$(3.4 \times 10^4 \pm 2.6 \times 10^4)$

Open values were for 3 bulked samples from a market in a month. Values in parenthesis were means for new or old stocks of dried pepper or dried tomato respectively.

'tataste' pepper and dried tomato respectively were respectively not significantly different at P = 0.05 and these moisture contents were considered high.

High moisture content of samples called for caution against mouldiness. That is, care should be taken to ensure adequate drying for hermetic storage against ingress of moisture during rains and flood. The idea of packaging crops in high or low density polythene bags for the hermetic character assumes adequate drying of crop to safe moisture content and the maintenance of the integrity of packaging material was reported by Williams (1981). Whereas polythene lined jute sacks were in use for packaging dried 'tatase' pepper and tomato in Kano, many bags were found torn on market displays and in stores, risking ingress of moisture during rains or flooding. Hence, there was the need for care in the handling of packs against damage.

Mouldiness

Table 2 shows mould loads of new and old dried pepper (tatase) and dried tomato samples from Kano markets.

Mean ± SD mould loads of new dried 'tatase' pepper and tomato were $2.7 \pm 1.9 \times 10^3$ and $4.3 \times 10^3 \pm 4.6 \times 10^2$ cfu/g were lower than those of respective old stocks, $3.0 \pm 2.3 \times 10^4$ and $3.4 \pm 2.6 \times 10^4$ cfu/g, which were not significantly different but showed increases in mould loads or mould growth in the prolonged storage under the inadequate packaging and storage condition practiced in Kano. Low mould loads in the order of 10^2 cfu/g was reported by Atada and Akano (1997) on dried 'tatase' pepper samples from markets in Ibadan between November and February that mostly corresponded with the time of old stocks in Kano have shown possibility of prolonged storage in good condition attributed to dry season in Ibadan.

The higher mould load in old samples in this study contrasted the report of decreased microbial load reported for adequately dried and packaged stored dried tomato by Idah and Aderibigbe (2007), as should be expected for well stored dried crops even under tropical condition. The lower mould loads of the new stock samples showed relatively of goodness in the microbial quality of dried 'tatase' pepper and tomato in the short duration of holding (1 to 3 months) when samples were drawn for this study. However, the goodness of drying needed to be confirmed by determination of the moisture content of sample for safe storage against mouldiness. The seeming retention of high moisture of old stocks in the long storage duration (8 to 12 months) before samples were drawn may explain the higher mould loads or mould growth that must have occurred on them. Therefore, the need for monitoring, regulation or penalty for carelessness during drying, packaging and storage cannot be overemphasized in Kano. While laboratory determination of moisture content may not be readily accessible to processors in Kano area, there should be conscious monitoring of sample during drying and storage at least by sensory approach of feeling products with hand to detect moisture, flexed feel when not dry enough or hard, light sometimes brittle feel of pepper or tomato if dryness was considerable.

The findings of high mould loads in old stocks of dried pepper and tomato confirms the earlier suggestion from the observed high moisture contents of samples which were not adequately dried and were maintained at the

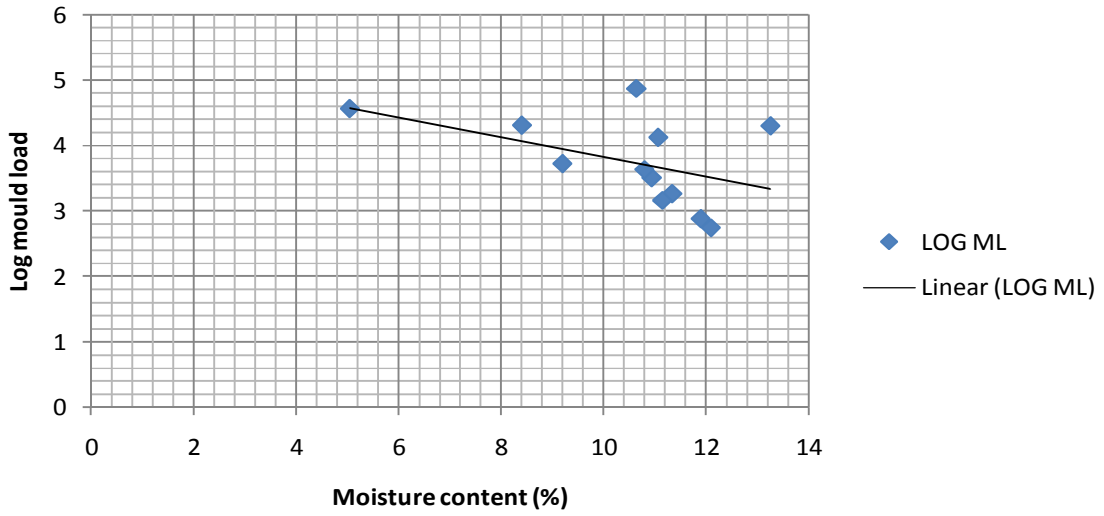

Figure 1. Moisture content / mould load relationship on dried 'tatase' pepper in Kano.

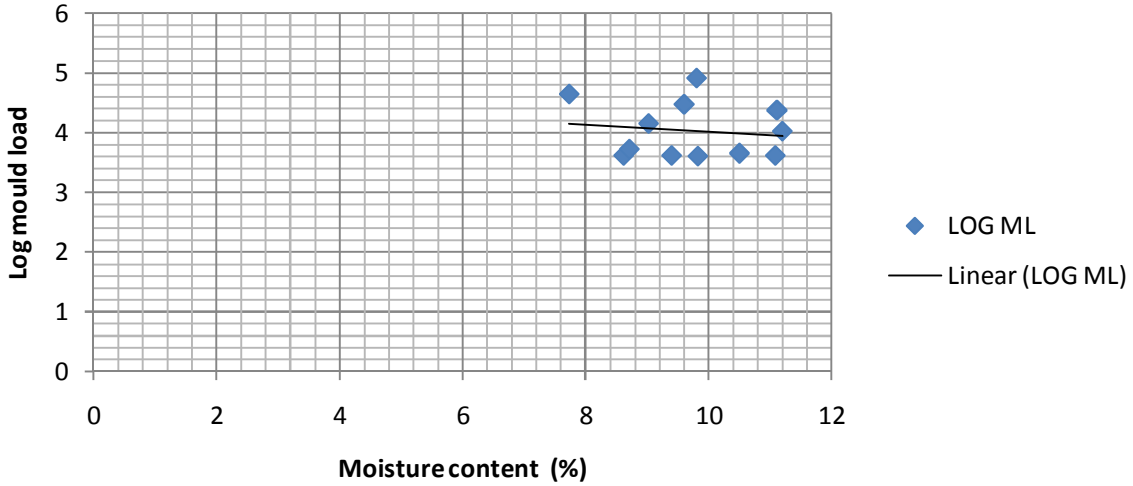

Figure 2. Moisture content / mould load relationship on dried tomato in Kano.

high level during storage under warm ambient temperature condition in Kano that permitted mouldiness. The non significant difference in mould loads of new and old stocks at P=0.05 may be due to post storage sifting of product where by much of the dirt were sorted off in the market prior to display and sampling for analyses. The moulds: *A. niger, A. falvus, Penicillium, Mucor hemalis* and *G. candidum* were associated with samples of dried 'tatase' pepper and dried tomato in this study. Of these, *A. niger* was the most commonly isolated while *A. flavus, Penicillium and Mucor* species were common on the dried pepper and dried tomato irrespective of whether the sample was new or old stock, but the yeast (*G. candidum*) was only occasionally isolated on new stocks, perhaps dying off during storage. The isolation of these moulds supported the report of Atanda et al. (1990) that *A. niger, A. falvus* and *G. candidum* were commonly isolated from dried 'tatase' pepper. The mouldiness of old stocks may considerably explain the discoloration of the samples rather than much of light because of the opaque packaging practice in Kano markets, where polythene lined sack was in practice for storage in market stores, though often found torn.

Moisture content / mould load relationships on dried 'tatase' pepper and tomato

Figures 1 and 2 showed that moisture contents/mould loads relationships on dried tatase pepper and dried

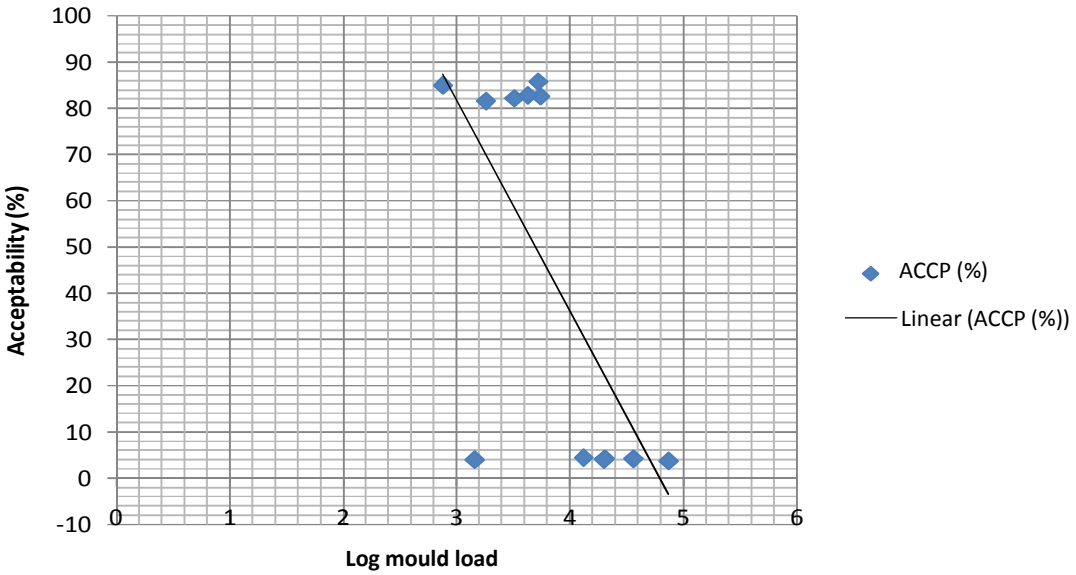

Figure 3. Log. mould loud / acceptability relationship of samples of dried pepper from markets in Kano.

tomato were of insignificant negative correlation coefficients of r = -0.47 and r = -0.14 respectively. These moderate and low negative correlation coefficients were not significant at P = 0.05, with the critical coefficient of correlation of 0.22 and 0.02 respectively, each at 10 degrees of freedom. Therefore, the mould quality of market samples of dried pepper or dried tomato may not be ascertained on the basis of the moisture content whether high or low. These findings were indications of the importance of information on storage time and moisture content in the interpretation of mouldiness of samples.

Insect infestation

Insect were rarely detected on dried 'tatase' pepper samples whether new or old. Only the cast of unknown insect was found in one sample from a market in December. On the other hand, insects including Tribolium, Ephestia, Ants *and Corcyra* species were found as living adults or dead in old stock of tomato. The non or occasional detection of insects in samples of dried 'tatase' pepper, suggested the unsuitability as food for insect pests of the stored products or was related to repulsion effect, perhaps due to some allergic or toxicity effect on insect pests that did not encourage infestation. As such, 'tatase' pepper may be considered for possible insecticidal uses, but dried tomato would not be so considered.

Mould load / acceptability relationship

Figures 3 and 4 showed significantly high negative correlation coefficients of r = -0.71 and r = -0.85 between log of mould load and acceptability at P = 0.05 for critical correlations of 0.51 and 0.71 with 10 degrees of freedom for dried 'tatase' pepper and dried tomato samples from markets respectively. Thus, the higher the acceptability of a sample, the lower is the mould load and vice versa. On the other hand, unacceptability significantly correlated positively, r = +0.71 and r = +0.81 for dried 'tatase pepper and for dried tomato respectively, with critical correlations of 0.51 and 0.66 respectively at 10 degrees of freedom as shown in Figures 5 and 6. This meant that the more unacceptable a sample was the higher was the mould load and vice versa.

The acceptability sample was a good and easy indicator of low mouldiness associated with bright coloured samples while discoloured samples were high in mould load. High mouldy samples of dried 'tatase' pepper and dried tomato had the possibility of contamination with mycotoxins perhaps including Aflatoxins. These should ordinarily limit marketability of the product, especially in elite super markets and international markets where more gains might be expected for sales of the dried products. Similarly, Delcourt et al. (1994) reported the need for determination of Aflatoxin content in determination of quality of dried pepper.

Conclusion

Results of the analyses of dried 'tatase' pepper and dried tomato samples from City and Yankabar markets in Kano for moisture contents suggested that drying might have been inadequate for prolonged storage under the local circumstance of packaging and storage as mould load increases. Mould loads or mouldiness is related

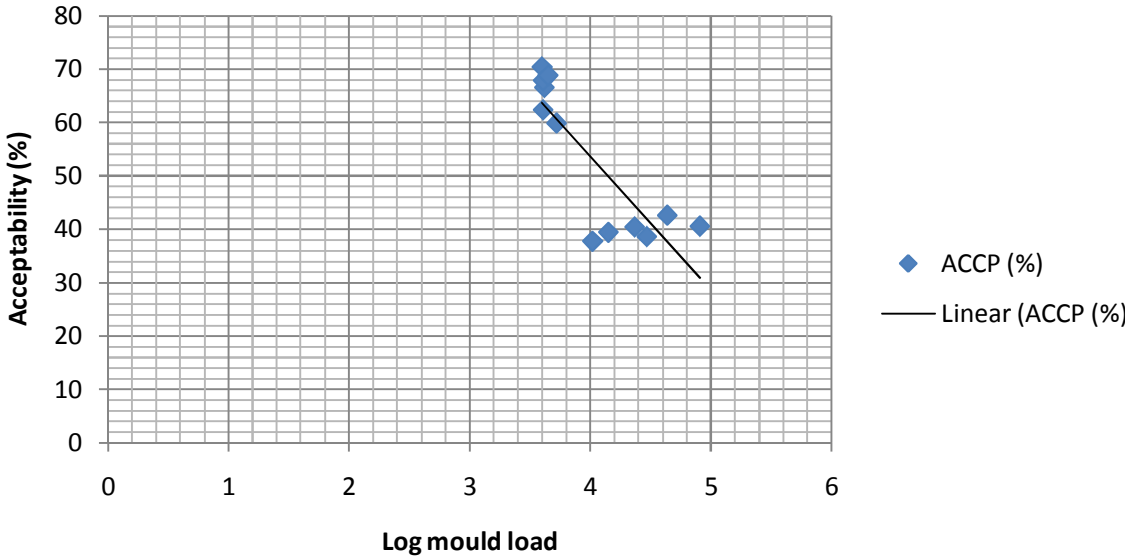

Figure 4. Log mould load/acceptability relationship of samples of dried tomato from markets in Kano.

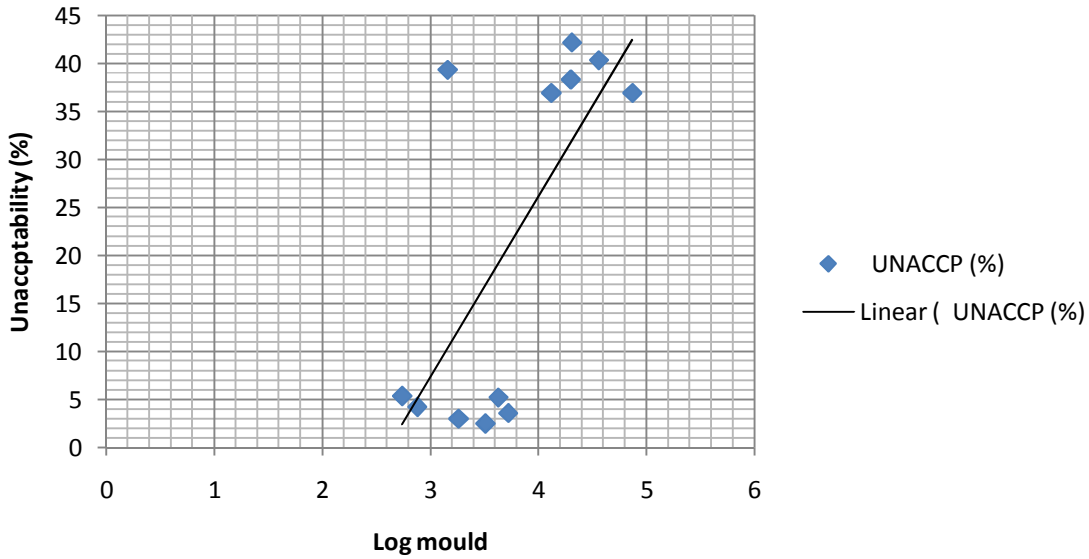

Figure 5. Log mould load/unacceptability relationship of samples of dried pepper from markets in Kano.

negatively to quantity and brightness of colour, and positively to the quantity of discolouration of dried 'tatase' pepper and dried tomato. However, moisture contents of samples which varied widely did not correlate significantly with mouldiness, which was observable in the market samples that were randomly drawn, and this indicated the importance of handling the stock history of state in interpreting results of moisture and mould quality analysis.

Further, discolouration which suggested mouldiness resulted in loss of appeal as indicated by the associated acceptability decrease, which meant risk of rejection and loss of sales ordinarily. Hence, the need for adequate and safely dried, packaged and stored dried 'tatase' pepper and dried tomato was globally due to the fact that the acceptable protocol cannot be overemphasized. Also, while this study suggested a minor insect infestation problem for dried 'tatase' pepper, it did not for dried tomato, which must necessarily be handled against insect infestation.

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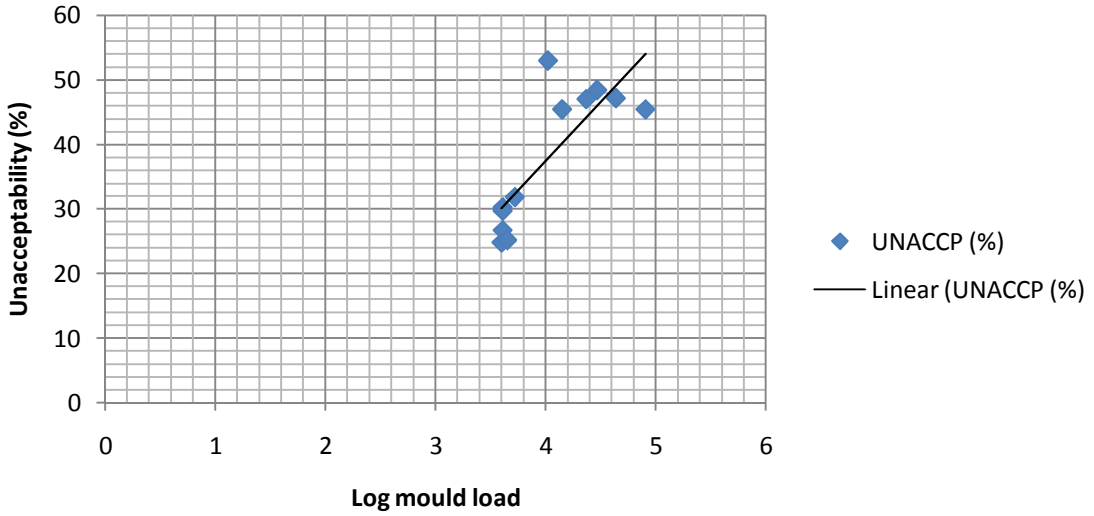

Figure 6. Log mould load / unacceptability relationship of samples of dried tomato from markets in Kano.

technicians in Kano station of the institute for assistance in sample collection and analysis.

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