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Physicochemical Properties of Butter Collected from Local Markets of North Shewa Zone, Oromia, Ethiopia

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Abstract
Dairy products are very important foods that supply nutrients for human beings. Butter is one of the popular dairy products in Oromia. This study aimed to assess some of the physicochemical properties of butter collected from local markets of North Shewa Zone of Oromia Regional State. Butter samples were collected on market day. A total of 118 butter samples were collected from three districts. Standard analytical procedures were used to analyse the physicochemical properties of the butter samples. The fat, moisture, free fatty acid and ash contents of butter ranged between 70.35 % - 92.34 %; 5.95 % - 27.95 %, 0.27 % - 9.69 %; and 0.04 % - 0.31 % respectively. Calcium, magnesium, potassium and phosphorus content of the butter ranged between 13.59 ppm- 537.49 ppm, 2.57 ppm – 42.12 ppm, 7.98 ppm – 224.17 ppm; and 12.20 ppm – 434.76 ppm respectively. The average free fat acidity and moisture content of butter failed to comply with codex international standards. Butter from Kuyu district contained higher amount of fat content when compared with Kimbibit and Wachale districts. The free fatty acid content of butter showed large variation among butter samples collected which could be attributed to storage of butter for market size; and unhygienic dairy processing technique. The concentration of mineral elements in butter followed the order Ca>P>K>Na>Mg>Fe>Zn. Further study on fatty acid profile, and effect of butter storage materials need to be investigated.

Keywords: *Butter, North Shewa, physicochemical properties, Local markets*

1. Introduction

Dairy products play crucial role in the improvement of livelihoods of the community if they are properly processed, managed and with available market chain. Dairy products contain high nutrients and are rich in milk fat globule membrane, conjugated linoleic acid and fatty acids beneficial for health (Kwak et al., 2013). Butter is one of the dairy products used for cooking and cosmetic purposes in Ethiopia (Alganesh & Yetenayet, 2017). It is essential part of nutritional value of milk that can be made from milk of different animal species. Cow milk is the dominant source of butter production (Fuquay et al., 2011). Butter that is used for cooking is processed to ghee by adding different spices. This increases the stability of butter by removing moisture which result in decrease in oxidation of lipids. Besides its use in household consumption, butter generate income for different community (Yilma et al., 2011; Neijenhuis, 2014). It has been stated that the current dairy production techniques in Africa may not

guarantee safe hygienic practices which can limit their possibilities of export of dairy products (Mattiello et al., 2018).

According to the community, the quality of butter is characterised by its origin, color, smell, consistency and degree of adulteration with foreign materials (Gebremedhi et al., 2014). These are traditional butter quality indicators/features which the community use to rate butter quality. According to the review conducted smoking of milk storage container and churning container by different plant species is believed to impart distinct flavour (Alganesh & Yetenayet, 2017). The literature supports that the quality of butter is characterized by feed, breed type and milk handlings (Gebremedhi et al., 2014). In some areas of Ethiopia feed is probably the main factor that affects the butter quality (Geographical locations). Study showed that the price of Butter from Debre Birhan was high which could be attributed to consumers' preference for Butter of particular area. As a result, Sheno (Kimbibit District), Wollega and Dire Inchini butter are with repute market according to the consumer perception. In Ethiopia, the geographical origin of butter affects its reputability(Gemeda, 2013; Derese et al., 2016).

The cattle feeding practices in Ethiopia is changing from time to time. There is a general decrease in green fodder and increase crop residue as animal feed. The breed composition of cattle according to CSA 2020/21 report is 2.29 %, 2.6 % and 15.4 % hybrid cattle for Ethiopia, Oromia and North Shewa Zone respectively (Central Statistical Agency (CSA), 2020) indicating large proportion of hybrid cattle composition in the study area.

Although the price of a commodity is affected by different factors, quality of a product affects its reputability. Therefore, if there is a difference in butter quality among different geographical locations the community should get market/price advantage. As far as literature is concerned there are no data that support the difference in butter quality with regard to physical and chemical properties except consumer perceptions at these locations. Therefore, this study was initiated to determine some physicochemical properties of butter collected from local markets of North Shewa Zone of Oromia Regional state.

2. Materials and Methods

Site Selection

Wachale, Kimbibit and Kuyu districts were selected from North Shewa Zone for the study by consulting with Zonal Livestock Agency. Based on the information obtained from Zonal Livestock Agency each districts were consulted. The selection of peasant associations (PAs) were done purposefully with dairy products expert from each district based on product availability and agro ecology. Three PAs were selected per district. Accordingly, Adadi Falee, Gara Chatu and Sike from Kimbibit District; Dawicha Kerenso, Wuye Gose and Biriti from Kuyu district; and Bole Bacho, Bidaru and Gimbichu from Wachale disricts were selected for the study. Except Kimbibit district (all PAs are categorized under highland agro ecology) low land, midland and highland agro ecologies were considered in the study.

Sampling

Butter samples were collected from the market on the market day of the PAs during month of April, 2022. Development agents (DAs) helped in identifying the dwellers of the PA to take samples. Butter samples were collected separately. A total of 118 butter samples were collected

(Kuyu and Wachale districts - 36 samples each; Kimbibit- 46 samples). Samples were taken in capped glass jar and sealed, and labelled appropriately. The samples were kept in ice box and brought to Food Science Research Directorate Laboratory and kept in deep freezer until analysis.

Analysis of some physicochemical properties of Butter

Reagents/Chemicals used during the study were analytical reagent grade. Double distilled water was used for dilution, reagent and calibration standard preparations. Standard procedures were used to analyse the physicochemical properties of butter samples. Samples were prepared according to AOAC official method 938.05. Moisture content was analysed using AOAC official method 920.116. Fat content (AOAC official method 938.06), ash content (AOAC official method 920.117) and free fatty acid (AOAC official method 940.28) were analysed using the stated methods. Minerals (Fe, Zn, Ca and Mg) were analysed using AAS (novAA 350 Flame Atomic Absorption Spectrophotometer), and K and Na- using Flame photometer (Jenway PFP7 Flame photometer).

Statistical Analysis

The data obtained were analysed using R statistical software package (Ri386 3.3.0 version). Descriptive statistics were used to describe the physicochemical properties of butter samples collected from the study sites. ANOVA at 5 % significance level and LSD mean separation method was used analyse the parameters. Correlation between some butter physicochemical compositions were analyzed using Pearson correlation coefficient model.

3. Results and Discussion

3.1.Fat, Moisture, Free Fatty Acid and Ash Contents of Butter

The fat content of butter samples collected from the study sites ranged from 70.35 % - 92.34% (Table 1). The average fat content of butter samples collected from market was 81.34±3.87 % which is higher than fat content reported (Çelik & Bakirci, 2000) and the standard (Codex Alimentarius, 2018). Fat content of butter ranged from 68.00- 90.00 % according to study conducted on Iranian traditional butter (Sarab et al., 2019). The variation in fat content of butter samples could be attributed to the removal of butter milk by farmers at different amount (Padure, 2021). The higher the butter milk removed during the dairy processing, the higher the fat content it will be. Non washing practices of butter after its production could yield higher yield of lower fat content butter (White et al., 1956). A study showed that feed had no significant difference on the fat content of butter (Middaugh et al., 1988). The study revealed that 32.20 % of butter samples collected did not comply with fat content requirement set by International food standards (Figure 1).

Butter samples contained higher amount of moisture content (17.04±3.83%) not within the standard set by Codex Alimentarius International Food Standards for butter i.e. max 16 % but similar with research reviewed by (Ashenafi, 2006) which is 17.2 %. Wider moisture content range obtained by other scholars ranging from 2-42 % (Mahony & Bekele, 1985). A research conducted in Türkiye showed higher moisture content of butter than results obtained by this study i.e. minimum of 8.72 % and maximum 31.63 % moisture content (Akgül et al., 2021). A study conducted on traditional butter prepared in a laboratory contained 17.5-26.2 % moisture (Idoui et al., 2010) and 0.78-33.5 % was also reported (Sarab et al., 2019). Up to 18.86±1.02%

moisture content was reported for butter collected from open market (Mekdes, 2008). 17.2 % moisture content was also reported by EMPHI 1995 report. Although analysis was for small number of butter samples, the moisture content of butter decreased along the value chain and were in accordance with the standard set (Gazu et al., 2018). The study revealed that 69.49 % of butter samples collected did not comply with moisture content requirement set by International food standards (Figure 1).

Table 1. Fat, moisture, non-fat solid, free fatty acid and ash contents of butter collected from North Shewa (n = 118)

Parameter	Mean ±SD	Median	Min.	Max.
Fat content (%)	81.34 ±3.87	81.24	70.35	92.34
Moisture content (%)	17.04 ±3.83	17.14	5.95	27.95
Non-fat solid (%)	1.62 ±0.32	1.62	0.24	2.59
Free fatty Acid (%)	1.86 ±1.86	1.04	0.27	9.69
Ash content (%)	0.13 ±0.05	0.13	0.04	0.31

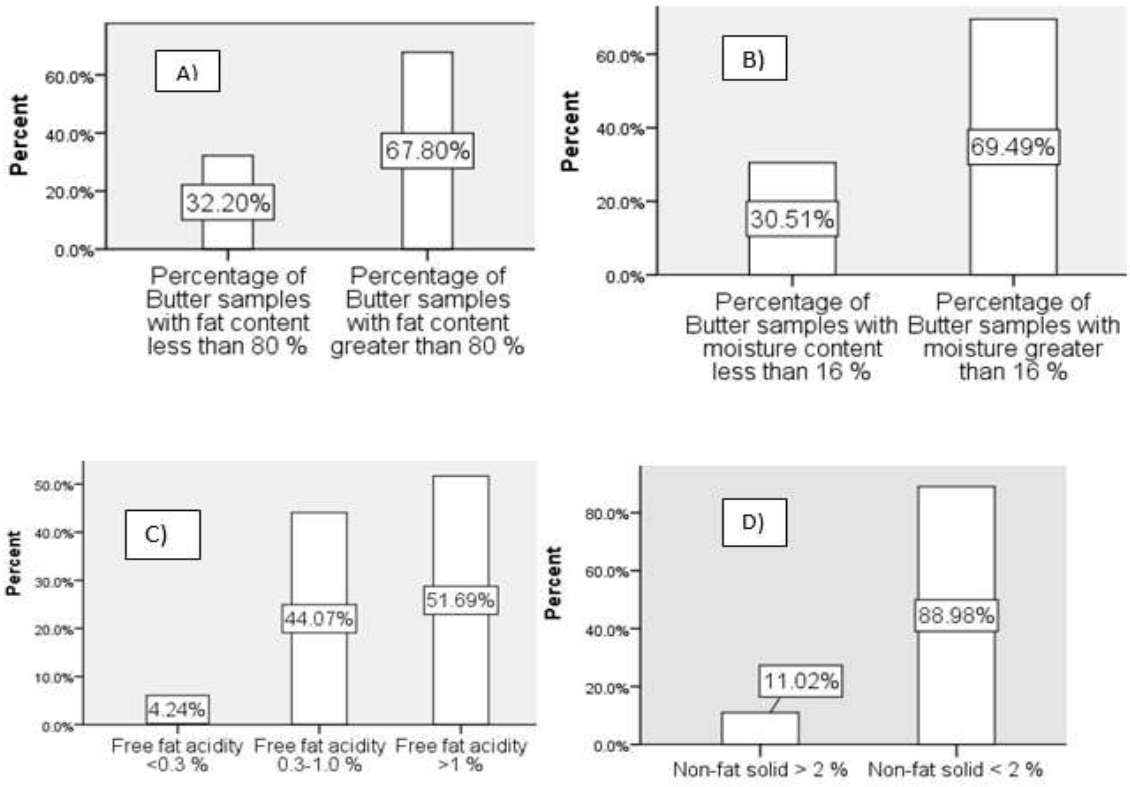

Figure 1.A) Percentage of butter samples with different fat content, B) percentage of butter samples with different moisture content C) Percentage of butter samples with free fatty acid<0.3, 0.3-1.0 and >1% D) Non-fat solid content <2 and >2 %

The free fatty acid content showed higher variation among the samples collected from the local markets (0.27 % min and max. 9.69 %, Table 1). The average free fatty acid was 1.86 ±1.86%.

This result was not in agreement with the study conducted by other scholars (Goncalves & Baggio, 2012) that ranged from 0.16-0.46 %. (Gazu et al., 2018)reported 2.09 % free fatty acid higher than this study. Other scholars reported the free fatty acid of butter samples from local markets of Dire Enchini and Ejere districts of West Shewa, Oromia, to be 0.82±0.05% and 0.62±0.1 % respectively even though the information was generated from three replications (Borena et al., 2018). The free fatty acid of Iranian traditional butter ranged from 0.1-0.99 % (Sarab et al., 2019) which could be attributed to the type and storage of butter. A maximum free fatty acid of about 23 % was obtained for older butter samples in Addis Ababa (Mahony & Bekele, 1985). The large range of free fatty acid can be attributed to accumulation of butter by farmers for market size (Ghilu et al., 2012) and non-hygienic practices during the dairy processing (Gazu et al., 2018; Shekhara et al., 2020). Butter storage methods can also lead to deterioration of butter (Kosikowsky et al., 1947). Producers bring butter to local market by packing it with different packaging materials which could deteriorate the butter to different degrees.

The non-fat solid content of the butter samples ranged from 0.24 %-2.59% (Table 1). The average of non-fat solid was 1.62 ±0.32 %. This result is in agreement with the maximum standard set as 2.0 % according to Codex standard for butter. It was reported that the non-fat solid content of butter ranged from 1.05 ± 0.14% (Queirós et al., 2016) and 0.72-1.42 % (Padure, 2021). In another study non-fat solid content of traditional butter ranged from 0.44-21.7 % (Sarab et al., 2019).

The ash contents of butter samples collected from the study area ranged between 0.04-0.31 %. The average ash content 0.13 ±0.05 % higher than the average ash content reported (0.114 %) (Borena et al., 2018) but others reported 0.2 % for ash content of butter (Ashenafi, 2006; Enb et al., 2009). In other study 0.02-0.55% ash content was obtained for unsalted butters (de Silva et al., 2021).

3.2.Calcium, Magnesium, Iron, Zinc, Potassium, Sodium and Phosphorus Contents of Butter

Some mineral element in butter from North Shewa were analysed. Results showed that calcium concentration was the highest of all on average and Zinc was the one with the lowest concentration (Table 2). Although there were large range of variations among the samples, Calcium (Ca), Potassium (K), Phosphorus (P), Zinc (Zn) and Iron (Fe) contents of butter samples were higher than reported by Zamberlin et al., (2012). Calcium (Ca), Potassium (K), Zinc (Zn) and Iron (Fe) contents of butter samples in the study areas were higher than results reported (Borena et al., 2018) but lower sodium and potassium content. The iron content of butter collected from local market in Tehran was reported to be 1.274±0.419 ppm (Vahedi et al., 2015), lower than Iron content reported by this study. The minimum - maximum and average iron and zinc contents of butter samples reported by Meshref et al., (2014) were 5.0693- 13.14 ppm and 6.69±0.437 ppm 2.815 - 8.893 ppm, and 5.98±0.407 ppm respectively. It was also reported that the iron and zinc content of butter to be 4.407 ppm and 19.086 ppm respectively (Enb et al., 2009). The higher content of iron may be attributed to feed, churning process or unhygienic practice that might lead to higher iron concentration in butter samples. The concentration of mineral elements in butter samples followed the order

Ca>P>K>Na>Mg>Fe>Zn but according to Borena et al., (2018) the order of magnitude of mineral elements in the butter samples increased in the order of K>Ca>Na>Mg >Fe>Zn.

Washing water and utensils used for milking and dairy processing can affect the quality of butter. Washing water of 0.4 ppm Fe could affect dairy products. Quantities of Iron higher than 1.5 ppm in milk could also affect the shelf life of butter due to their catalytic effect (Lante et al., 2006).

Table 2. Calcium, Magnesium, Iron, Zinc, Potassium, Sodium and phosphorus content of butter collected from North Shewa (n = 118)

Parameter (on dry basis)	Mean ±SD	Median	Min.	Max.
Calcium (ppm)	245.64 ±70.43	243.71	13.59	537.49
Magnesium (ppm)	21.36 ±6.17	20.94	2.57	42.12
Iron (ppm)	3.04 ±2.28	2.44	0.54	15.86
Zinc (ppm)	2.63 ±1.25	2.54	0.50	7.01
Potassium (ppm)	130.77 ±31.27	133.32	7.98	224.17
Sodium (ppm)	61.16 ±31.98	53.52	6.65	158.72
Phosphorus (ppm)	207.35 ±64.32	204.50	12.20	434.76

3.3.Physicochemical Properties of Butter among Districts

The Fat contents of butter samples collected was significantly higher for Kuyu district (Table 3). The moisture content of butter samples was in a good agreement with standard for Kuyu district and it was significant.

Table 3. Comparison of fat, moisture and potassium contents of butter in North Shewa Zone, Oromia.

District	Fat Content (%)	Moisture Content (%)	Potassium (ppm)
Kimbibit	80.10^{b}	18.28^{a}	136.29
Kuyu	83.07^{a}	15.30^{b}	126.68
Wachale	81.19^{b}	17.21^{a}	127.79
CV	4.56	21.91	24.25
P-value	0.00157	0.00123	0.3746

Means followed by different superscript letters in the same column are significantly different at P<0.05.

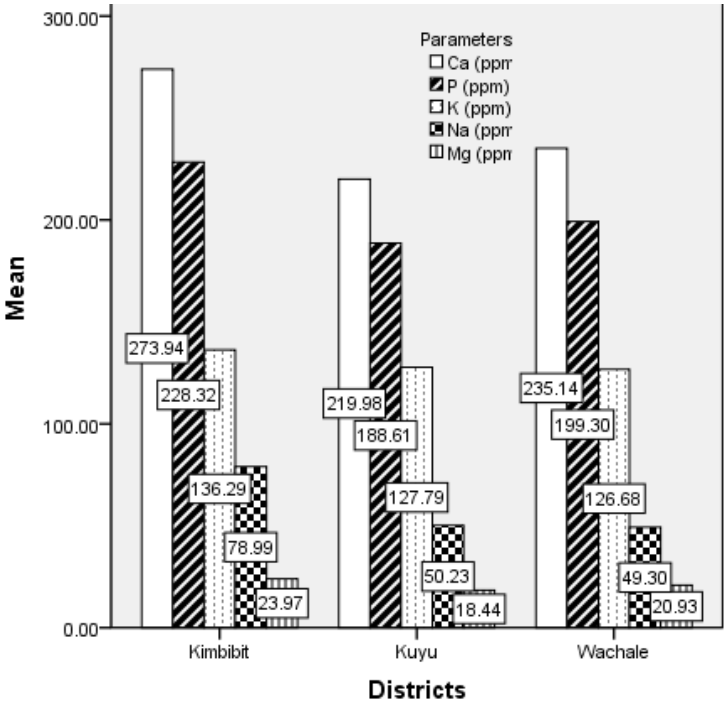

Figure 2. Calcium (Ca), phosphorus (P), Potassium (P), Sodium (Na) and Magnesium (Mg) content of Butter collected from Kimbibit (n=46),Kuyu (n=36) and Wachale (n=36) districts of North Shewa, Oromia

The mineral content analysed showed similar trend along the districts (Figure 2). Calcium content of butter was highest when compared with other minerals. Mineral content follows the order Ca>P>K>Na>Mg>Fe>Zn.

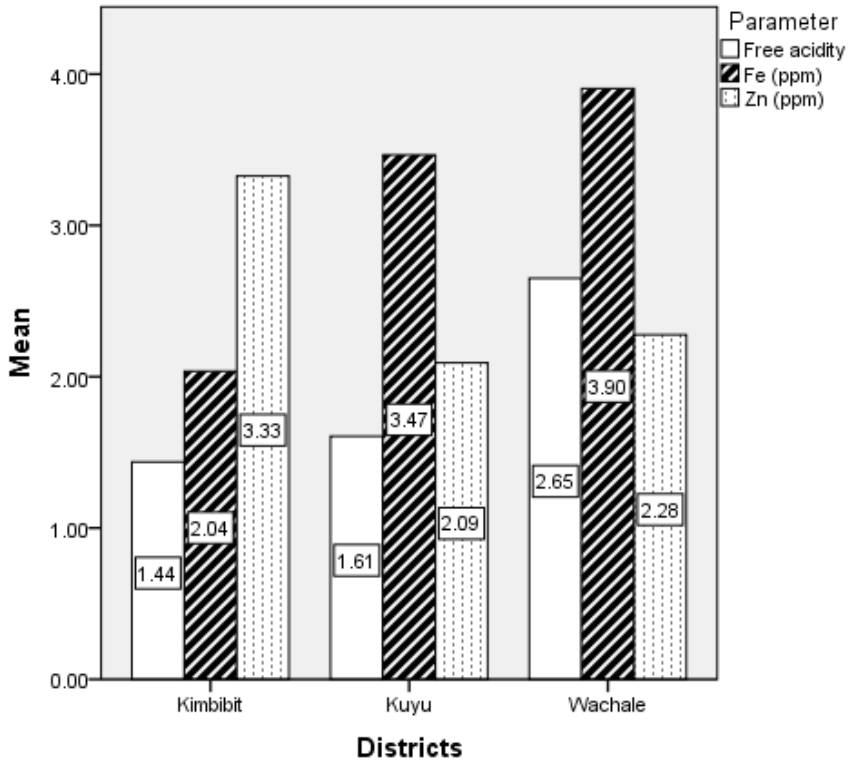

Figure 3. Free fatty acid, Iron (Fe) and Zinc (Zn) content of Butter collected from Kimbibit (n=46), Kuyu (n=36) and Wachale (n=36) districts of North Shewa, Oromia

The free fatty acid, Iron and Zinc content of butter samples did not show similar trends with Ca, P, K, Na and Mg (Figure 3). Iron content and free fatty acid of butter samples shown increase along Kimbibit, Kuyu, Wachale districts.

Butter handling process proper sanitation and use of fumigated container for its storage affects the shelf life of butter according to butter producers (Gebremedhi et al., 2014). The community used to keep butter in different storage materials such as clay pot, plastic material and metal containers (Derese et al., 2016).

3.4.Correlation Coefficients between Some Butter Physicochemical Parameters

The correlation coefficient between some physicochemical properties of butter samples collected from North Shewa Zone are shown in Table 4. Ash content moderately correlated with the phosphorus, calcium and magnesium. Phosphorus was very strongly correlated and strongly correlated with calcium and magnesium respectively according to (Schober et al., 2018) correlation coefficients interpretation.

Table 4. Correlation coefficients between some butter physic-chemical parameters

	Ash	Moisture	Fat	Non-fat solid	P	Na	K	Fe	Zn	Ca	Mg	Free fatty acid
Ash	1											
Moisture	.279**	1										
Fat	-.304**	-.997**	1									
Non-fat solid	.328**	.057	-.140	1								
P	.624**	.286**	-.315**	.379**	1							
Na	.104	.206*	-.225*	.245**	.458**	1						
K	.262**	.180	-.212*	.410**	.659**	.322**	1					
Fe	-.146	.035	-.037	.030	.029	.038	.084	1				
Zn	.128	.241**	-.254**	.186*	.216*	.258**	.218*	-.079	1			
Ca	.618**	.379**	-.418**	.505**	.899**	.539**	.655**	.059	.342**	1		
Mg	.589**	.342**	-.373**	.407**	.888**	.504**	.629**	.005	.322**	.885**	1	
Free fatty acid	.242**	-.096	.089	.076	.158	-.109	.040	.095	.119	.074	.234*	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

4. Conclusions

Dairy products are important source of nutrients throughout the World. This study was conducted to analyse some physicochemical properties of butter collected from local markets of North Shewa Zone of Oromia Regional State. The study revealed that the average fat content of butter collected from local markets of North Shewa Zone comply to International food standard whereas the moisture content and free fatty acids failed to comply. These non-conformities make butter unfit for export to countries that are abide by the Codex International food standards even though the moisture content of the butter may comply as butter moves to higher value chain. The study shows the necessity to control the quality of butter and provide training on the hygienic practices to be followed by the butter producers. Butter from Kuyu district contained higher fat content than Kimbibit and Wachale districts which implies that more ghee yield can be obtained from butter collected from Kuyu district. The concentration of mineral elements in butter samples followed the order Ca>P>K>Na>Mg>Fe>Zn.

Further study on fatty acid profile of butter in the study area is required. The effect of butter storage materials and mineral rich feed on the storability of butter need to be investigated.

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