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RESEARCH ARTICLE

EFFECTS OF PROCESSING CONDITIONS ON THE QUALITY OF KINDIRMO MADE FROM WHOLE COW MILK AND COW–SOYMILK MIXTURES - I

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ABSTRACT

Six production batches (six treatments in each batch) of *kindirmo* were carried out in this research to study the effects of fermentation times (5h, 12h and 24h), milk type (whole cow milk and cow–soymilk mixture), starter culture type (kindirmo and DVI – Direct Vat Inoculum) and starter culture age (24h and 48h) and volume of inoculum (2% and 3%) on pH, titrable acidity and organoleptic acceptability of kindirmo from whole cow milk and cow–soymilk mixtures. The research design was a 2*3*2*3 with milk type being the main factor while the sub-factors were respectively starter culture type, inoculum volume and fermentation time. Laboratory analyses carried out were pH and titrable acidity while sensory evaluation was a seven-point Hedonic test for taste, colour, sweetness, texture, mouth-feel and general acceptability. There were also ranking tests on the samples. Means, Analyses of Variance (ANOVA) and Duncan Multiple Range Tests were the statistical tools of SPSS (Statistical Package for Social Sciences) used for data analyses. Results showed pH to be 3.70 – 5.70 while titrable acidity was 0.04 – 0.15 both indicating highly fermented to low fermentation. Ranges of scores for sensory parameters were flavour (3.1 – 6.3), colour (3.3 – 6.3), taste (3.1 – 6.1) and sweetness (2.8 – 6.5). Others were texture (2.0 – 6.1), mouth-feel (2.7 – 6.3) and general acceptability (2.9 – 6.5). ANOVA on the entire 36 kindirmo treatments (i.e. all the six batches jointly together) showed that all the processing conditions have significant effects on the titrable acidity, pH and all the sensory attributes of kindirmo ($P \leq 0.05$). However, separate ANOVA for each production batch exclusively for each of these factors, showed that significant differences ($P \leq 0.05$) occurred among the kindirmo for all the productions (batches) except in 3%-12h production where only pH, titrable acidity, colour, texture and mouth-feel significantly affected kindirmo quality, whereas flavour, taste, sweetness, general acceptability and ranking sensory factors had no significant effect on kindirmo quality ($P \leq 0.05$). The highest reduction in pH (3.70) were observed in virtually all kindirmo of 3%-24h production, whereas the least reduction in pH were in kindirmo of treatments CD24 and SD24 for 2%-5h and 12%-5h productions. The titrable acidity values follow the same trend as in pH values. It was also found that 20% substitution of cow milk with soymilk in kindirmo production was quite acceptable by the consumers even by those who have never tasted soymilk in the past. The use of kindirmo as starter culture using the back-slop method is more efficient in fermentation than the use of commercial starter culture. This was most likely due to the fact that inoculation temperature of the starter culture was at room temperature rather than at 42 – 42^{O}C which was the inoculation temperature for commercial starter cultures in yoghurt production. This shows that kindirmo is different from yoghurt and that the LAB present in kindirmo is less thermophilic than the *Lactobacillus bulgaricus* and *Streptococcus thermophilus* present in yogurt. Also the starter culture ages of between 24h and 48h had no significant difference ($P \geq 0.05$) on kindirmo quality, except for leftover kindirmo of previous day's productions, deliberate effort should not be made at producing starter culture of more than 24h old as at it is economically unwise.

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INTRODUCTION

Perdigon *et al*. (1995) and El Zubeir *et al* (2005) reported that fermentation confers nutritious, shelf stability and health promoting attributes to fermenting fermented milk over fresh milk. The centrality of fermented milk in the dairy industry is such it is the point from which other products are made (Thapa, 2000). *Kindirmo* is a traditional full-fat fermented cow milk product (Igwe and yakubu, 2000). It is popular in

Northern Nigeria and usually produced at the household level especially by women of the *Fulani* tribe herdsmen (Eneji and Mshelbwi, 1985). Processing variables such as type and volume and age of starter culture as well as fermentation temperature and time affect the quality of kindirmo (Ezeaba, 2001; Ukeyima, 2001; Kwaghgeman, 2001; Bamsida, 2002; El Zubeir Ibtisam and Marowa, 2009) Other processing conditions that affect *kindirmo* quality include pasteurization temperature and time and inoculation temperature (Kwaghgeman, 2001). Heating milk leads to loss of quaternary, tertiary and sometimes secondary protein structures resulting in protein gel formation. However, the thickness and strength of gel formed is dependent on the level of heating. For example, heating conditions ranging from 85 – 95^{o}C for 15 – 30 min are generally considered necessary for conventional processing of milk for yoghurt manufacture (Davies *et al*., 1980; Schmidt, 1980; Schmidt and Morris, 1984). Also Schmidt (1980) further reported that insufficient heating results in weak-bodied yoghurt, while excessive heating can lower gel-strength and result in grainy-textured yoghurt with a tendency to synerese. The report further stated that ultra-high-temperature processed yoghurt i.e. 138^{o}C for 3 or 6 sec had lower gel firmness but also had less syneresis than yoghurt from milk conventionally processed at 82^{o}C for 20 min.

Virtually all natural food fermentations are the result of the activities of more than one microorganisms (MCOs) either working together or in a sequence (Ray, 2001). The MCOs mainly responsible for food fermentation are the LAB. These are groups of MCOs having similar physiological and ecological (not taxonomic) characteristics (Varnam, 2002). LAB metabolizes carbohydrates producing only or mainly lactic acid. As reported in Bergey's Manual of Determinative Bacteriology (Sneath, 1986), and also by Axlesson (1993) and Schleifer *et al*. (1985), bacteria species that constitute LAB include *Streptococcus, Leuconostoc, Pediococcus* and *Lactobacillus*. Others (not used as starter cultures) are *Enterococcus, Aerococcus, Vagococcu, Tetragenococcus* and *Carnobacterium* (Ray, 2001). However, though LAB have been implicated in nearly all fermentation of milk products, but they vary in species and strain (Ray, 2001). Igwe (2011) found out that the LAB responsible for fermentation of kindirmo is different from the ones responsible for yoghurt fermentation. This goes a long way to justify that starter culture type will affect the quality of fermented products. This disparity in quality of most market samples of *kindirmo* has been reported by Amaefula (2001) and Igwe and Ojimelukwe (2008). Therefore, the objective of this research are to find out the effect of processing conditions such as starter culture characteristics (age, type and percentage inoculum volume), use of whole cow milk and cow-soymilk composites as a fermentation substrate and different fermentation times.

MATERIALS AND METHODS

Materials

All milk samples for the study were obtained from the animal farm of the Federal University of Technology, Yola (FUTY). Kindirmo used was bought from *kindirmo* sellers within FUTY. All reagents and the commercial starter culture, DVI (Direct VAT Inoculum) used in this study were of Analytical grade and obtained from commercial suppliers. Soybean, vanilla flavour and sugar were purchased from Jimeta main market, Adamawa State.

Research Design

Effects of processing conditions such as milk and starter culture types, starter culture concentration and fermentation time on *kindirmo* quality were investigated using a research design of 2 * 3 *2 * 3 factorial experiment giving a total of thirty six kindirmo treatments. This is as shown in Figure 1.

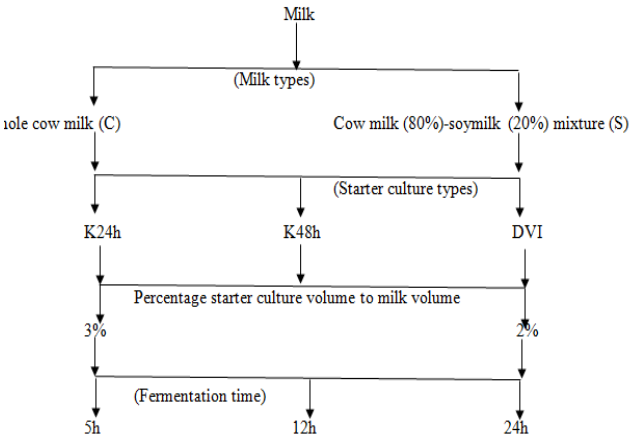

Fig. 1: Flow Chart for Production of *kindirmo* using a 2 * 3 * 2 * 3 factorial design

There were a total of six batches of productions of six *kindirmo* treatments in each batch. The symbols of each of the six *kindirmo* treatments are given in Table 1. Titrable acidity and pH analyses and sensory evaluations were conducted for all the kindirmo samples.

Table 1: Symbols for kindirmo of different processing treatments

N	Symbol	Description
I.	Samples	The same codes in each of the six batches in the first experiment
1.	CK24	From whole cow milk (C) using 24h old kindirmo as starter culture (K24h)
2.	CK48	From whole cow milk (C) using 48h old kindirmo as starter culture (K48)
3.	SK24	From cow-soymilk mixture (S) using 24h old kindirmo as starter culture (K24)
4.	SK48	From cow-soymilk mixture (S) using 48h old kindirmo as starter culture (K48)
5.	CDV	From whole cow milk (C) using 24h old commercial starter culture (DV)
6.	SDV	From cow-soymilk mixture (S) using 24h old commercial starter culture (DV)

NB: The same codes in each of the six batches of experiments

Processing operations

Method of laboratory production of kindirmo from whole cow milk or cow milk-soymilk mixture

The processing flowchart is shown in figure 2. Whole cow milk or cow milk-soymilk mixture was placed in a stainless aluminum pot was heated at 90^{o}C for 15 seconds.

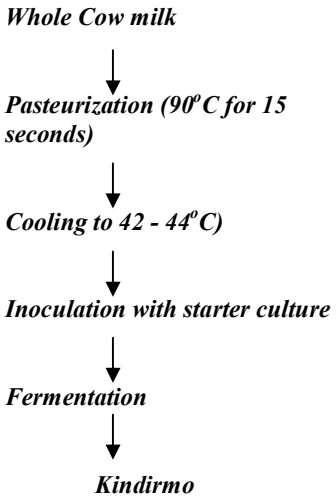

Fig 2. Flow chart for laboratory production of kindirmo

It was then allowed to cool to 42 - 44°C. The heated and cooled whole cow milk or cow milk-soymilk mixture was inoculated with either 2% or 3% of starter culture (either 24h kindirmo or 48h kindirmo or 24h DVI) volume to milk volume. It was then allowed to ferment for either 5h or 12h or 24h to produce *kindirmo*.

Processing of soymilk from soybean

Soymilk production from soybean according to Iwe (2003) is shown in figure 3

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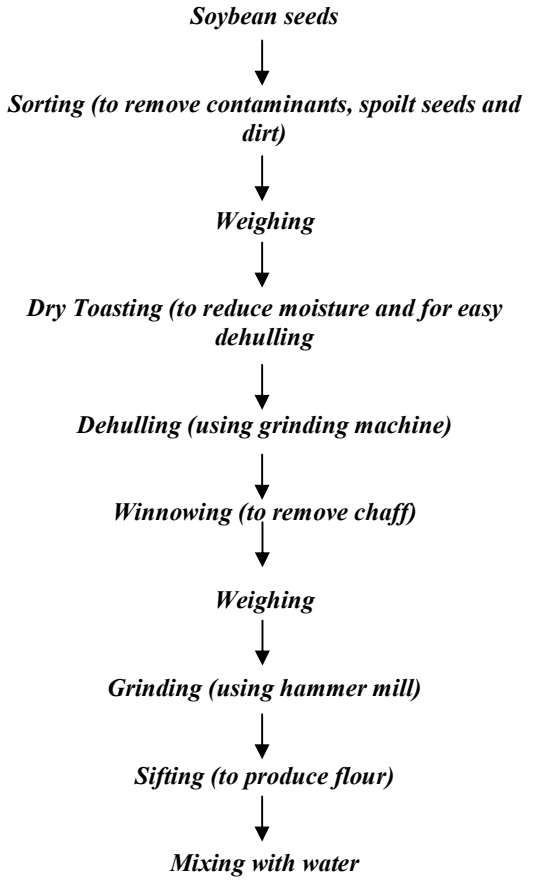

Fig 3. Flowchart laboratory soymilk processing from soybean

Soybean (2kg) was sorted by hand-picking to remove debris. It was toasted in an aluminum pot so as to facilitate subsequent dehulling. During toasting, the soybeans were continuously stirred with spoon until cracks started appearing on the seed coat. It was removed and sprayed on a mat to cool at ambient temperature before dehulling using a dehulling (an adjusted milling) machine. The dehulled seeds were winnowed to remove chaff. The decorticated seeds were then weighed. The soybean seeds were ground to powder using a hammer mill and sifted to a powder using a filter cheese cloth. The soybean powder was then mixed with water in a ratio of 1kg to 10 litres (Based on preliminary test) of water. The mixture was thoroughly stirred before filtering using a muslin cloth. The filtrate is soymilk extract.

Starter culture (DVI, K24 and K48h) preparation.

Fresh cow milk was pasteurized at 90°C for 15 seconds. The pasteurized milk was cooled to between 42 - 44°C and inoculated with 2% starter culture (kindirmo or DVI). It was then allowed to ferment for 24 hours (for K24 and DVI starter cultures) or for 48 hours as in K48 starter culture preparation (Figure 4).

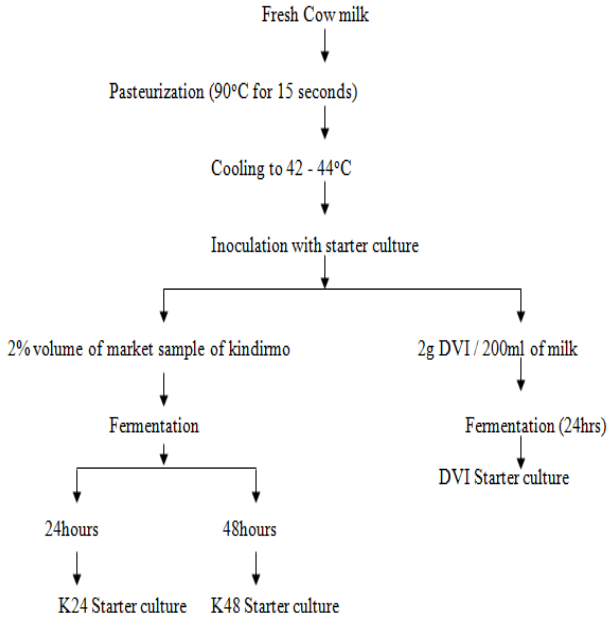

Fig 4. Flow chart for the production of Starter culture (DVI, K24 & K48)

Methods of analyses

Formol titration and Wener – Schmid methods were used for protein content and lipid determinations respectively as reported in Pearson's chemical analyses of foods (Kirk and Sawyer, 1991). The AOAC (1990) oven drying method was used for moisture content while muffle furnace method was used for ash content. Carbohydrate content determination was calculated by weight difference. The pH meter and the titration methods were respectively used to determine the pH and titrable acidity (Kirk and Sawyer, 1991). A seven-point Hedonic test was used on fifteen semi-trained taste-panelists that constituted of year three and five students as well as technologists of Department of Food Science and Technology, Federal University of Technology, Yola. Quality indices evaluated were taste, flavour, sweetness, mouth-feel, texture, overall acceptability and ranking tests. Means, percentages, analyses of variance (ANOVA) and regression were the statistical tools used in the analysis of data. Turkey's test was used for mean separation. Statistical Package for Social Sciences (SPSS) was the computer software used for statistical analysis.

RESULTS AND DISCUSSIONS

Results of pH, titrable acidity and percentage moisture composition of liquid cow milk, soymilk and soy-powder under different conditions are shown in Table 2. Expectedly, significant differences ($p \leq 0.05$) in percentage moisture composition were observed among the samples due to their physical states (liquid and powder) and heating that was involved

Table 2: Percentage Moisture, Titrable acidity and pH of Soymilk, Cow milk and Soybean powder under different conditions

SNo.	Milk type	%Moisture	pH	Titrable acidity
1.	Fresh raw Cow milk	$87.68^{c} \pm 0.288$	$6.70^{a} \pm 0.025$	$0.018^{b} \pm 0.001$
2.	Pasteurized Cow milk	$80.92^{e} \pm 0.370$	$6.59^{b} \pm 0.010$	$0.018^{b} \pm 0.001$
3.	Soy Powder	$6.79^{f} \pm 0.183$	$6.38^{d} \pm 0.031$	$0.009^{c} \pm 0.001$
4.	Fresh Soymilk	$94.50^{a} \pm 0.500$	$6.44^{c} \pm 0.010$	$0.007^{d} \pm 0.001$
5.	Pasteurized Soymilk	$93.14^{b} \pm 0.287$	$6.48^{cd} \pm 0.127$	$0.007^{d} \pm 0.001$

Figures are means ± standard deviations of 3no replicate readings.
Within a column, means with same superscript are significantly not different (P = 0.05).

That the pH of all the samples were between 6.37 – 6.70, which is within the acceptable range (Alfa-laval, 1985), does show that all the starting materials are weakly acidic and will most likely have uniform effect on the eventual kindirmo produced from them. Table 3 gives the pH, titrable acidity and organoleptic acceptability of thirty-six kindirmo treatments produced in the six batches of experiment i.e. 2%-5h, 2%-5h, 2%-24h, 3%-5h and 3%-24h. When all the 36 kindirmo treatments were analyzed (i.e. all the six batches jointly) together, it was found out that processing conditions (inoculum volume ratio of starter culture to milk volume ratio, fermentation time, starter culture type and age and milk type) have significant effects on the titrable acidity, pH and all the sensory attributes of kindirmo ($P \leq 0.05$). However, separate ANOVA for each production batch exclusively for each of these factors, showed that significant differences ($P \leq 0.05$) occurred among the kindirmo for all the productions (batches) except in 3%-12h production where only pH, titrable acidity, colour, texture and mouth-feel significantly affected kindirmo quality, whereas flavour, taste, sweetness, general acceptability and ranking sensory factors had no significant effect on kindirmo quality. The highest reduction in pH (3.70) were observed in virtually all kindirmo of 3%-24h production, whereas the least reduction in pH were in kindirmo of treatments CD24 and SD24 for 2%-5h and 12%-5h productions. The titrable acidity values follow the same trend as in pH values. This follows the general principle of the longer the fermentation time the more the acid production (http://www.fao.org/docrep, 2005). Based on sensory factors of ranking and general acceptability, kindirmo from all the production batches (2%-5h, 2%-5h, 2%-24h, 3%-5h and 3%-24h) except for 3%-12h batch had at least one of the ten best kindirmo samples. Also it was found out that it is economically unwise to deliberately age (grow) the starter culture for upwards of 48hrs as against 24h of age. This is due to the fact that there is no significant difference between kindirmo fermented with starter culture of different ages at least for the first most acceptable sixteen kindirmo samples.

The milk types (whole cow milk and cow milk – soymilk mixtures) affected the quality of kindirmo of different treatments ($P \leq 0.05$). At 2%-5h, significant difference was observed in the quality of kindirmo of treatments CK24 and SK24 on one hand and between of treatment CK48 and SK48 ($P \leq 0.05$). But when the commercial starter culture (DVI) is used in processing kindirmo, significant differences ($P \leq 0.05$) were observed for most of the parameters between kindirmo made from cow milk (CD24) and that from soymilk (SD24). In summary at 2%-5h, when kindirmo is used as starter culture, the sensory ratings of kindirmo made from both cow milk and soymilk are appreciably high. This appreciable rating gives the hope that the mission of gradually substituting cow milk with soymilk will eventually be a dream come true. More so, all the taste panelists claimed they have not consumed kindirmo made from soymilk previously. At 2%-12h, no much differences were observed between the kindirmo samples produced either with whole cow milk or cow-soymilk composite. For example, though significant differences ($P \leq 0.05$) exist between the pH and titrable acidity of CK24 and SK24 kindirmo treatments, but the sensory factors were not significantly affected ($P \geq 0.05$). The same trend was also observed between CK48 and SK48 kindirmo treatments. But this trend was not observed between SD24 and CD24. Here, except for colour and texture, significant difference ($P \leq 0.05$) was observed among all the other factors. Still at 2%-12h, generally, kindirmo produced using DVI starter culture from whole cow milk as fermentation substrate was ranked higher than others. Conversely, kindirmo from cow-soymilk composite using DVI was rated the most disliked. Similarly, all the kindirmo samples made from whole cow milk were ranked higher than kindirmo from cow-soymilk composite.

For 2%-24h, the type of milk used as fermentation substrate (cow milk and soymilk) had significant effects on the pH and titrable acidity, but lesser effect on sensory scores of kindirmo produced from them ($P = 0.05$). This was observed between kindirmo of treatments CK24 and SK24. The same are the cases with CK48 and SK48 on one hand and between SD24 and CD24 on the other hand. The same trend was observed at 3%-5h, except that significant difference was observed only on the titrable acidity between CD24 and SD24 ($P \leq 0.05$). At 3%-12h, the effect of milk type showed that with the use of 24h old kindirmo starter culture (SK24 & CK24), no significant difference ($P \geq 0.05$) was observed between their

Table 2. Effects of fermentation time, milk type, starter culture type and age and volume of inoculum on pH, titrable acidity and acceptability of kindirmo from cow milk – soymilk mixtures from first experiment

SN	Trts	pH	T. Acid	Flavor	Color	Taste	Sweetness	Texture	M/Feel	Accept	Ranking
I	**2%-5h**										
1.	CK24	4.70e (c)	0.08h (a)	5.2abc (ab)	6.0ab (a)	4.7abc (ab)	4.5abcde (ab)	5.3a-e (a)	5.5ab (a)	5.9abcd (a)	5.3abcd (ab) – 5th (2nd)
2.	CK48	4.70e (c)	0.08h (a)	5.5abc (a)	5.6ab (ab)	5.3abc (a)	5.3abcd (a)	5.0a-e (a)	5.5ab (a)	5.5a-e (a)	5.4abc (a) – 3rd (1st)
3.	SK24	4.50g (d)	0.08h (a)	4.0abcd (ab)	5.0abc (ab)	4.8abc (ab)	3.8bcde (ab)	5.3a-e (a)	3.4bc (c)	3.6def (bc)	2.5f-k (c) – 29th (5th)
4.	SK48	4.70e (c)	0.08h (a)	4.7abcd (ab)	4.9abc (ab)	4.8abc (ab)	4.6abcde (ab)	4.8a-e (ab)	4.8abc (ab)	5.0a-f (ab)	4.2a-g (b) – 13th (3rd)
5.	CD24	5.70a (a)	0.04l (c)	4.3abcd (ab)	4.3abc (bc)	4.4abc (ab)	5.4abcd (a)	2.8ef (bc)	3.7bc (ab)	3.8cdef (bc)	2.7f-k (c) – 27th (4th)
6.	SD24	5.40b (b)	0.05k (b)	3.4cd (b)	3.3c (c)	3.4bc (b)	3.4cde (b)	2.0f (c)	3.5bc (c)	2.9f (c)	1.3k (d) – 36th (6th)
II	**2%-12h**										
7.	CK24	4.50g (e)	0.15c (A)	4.3abcd (ab)	5.6ab (ab)	4.1abc (bc)	4.0bcde (ab)	4.4a-f (ab)	4.7abc (ab)	4.2a-f (b)	3.5b-j (bc) – 17th (3rd)
8.	CK48	4.70e (c)	0.14d (B)	4.8abcd (ab)	5.6ab (ab)	5.4abc (ab)	5.2bcde (ab)	4.9bcde (ab)	4.8abc (ab)	5.6a-e (ab)	4.5b-f (ab)- 7th (2nd)
9.	SK24	4.50g (e)	0.14d (B)	3.3cd (b)	4.6abc (b)	3.3bc (c)	3.7bcde (b)	4.2a-f (b)	4.0abc (b)	3.7cdef (b)	2.7f – k (c)- 27th (5th)
10.	SK48	4.60f (d)	0.15c (A)	4.3abcd (ab)	4.8abc (ab)	4.7abc (abc)	4.2a-e (ab)	5.0a-e (ab)	5.0abc (ab)	4.3a-f (b)	3.3c-k (bc) – 20th (4th)
11.	CD24	5.70a (a)	0.13e (C)	6.1ab (a)	6.4a (a)	6.1a (a)	5.9ab (a)	6.1a (a)	6.3a (a)	6.4ab (a)	5.7ab (a) – 2nd (1st)
12.	SD24	5.40b (b)	0.12f (D)	3.6bcd (b)	5.0abc (ab)	3.1c (c)	3.7bcde (b)	5.2a-e (ab)	3.8abc (b)	3.7cdef (b)	2.2g-k (c) – 31st (6th)
III	**2%-24h**										
13.	CK24	3.90n (c)	0.15c (a)	3.3cd (b)	4.0bc (ab)	3.5bc (b)	3.1de (b)	3.8a-f (ab)	3.7bc (ab)	3.5def (b)	3.4c-k (bc) – 18th (3rd)
14.	CK48	4.03kl (b)	0.14d (b)	5.1abcd (ab)	5.1abc (ab)	3.8abc (ab)	3.8bcde (ab)	4.7a-e (ab)	3.8abc (ab)	4.0b-f (ab)	4.3a-g (ab) – 11th (2nd)
15.	SK24	4.10j (b)	0.14d (b)	4.2abcd (ab)	4.8abc (ab)	4.4abc (ab)	3.1de (b)	4.1a-f (ab)	3.5bc (ab)	4.5a-f (ab)	3.1e-k (b) – 23rd (4th)
16.	SK48	3.90n (c)	0.15c (a)	3.8abcd (ab)	3.8bc (b)	3.3bc (b)	3.4cde (ab)	3.2cdef (b)	2.7c (b)	3.6def (b)	2.0hijk (c) – 32nd (6th)
17.	CD24	4.07jk (c)	0.13e (c)	5.6abc (a)	5.6ab (a)	5.3abc (a)	5.3abcd (a)	5.6abc (a)	4.7abc (a)	5.8abcd (a)	5.4abc (a) – 3rd (1st)
18.	SD24	4.20i (a)	0.12f (d)	3.2cd (b)	4.4abc (ab)	3.2bc (b)	2.8e (b)	4.7a-e (ab)	2.8c (b)	3.7cdef (ab)	2.9e-k (bc) – 25th (6th)

kindirmo samples made from whole cow milk and from cow-soymilk composite. However, using the DVI starter at 24h age, significant differences ($P \leq 0.05$) was observed on the pH, titrable acidity, texture and mouthfeel of kindirmo samples made from whole cow milk (CD24) and from cow-soymilk composite (SD24). But at 48hrs age (SK48 & CK48), though significant difference was observed on the pH and titrable acidity, no significant difference was observed on the sensory scores ($P = 0.05$).

At 3%-24h, the type of milk substrate used as fermentation substrate had no significant effect on kindirmo treatments (SK24 and CK24) that used 24h old kindirmo as starter culture ($P \geq 0.05$). Similarly, kindirmo of treatments SK48 and CK48 that used 48h old kindirmo as starter culture had no significant effect on kindirmo quality ($P \geq 0.05$). The exception here is the differences on sensory factors as flavour and general acceptance. Also for kindirmo from CD24 and SD24, significant differences ($P \leq 0.05$) were observed in pH; titrable acidity, flavour and ranking test at 3%-24h (Table 3). In conclusion, though kindirmo produced from whole cow milk were generally rated higher than kindirmo, from cow-soymilk composite, nonetheless, kindirmo from cow-soymilk composite has performed fairly well with significant consumer acceptance. Therefore, 20% level of substitution of cow milk with soymilk for kindirmo production is hereby recommended as a way of easing the pressure on animal milk supply. Starter culture types were found to have significant effect on the quality of kindirmo from cow milk and cow milk – soymilk mixtures ($P \leq 0.05$). At 2%-5h production, the commercial starter culture (DVI) when compared to the traditional starter cultures i.e. kindirmo of 24h and 48h old, did not perform very well at this inoculum volume and fermentation temperature and time (table 2). The pH - 5.40 and 5.70 respectively for SD24 and CD24 show that the commercial starter culture has not produced appreciable quantities of acids. This is also corroborated in their low levels of sensory ratings. The low level of activity of DVI when compared to the traditional kindirmo starter culture could most likely be due to fermentation temperature, which was $28^{o}C$ as against the recommended 44^{oC} DVI

Table 2 continued

SN	Trts	pH	T. Acid	Flavor	Color	Taste	Sweetness	Texture	M/Feel	Accept	Ranking
IV	**3%-5h**										
19.	CK24	$4.50^{g\ (c)}$	$0.08^{h\ (b)}$	$6.3^{a\ (a)}$	$5.6^{ab\ (ab)}$	$6.0^{a\ (a)}$	$6.5^{a\ (a)}$	$5.8^{abc\ (ab)}$	$5.8^{ab\ (a)}$	$6.5^{a\ (a)}$	$4.9^{a-e\ (a)} – 6^{th}\ (1^{st})$
20.	CK48	$5.20^{c\ (a)}$	$0.07^{i\ (c)}$	$5.0^{abcd\ (ab)}$	$4.2^{abc\ (b)}$	$4.9^{abc\ (ab)}$	$5.2^{a-e\ (ab)}$	$3.6^{a-f\ (c)}$	$4.6^{abc\ (abc)}$	$5.0^{a-f\ (abc)}$	$3.6^{b-j\ (ab)} – 16^{th}\ (4^{th})$
21.	SK24	$4.30^{h\ (d)}$	$0.10^{g\ (a)}$	$3.3^{cd\ (c)}$	$4.4^{abc\ (b)}$	$3.4^{bc\ (b)}$	$2.8^{e\ (c)}$	$3.9^{a-f\ (bc)}$	$2.9^{c\ (c)}$	$3.5^{def\ (c)}$	$1.6^{jk\ (c)} – 35^{th}\ (6^{th})$
22.	SK48	$4.90^{d\ (b)}$	$0.07^{i\ (c)}$	$4.3^{abcd\ (bc)}$	$4.2^{abc\ (b)}$	$4.2^{abc\ (ab)}$	$4.6^{a-e\ (b)}$	$3.4^{b-f\ (c)}$	$3.6^{bc\ (bc)}$	$4.2^{a-f\ (bc)}$	$2.9^{e-k\ (bc)} – 25^{th}\ (5^{th})$
23.	CD24	$4.90^{d\ (b)}$	$0.08^{h\ (b)}$	$5.1^{abcd\ (ab)}$	$6.3^{a\ (a)}$	$4.8^{abc\ (ab)}$	$5.0^{a-e\ (ab)}$	$5.6^{abc\ (ab)}$	$5.1^{abc\ (ab)}$	$5.4^{a-e\ (ab)}$	$4.4^{a-f\ (ab)} – 10^{th}\ (3^{rd})$
24.	SD24	$4.90^{d\ (b)}$	$0.06^{j\ (d)}$	$5.6^{abc\ (ab)}$	$5.5^{abc\ (ab)}$	$5.6^{ab\ (a)}$	$4.5^{a-e\ (bc)}$	$6.2^{a\ (a)}$	$5.5^{ab\ (ab)}$	$5.7^{a-e\ (ab)}$	$4.5^{a-f\ (ab)} - 7^{th}\ (2^{nd})$
V	**3%-12h**										
25	CK24	$3.90^{n\ (c)}$	$0.16^{b\ (A)}$	$4.8^{abcd\ (ns)}$	$3.8^{bc\ (b)}$	$4.2^{abc\ (ns)}$	$4.2^{a-e\ (ns)}$	$5.5^{abc\ (ab)}$	$5.1^{abc\ (ab)}$	$4.0^{b-f\ (ns)}$	$3.0^{e-k\ (ns)} – 24^{th}\ (6^{th})$
26	CK48	$3.99^{m\ (b)}$	$0.16^{b\ (A)}$	$4.8^{abcd\ (ns)}$	$5.0^{abc\ (ab)}$	$4.5^{abc\ (ns)}$	$4.7^{a-e\ (ns)}$	$4.0^{a-f\ (bc)}$	$4.6^{abc\ (ab)}$	$4.8^{a-f\ (ns)}$	$3.4^{c-k\ (ns)} – 18^{th}\ (3^{rd})$
27	SK24	$3.90^{n\ (c)}$	$0.16^{b\ (A)}$	$4.9^{abcd\ (ns)}$	$5.8^{ab\ (a)}$	$3.9^{abc\ (ns)}$	$4.4^{a-e\ (ns)}$	$4.5^{a-f\ (abc)}$	$4.7^{abc\ (ab)}$	$5.2^{a-f\ (ns)}$	$3.3^{c-k\ (ns)} – 20^{th}\ (4^{th})$
28	SK48	$3.90^{n\ (c)}$	$0.15^{c\ (B)}$	$5.1^{abcd\ (ns)}$	$5.0^{abc\ (ab)}$	$4.5^{abc\ (ns)}$	$4.6^{a-e\ (ns)}$	$4.5^{a-f\ (abc)}$	$4.3^{abc\ (ab)}$	$4.8^{a-f\ (ns)}$	$3.9^{a-I\ (ns)} – 15^{th}\ (2^{nd})$
29	CD24	$4.00^{lm\ (a)}$	$0.13^{e\ (D)}$	$4.9^{abcd\ (ns)}$	$5.6^{ab\ (a)}$	$4.6^{abc\ (ns)}$	$4.8^{a-e\ (ns)}$	$6.0^{ab\ (a)}$	$5.6^{ab\ (a)}$	$5.4^{a-e\ (ns)}$	$4.1^{a-h\ (ns)} – 14^{th}\ (1^{st})$
30	SD24	$3.90^{n\ (c)}$	$0.14^{d\ (C)}$	$4.9^{abcd\ (ns)}$	$5.9^{ab\ (a)}$	$4.2^{abc\ (ns)}$	$4.9^{a-e\ (ns)}$	$2.9^{def\ (c)}$	$3.4^{bc\ (b)}$	$3.9^{cdef\ (ns)}$	$3.2^{d-k\ (ns)} – 22^{nd}\ (5^{th})$
VI	**3%-24h**										
31	CK24	$3.70^{o\ (b)}$	$0.19^{a\ (A)}$	$6.2^{a\ (a)}$	$5.8^{ab\ (a)}$	$5.6^{ab\ (a)}$	$5.8^{abc\ (a)}$	$5.4^{a-e\ (a)}$	$5.7^{ab\ (a)}$	$6.1^{abc\ (a)}$	$5.8^{a\ (a)} – 1^{st}\ (1^{st})$
32	CK48	$3.70^{o\ (b)}$	$0.19^{a\ (A)}$	$5.3^{a\ (a)}$	$5.7^{ab\ (a)}$	$4.7^{abc\ (ab)}$	$5.0^{a-e\ (ab)}$	$4.8^{a-e\ (ab)}$	$5.1^{abc(ab)}$	$5.3^{a-f\ (abc)}$	$4.5^{a-f\ (b)} – 7^{th}\ (2^{nd})$
33	SK24	$3.70^{o\ (b)}$	$0.19^{a\ (A)}$	$4.5^{abcd\ (ab)}$	$4.6^{abc\ (ab)}$	$4.2^{abc\ (ab)}$	$4.4^{a-e\ (ab)}$	$3.7^{a-f\ (ab)}$	$3.8^{abc\ (ab)}$	$4.0^{b-f\ (bcd)}$	$2.4^{f-k\ (c)} – 30^{th}\ (4^{th})$
34	SK48	$3.70^{o\ (b)}$	$0.19^{a\ (A)}$	$2.6^{d\ (b)}$	$3.8^{bc\ (b)}$	$3.2^{bc\ (b)}$	$3.2^{de\ (b)}$	$3.3^{cdef\ (b)}$	$3.6^{bc\ (b)}$	$3.3^{ef\ (d)}$	$1.9^{ijk\ (c)} – 34^{th}\ (6^{th})$
35	CD24	$3.70^{o\ (b)}$	$0.19^{a\ (A)}$	$5.4^{abc\ (a)}$	$5.6^{ab\ (a)}$	$4.7^{abc\ (ab)}$	$4.9^{a-e\ (ab)}$	$5.2^{a-e\ (ab)}$	$4.6^{abc\ (ab)}$	$5.4^{a-e\ (ab)}$	$4.3^{a-g\ (b)} – 11^{th}\ (3^{rd})$
36	SD24	$3.90^{n\ (a)}$	$0.15^{c\ (B)}$	$3.1^{cd\ (b)}$	$5.8^{ab\ (a)}$	$3.8^{abc\ (ab)}$	$3.5^{bcde\ (b)}$	$4.2^{a-ef\ (ab)}$	$3.7^{bc\ (b)}$	$3.5^{def\ (cd)}$	$2.0^{h-k\ (c)} – 32^{nd}\ (5^{th})$

Figures are Means of 15 sensory scores, except for pH & T. Acidity, which is for three measurements
There are six Productions (2%-5h, 2%-5h, 2%-24h, 3%-5h and 3%-24h) of 36 kindirmo treatments.
Positions under the column 'Rank' ($1^{st} – 36^{th}$) is on a numerical basis; Trts = Treatments; & T. Acidity = Titrable acidity.
Means with Same Superscript(s), either in Parentheses or Not are significantly not different with each other (P =0.05).
Superscripts not in parentheses are for means separation for the entire 36 kindirmo treatments.
Superscripts in Parentheses are for Means Separation for Each production i.e. only 6no Kindirmo samples in each case.

(http://www.fao.org/docrep, 2005). Conversely, the comparative better performance of kindirmo starter culture implied that the strains of LAB present in kindirmo unlike the LAB in commercial starter culture are already accustomed to room temperatures (Igwe, 2000 and 2011). At 2%-12h (table 2), the type of starter culture used did not significantly affect the quality of kindirmo samples. For example, CK24 and CD24 kindirmo samples were not significantly different in all the factors except titrable acidity. The same is also true of SK24 and SD24 kindirmo samples ($P \geq 0.05$). In conclusion, using 2% kindirmo as starter culture at 12h fermentation time, no significant difference ($P \geq 0.05$) was observed when using either DVI or kindirmo as starter culture. The type of starter culture used in kindirmo production (CK24, CD24 and SD24) at 2% inoculum volume and 24h fermentation time (2%-24h) significantly affected the quality parameters of pH, titrable acidity and ranking sensory scores ($P \leq 0.05$). The sensory factors were not much affected ($P = 0.05$). At 3%-5h all the kindirmo samples, irrespective of starter culture type and age and milk type were better than the kindirmo samples at 2% inoculum volume. This is reflected in the ranges of the values of pH (4.30 – 5.20) and titrable acidity (0.06 – 0.10). Also, the sensory values scores were promising. The sensory score ranged from 3.3 of SK24 flavour to 6.5 of CK24 general acceptability. Unlike in 2%-5h, the DVI starter culture in 3%-5h produced much more acceptable fermented products. This is to the extent that SD24 and CD24 were ranked 2^{nd} and 3^{rd} respectively. Also the kindirmo starter culture fared better with whole cow milk as substrate compared to when cow-soymilk composite is used as the substrate. With 3%-12h it was observed that starter culture type significantly affected ($P \leq 0.05$) the pH, titrable acidity and only such sensory factors as colour, texture and mouthfeel of the kindirmo samples. The starter culture type used showed significant difference on the

kindirmo sample produced. The kindirmo produced by DVI starter culture in CD24 unlike in SD24 was distinct in pH, titrable acidity and virtually all sensory attributes. It was ranked the best among 6 kindirmo samples produced at 3% inoculum volume ratio and 12h fermentation.

At 3%-24h (table 3), significant differences ($P \leq 0.05$) were observed among the kindirmo samples for the pH, titrable acidity and all the sensory factors. Though significant difference ($P \leq 0.05$) was observed among kindirmo fermented with different types of starter culture, but there are some peculiarities. For example, whatever the starter culture used, kindirmo produced from whole cow milk (CK24, CK48 & CD24) were rated better than kindirmo from cow-soymilk composite (SK24, SK48 & SD24 produced using DVI as starter culture (CD24). Furthermore, there was no observed statistical difference ($P \leq 0.05$) of the effect of starter culture between kindirmo from CK24 and CK48. But the differences in numerical rating might have accounted for the differences in results of ranking test, which is CK24 (1^{st}) and CK48 (2^{nd}). Similar trend is observed between kindirmo from SK24 and SK48.

Though, it has been observed that at 3% - 24h fermentation, that kindirmo made from whole cow milk were rated higher than that from cow-soymilk composites, but some uniqueness exist between kindirmo produced using the same starter culture of the same age. For example, statistically speaking, except in ranking test, the pH, titrable acidity and Hedonic sensory ratings of kindirmo from SK24 and CK24 had no significant differences between them ($P = 0.05$). But for kindirmo from CK48 and SK48, significant differences ($P \leq 0.05$) were observed only in flavour, colour and ranking test. In conclusion, kindirmo and DVI were good starter cultures for kindirmo production. But using kindirmo offers a higher comparative advantage than the LAB present in DVI as the fermenters (microorganisms) present in kindirmo thrives well at fermenting room temperature. The effect of percentage starter culture inoculum volume on the quality of kindirmo from whole cow and cow milk – soymilk mixtures was also investigated. Generally, increased acidity was observed at 3% inoculum volume higher than at 2% inoculum volume for the three fermentation times i.e. 5h, 12h and 24h (table 2). Also, sensory ratings at 3% inoculum volume were correspondingly higher than that at 2% inoculum volumes. At 5h fermentation time significant differences on kindirmo were observed for pH in all the cases, while for titrable acidity it is only on kindirmo treatment of CK24 that no significant difference was observed ($P = 0.05$). As for the sensory factors, significant differences were observed on all the sensory factors of kindirmo except for sweetness and mouth-feel ($P = 0.05$). Also observed is the absence of uniform trend on variation of the sensory scores based on the percentage inoculum volume to milk substrate volume ratio. Based on numerical ranking values (table 2), the order of degree of acceptability of kindirmo is: CK48 (2%-5h) > CK24 (2%-5h) > CK24 (2%-5h) > SD24 (2%-5h).

At 12h fermentation time, percentage inoculum volume significantly affected the pH of kindirmo of SK24 and SD24 whereas for titrable acidity, it was only kindirmo of SK48 and CD24 treatments that were not significantly affected ($P = 0.05$). Except for kindirmo of CD24 (2%-12h), which had the highest sensory rating, generally, kindirmo of 3%-12h processing treatments have comparatively higher sensory ratings. For 24h fermentation time, it was observed that inoculum volume significantly ($P \leq 0.05$) affected the quality of *kindirmo* of all the six (CK24, CK48, SK24, SK48, CD24 and SD24) treatments. Titrable acidity, pH and some sensory factors were affected. Though most of the sensory factors were not significantly ($P \geq 0.05$) affected by the inoculum volume but in general, sensory ratings at 3%-24h were in all cases numerically higher than at 2%-24h. For *kindirmo* of CK24 treatment, quality factors affected include pH, titrable acidity, flavour, colour, general acceptability and ranking tests. The sensory values of *kindirmo* of 3%-24h were much higher than that of 2%-24h treatment. For example, the sensory values of CK24 *kindirmo* at 3%-24h ranged between 5.4 (texture) to 6.2 (flavour) as against 3.1 (sweetness) to 40 (colour). For *kindirmo* of CK48 treatment, similar trend was observed. Significant difference was observed between kindirmo of 3%-24h and 2%-24h for pH, titrable acidity and not on sensory scores ($P = 0.05$). Also, though sensory values of kindirmo at 3%-24h were higher than at 2%-24h, but the margin between the two treatments was lower for kindirmo of CK24 than of CK48. For kindirmo of SK24 treatment, quality factors affected included pH, titrable acidity, flavour, colour, general acceptability and ranking tests. The sensory values of kindirmo of 3%-24h are much higher than that of 2%-24h treatment. For example, the Hedonic values of CK24 kindirmo at 3%-24h for all the sensory factors ranged between 5.4 (texture) to 6.2 (flavour) as against 3.1 (sweetness) to 40 (colour) for 2%-24h. Similarly, for kindirmo of CK48 treatment, similar trend was observed. Significant difference was observed between kindirmo of 3%-24h and 2%-24h for pH, titrable acidity and not on sensory scores ($P = 0.05$). Also, though sensory values of kindirmo at 3%-24h were higher than at 2%-24h, but the margin between the two inoculum volumes was lower for kindirmo treatment of CK24 than for CK48.

Table 3 shows that fermentation times (i.e. 5h, 12h and 24h) irrespective of inoculum to milk substrate volume ratio, significantly affected the pH, titrable acidity and sensory qualities of kindirmo ($P \leq 0.05$). For kindirmo of CK24 treatment at 2% inoculum to milk substrate volume ratio, significant differences were observed only on the pH, titrable acidity and sensory qualities of kindirmo ($P \leq 0.05$). But at 3% inoculum to milk substrate volume ratio, fermentation time had significant effect on kindirmo of CK24 for pH and titrable acidity and not on sensory factors ($P = 0.05$). For kindirmo of CK48 treatment, at 2% inoculum to milk substrate volume ratio, fermentation time significantly affected the pH and titrable acidity but had no significant effect on sensory attributes of kindirmo ($P = 0.05$). Also no significant difference was observed on the titrable acidity of kindirmo of 2%-12h and 2%-24h ($P = 0.05$). However at 3% inoculum to milk substrate volume ratio, similar trend was observed as fermentation time only affected pH and titrable acidity and not much on sensory factors of CK48 ($P = 0.05$).

For kindirmo where different ages (24h & 48h) of kindirmo were used as starter culture, a particular trend of effect of fermentation time on the quality of kindirmo was observed. For example, irrespective of whether whole cow milk (CK24 and CK48) or cow – soymilk composites (SK24 and SK48)

was used as fermentation substrate, the desirability of resultant kindirmo decreased as fermentation time increased. At 2% inoculum, irrespective of starter culture age and milk type, fermentation time, did not significantly affect the kindirmo quality ($P \geq 0.05$). The implication therefore is that except for some leftover kindirmo starter culture, it is uneconomical to hold production for additional 24h (for starter culture preparation) since it will have no significant effect on the kindirmo quality. When the DVI was used as starter culture and at 2% inoculum to milk substrate volume ratio, the pH of kindirmo of CD24 was same at 2%-5h and 2%-12h and not at 2%-24h. But the pH varied from each other at 3%-5h, 3%-12h and 3%-24h ($P = 0.05$). The same trend of variation was observed on the titrable acidity and sensory attributes of the kindirmo of CD24 preparation at both 2% and 3% inoculum to milk volume ratios. For kindirmo of SD24, fermentation time has the same type of significant effect on kindirmo quality as in CD24 above.

Conclusion

Several conclusions were drawn from this research. The first was that all the processing conditions of fermentation time, milk type, starter culture type and age significantly affected the kindirmo quality ($P \leq 0.05$). Secondly, 20% substitution of cow milk with soymilk in kindirmo production was quite acceptable by the consumers even by those who have never tasted soymilk in the past. Thirdly, the use of kindirmo as starter culture using the back-slop method is more efficient in fermentation than the use of commercial starter culture. This was most likely due to the fact that inoculation temperature of the starter culture was at room temperature rather than at 42 – 42^{O}C which was the inoculation temperature for commercial starter cultures in yoghurt production. This leads to the fourth conclusion that kindirmo is different from yoghurt and that the LAB present in kindirmo is less thermophilic than the *Lactobacillus bulgaricus* and *Streptococcus thermophilus* present in yogurt (Igwe, 2011). The fifth finding was that starter culture ages of between 24h and 48h had no significant difference ($P \geq 0.05$) on kindirmo quality. Hence, except for leftover kindirmo of previous day's productions, deliberate effort should not be made at producing starter culture of more than 24h old as at it is economically unwise.

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