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EFFECT OF STATIC MAGNETIC FIELD ON MICROBIAL GROWTH KINETICS AND PHYSIOCHEMICAL PROPERTIES OF NONO (FERMENTED MILK DRINK)

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ABSTRACT

This study assessed the effect of 0.5T static magnetic field (SMF) on microbial growth kinetics and physiochemical properties of Nono drinks stored at uncertain condition for six days. Magnetatic bacterial were predominated by *Lactobacillus casei* (40%), *Corynebacterium sp*(50%), and *Staphylococcus sp* (10%); while fungi were *Penicillum sp*(30%), *Mucorsp*(20%) and *Aspergillus sp*(50%). SMF significantly (P<0.05) altered the average pH (2.26-2.31) and total titratable acidity (0.13-0.17%v/v) compared to the average controls of 2.08 and 0.20%v/v respectively. However, SMF had no significant impact on the temperature and sensory properties (≤ 3 score of 7-point hedonic scale ranking) of Nono drinks when compared to the control samples after six days assessment. Microbial growth kinetic was relatively stable within 72hrs, thereafter, SMF treated samples steadily declined by 30.5%while non-SMF (control) samples increased by 26.25%. Microbial growth kinetics was observed to have direct and inverse correlations to total titratable acidity and pH respectively. Conclusively, SMFhave correlative inhibitory impact on microbial growth rate with consequential acidityincrease that would slow down the rate of spoilage. Thus, inclusion of SMF to hurdle technology would prolong diary products' shelf-life with minimal sensory alterations.

Keywords: Static magnetic field, microbial kinetics, Nono, physiochemical

INTRODUCTION

Nono is a yoghurt-like product that is popular in the northern region of Nigeria and many sub-sahara regions of Africa. Though, the name might differ in these regions, but it is a product of overnight fermented skimmed fresh milk, processed from the excess milk, as a means of storage and preservation **(Akinyele *et al.*, 1999)**. This highly nutritional diary products (>85% moisture) support the proliferations of wide range of microorganisms. Thus, inadequate standardized hygienic methods of processing and handling of this home-made food drink, would pose a serious public health and food safety concern.It is usually consumed within 6 hour after preparation to guarantee safety or thermal treatments are mainly used for preservation.Traditional and contemporary methods of preservations are designed to limit microbial and other factors that comprise the quality (safe and pure) of food. Most food processing techniques apply thermal processes to prolong food shelf life. Milk products as well as vegetables, fruits, and juices are heat sensitive ready-to-eat foods that are adversely affected with thermal preservative treatments. Unfortunately, thermal method compromises the sensory and nutritional qualities as well as the economic value. However, refrigerators have proven effective in preservation but may be out of reach to the low-income producers and street vendors of these fermented milk drinks.
Popularity of magnetic treatment in food industry have increased within the last decade. However, scanty literatures are available on the application of magnetism to regulate microbial growth kinetics in foods. Inactivation of microorganisms with static magnetic field in milk, orange juice, yoghurt and bread roll dough have been documented by Hoffman as far back as in the year 1985. Hoffman reported that only one pulse of static magnetic field was able to reduce and maintain the bacteria population between 10^2 and 10^3cfu/g **(USFDA, 2015)**. Other studies such as **Frankel and Liburdy (1995); Grigelmo-Miguel *et al.*, (2011)** have recorded successful inhibition of microbial growth with no detrimental quality (sensory and safe) alterations of the food products. The magnetic field polarizes the mineral ions thereby distorting the ion distribution channel within the microbial cell wall and membrane, consequently, limiting osmoregulation and metabolic activities.**Strasak *et al.*, (2002)** observed a decline in ability of E. *coli* to form colonies and biofilm due to exposure magnetic that adversely affected oxidoreductive activity.
Magnetism impact on fungi seem to be significant at the range of 20T-200T flux for different magnetatic fungi such as *Aspergillusniger* and *Alternaria alternate* **(Nagy, 2015)**. It was also reported that low magnetic flux (0.1T - 1.5T) are able to reduce fungi kinetic by 10%. However, according to **Mateescu *et al.*,(2011)** magnetic flux could increase the growth kinetics of magnetatic fungi upto 33%.
Considering the seeming prospect of magnetism in food industry against the adversity of thermal treatments on ready-to-eat foods; there is an urgent need for non-thermal processes with minimal detrimental impact on food product value. Thus, the ideology of this study is to access the effect of static magnetic field on microbial kinetics and physiochemical properties of Nono drinks.

MATERIALS AND METHODOLOGY

Sample collection

A total of 10 Nono samples were collected from two major markets (5 samples from each market) in Agaie LGA of Niger State - Nigeria with clean 100mL plastic bottles. Each set of 5 samples from each markets were bulked together and labeled as Sample A and sample B. Transportation of the samples from the markets to laboratory were done under ice bag (4^0C) prior to the laboratory analysis.

Isolation of Magnetatic Microorganisms

Collection of magnetic microorganisms were done using the method described by **Chawader and Bjekal (2008)**. This technique is based on the cells swimming response to a magnetic field. The polar end of a permanent magnet (0.5T) was attached 1cm above and below a beaker containing the 100mL of nono samples. After 4-8hrs of incubation at room temperature, 5mL of the sample in the beaker near the wall adjacent the magnetswere collected with a clean syringe and transferred to a sterile test tube and used for serial dilution.

Relevant biochemical test were done for microbial characterization **Cheesbrough (2000)**.

Magnetatic Assessment

Isolates were tested for magnetatic response using spreading techniques of their growth on semi solid medium (0.8% agar). The isolates were inoculated in a straight line at the center of the medium in Petri dish. The plates were incubated in a magnetic field created by placing the opposite poles of two different bar magnets on either sideperpendicular to the line of streaking at 35^{0}C(bacteria) and 25^{0}C (fungi) for 24 - 48hr and 5 - 7days respectively. The growth pattern after incubation was observed for any spreading towards the magnetic poles.

Determination of Physiochemical Parameters

Temperature and pH

Temperatures and pH parameters of the Nono samples were monitored on site using automatic digital pH and thermometer device with 0-110^{o}C range. The probes of the device were dipped into the fermented milk drinks and readings were taken immediately after a 5-mins wait.

Total titratable acidity (TTA):

The titratable acidity (TTA) was determined using 20mL of the fermented milk sample and it was titrated drop by drop with 0.1N NaOH to pH 7.1 (Hana meter HI-1221, 2009). The result was expressed as equivalent of NaOH 0.1N/g (%v/v).

Sensory evaluation

Sensory quality of samples were evaluated by 50 assessors (trained and untrained), selected among the staff and students of IBB university, Lapai using 7-point hedonic scale rankingas describe by **Balogu et al., (2017)** slight modifications. Only seasoned consumers of nono drinks with at least 24h exposure prior were selected to limit biasness. Scores were expressed in two categories for aroma (≤3 = Agreeable, ≥4 = non-agreeable), texture (≤3 = watery, ≥4 = semi watery) and appearance (≤3 = creamy white, ≥4 = off white).

Software statistical analysis

Data generated from microbial and physicochemical assessments were subjected to applicable statistical tools (ANOVA, Chi-square, and Duncan's Multiple Range Test) using SPSS software (version 20 of 2014), and significance was taken at P =0.05.

RESULT AND DISCUSSION

Results

Sensory qualities (appearance, aroma and texture) of Nono drinks treated with SMF did not have any observable changes compared to the non-SMF (control) samples after six days storage (table1).

Table 1 Sensory Evaluation of Nono samples stored under Static Magnetic field

Sample	Aroma	Texture	Appearance
Sample A	agreeable	Watery	Creamy white.
Sample B	agreeable	Watery	Creamy white.
Control	agreeable	Watery	Creamy white.

NB: Aroma (≤3 = Agreeable), texture (≤4 = watery) and appearance (≤4 = creamy white): 7-point hedonic score ranking

Comparative Microbial load of magnetatic microbes were significantly (p<0.05) lower (3.38×10^{5}cfu/mL) than control with 11.5×10^{5}as shown in figure 1.

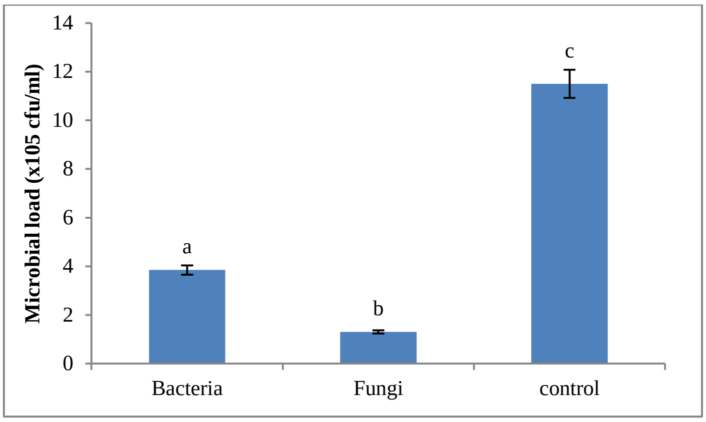

Figure 1 Comparative Magnetatic Microbial load from Nono drink.
NB: Bars with different alphabets are statistically significant (P<0.05)

Prevalence of magnetatic*Lactobacilluscasei* (40%) and *Corynebacteriumsp* (50%) were significantly different (p<0.05) from *Staphylococcus aureus* with 10% (fig 2).

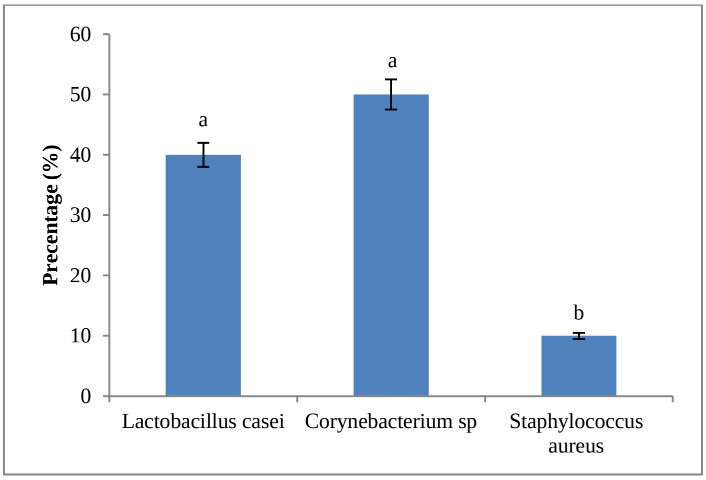

Figure 2 Prevalence of magnetatic Bacterial isolated from Nono drink
NB: Bars with different alphabets are statistically significant (P<0.05)

Magnetatic fungi of *Aspergillussp* (50%), *Penicillumsp* (30%) and *Mucorsp* (20%) were significantly different (p<0.05) from each other (fig 3).

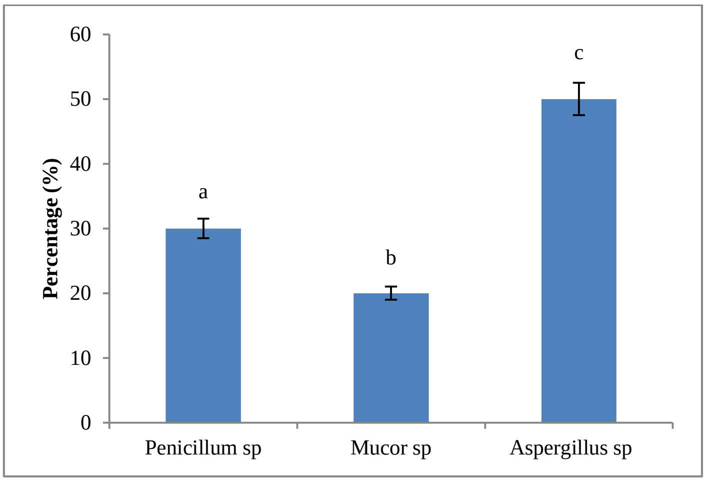

Figure 3 Prevalence of magnetatic Fungal isolated from Nono drink
NB: Bars with different alphabets are statistically significant (P<0.05)

SMF had no significant (P>0.05) effect on the temperature of Nono drinks (28.17^{o}C - 28.33^{o}C) within six days storage compared to the control sample that had an average temperature of 28.35^{o}C (fig 4).

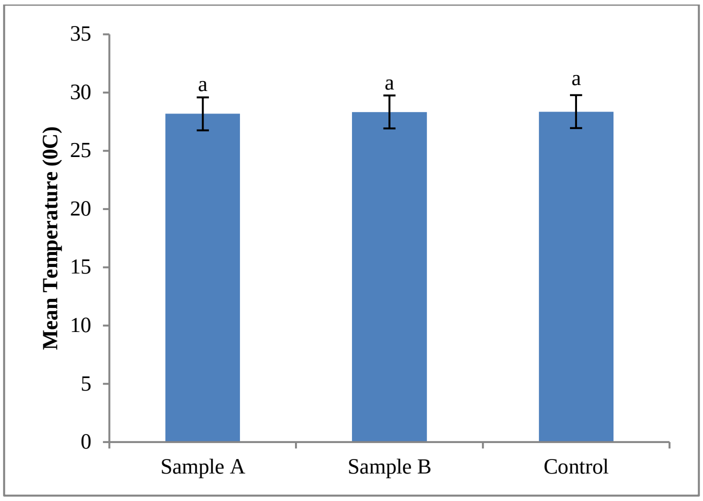

Figure 4 Effect of SMF on the Temperature of the Nono drink stored for 6-days
NB: Bars with different alphabets are statistically significant (P<0.05)

Significant (P<0.05) increase in pH (2.26 - 2.30) were observed in SMF treated samples when compared to the mean pH of 2.07 observed in non-SMF treated samples (fig 5).

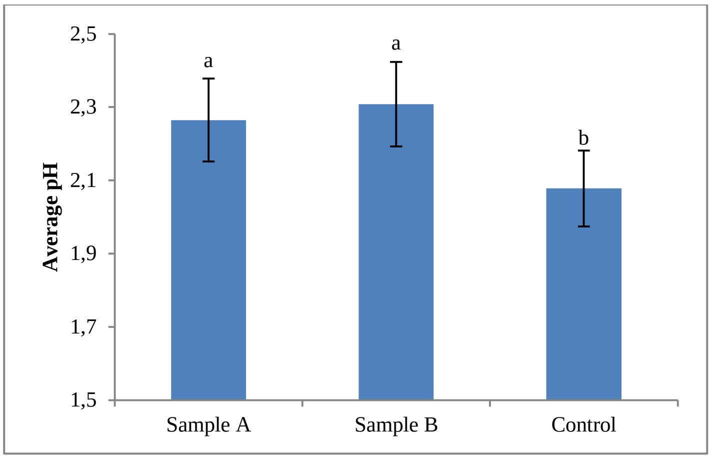

Figure 5 Effect of SMF on the pH profile of the Nono drink stored for 6-days
NB: Bars with different alphabets are statistically significant (P<0.05)

Total titratable acidity (TTA) of SMF treated samples (0.125 -0.170 %v/v) were inconsistent and significantly (P<0.05) lower than the control mean value of 0.2 %v/v (fig 6).

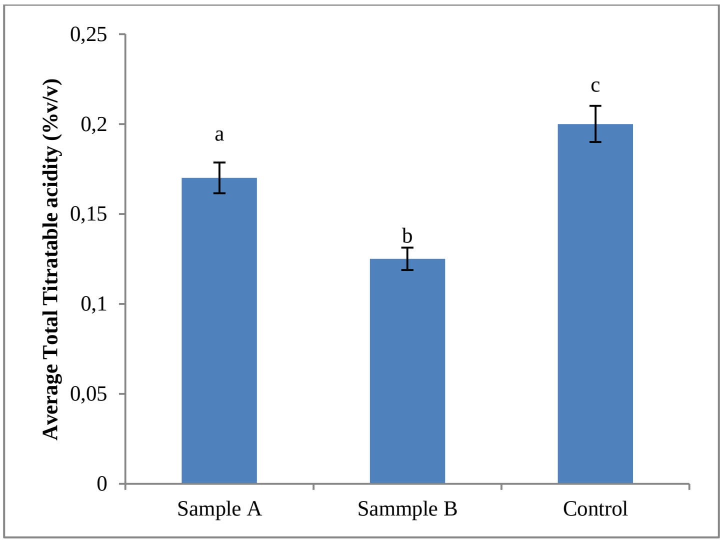

Figure 6 Effect of SMF on the Total Titratable Acidity (TTA) of Nono drink stored for six days.
NB: Bars with different alphabets are statistically significant (P<0.05)

Microbial growth kinetic of SMF treated samples experienced a decline from 1.80 x 10^{5}cfu/mL to 1.26 x 10^{5}cfu/mLwithin 6 days. However, non-SMF exposed samples increased from 1.79 x 10^{5}cfu/mLto 2.26 x10^{5}cfu/mL (fig. 7).

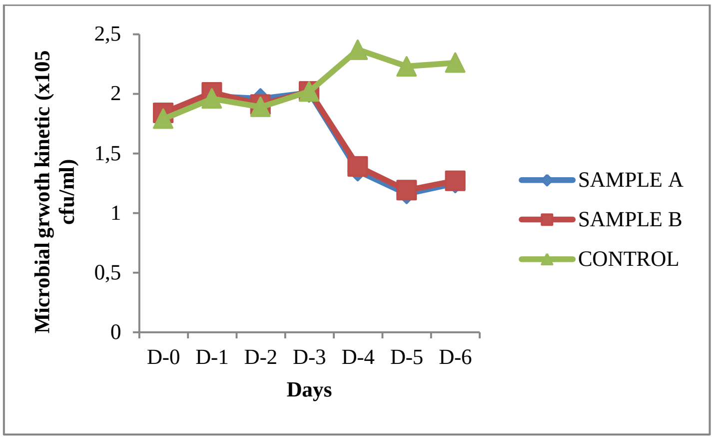

Figure 7 Effect of SMF on microbial growth kinetics in Nono drink stored for six days.

Trendy correlative effect of SMF on microbial kinetic and physiochemical properties of Nono drinks were observed, such that microbial growth kinetics were inversely and directly proportional to pH and Titratable acidity respectively (Fig. 8)

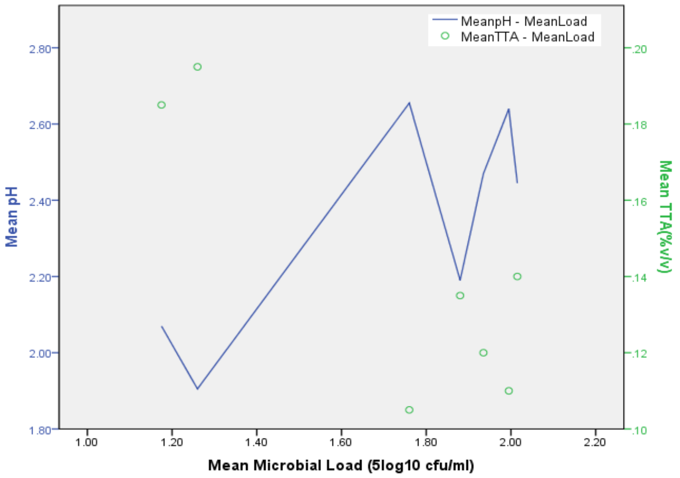

Figure 8 Correlative effect of SMF on Microbial kinetic and physiochemical qualities of Nono drink stored at uncertain condition for six days

DISCUSSION

Universality of magnetic microbes are ubiquitous in aquatic environment and cosmopolitan in distribution in others environment such as soil and food **(Spring and Schleifer 1995**; **Matsunaga *et al.*,1991; 2000).** Spore-formers are good magnetic microorganisms and they exhibit consistent growth kinetic response. USFDA (2015) reported similar prominent spore forming isolates with consistent microbial kinetic responses tomagnetic field. Most documented responses are more of bacterial than fungal isolates **(USFDA, 2015; .Haile *et al.*, 2008; Okuno *et al.*, 1993; San Martin *et al.*, 2001)**. Consequentially, observing more than 90% prevalence of magnetatic bacterial load over fungal species was not considered extreme for ready-to-eat Nono.

High demand for fresh-like ready-to-eat processed foods is stretching and consequently driving the contemporary food industry and market. Popularity of non-thermal technologies such as magnetic fields are gaining grounds **(Butz and Tauscher 2002)**, with fluxes of various intensities exhibiting effective inactivation of microbial kinetics**(USFDA 2015)**, with either minimal or no sensory and physiochemical alterations. Insignificant sensory alteration of Nono drink exposed to 0.5T SMF suggests that flux of 0.5T SMFs induces insignificant particulate disorientation unlike the thermal processes that result to physical and chemical changes. Evidently, temperature, texture, appearance and flavor ofNono samples subjected to 0.5T maintained insignificant changes. This validate **Khlil *et al.*,(2010)** report of non-alteration in sensory properties of milk sterilized with magnetic system.

Controversies trails the impact of SMF on microbial kinetics, with majority of the scarce reports of **San Martin *et al.*, (2001)**,**Caubet, (1999)**and **Malko *et al.*, (1994)** kicking against an earlier report of **Hofman (1985)** that magnetic field inhibits microbial kinetics. Apparently, the controversies may linger as significant consistent suppression of microbial kinetics upto 30 folds were observed in this study within 72 - 144hrsexposure to 0.5T. Perhaps, the compositions of foods and exposure time have direct correlationto the microbial kinetics responses. **USFDA (2015)** documented a reduction in reproduction rate of *Saccharomycescerevisiae* within 72hrs of 0.465T static magnetic field exposure**. Okuno *et al*. (1993)** further stretched the augmentwith their report that magnetic field enhances microbial growth kinetic. It is the opinion of this study that magnetic and non-magnetic microbes have varying responses to magnetic field andextensive studies on consistentparameters would unravel these controversies. Interestingly microbial growth kinetics correlates inversely and directly to pH and total acidity respectively. Modelling these parameters would hasten the inclusion of magnetic field treatment as part of the hurdle technology for longer shelf-life and improving the quality of fresh-like ready-to-eat processed dairy foods.

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