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Effect of Thermization and storage period on the quality parameters of yoghurt

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Abstract

This research work was to investigate the effect of thermization and storage period on the quality parameters of yoghurt. The proximate, physiochemical and sensory evaluation of yoghurt thermized at 50 – 70 °C and stored at 0 – 4 weeks were studied. The moisture contents ranged from 86.15 to 89.94%, ash content ranged from 0.25 to 0.89%, fat content ranged from 2.98 to 3.91%, protein content ranged from 3.21 to 5.08%, carbohydrate content ranged from 3.25 to 5.07% and total solid ranged from 10.07 to 13.85%. There was decrease in the pH and total titratable acidity of the sample as days passes by, the value increase from 3.90 to 6.90 (pH tends towards alkaline) and 0.53 to 0.83% (total titratable acidity). Also, it was observed that yoghurt sample thermized at 65 °C had the most sensory properties (taste, odour, texture, appearance and overall acceptability) acceptability. The findings reveals that the higher the thermization temperature, the lower the degree of deterioration and also, that storage reduces the quality parameters/attributes of the yoghurt hence makes the yoghurt unfit for consumption.

Keywords: Yoghurt; Thermization; Storage period; Quality parameters

1 Introduction

The word yoghurt is derived from the Turkish word *jugurt* which means dense thick [1]. Yoghurt is a food produced by bacterial fermentation of milk [2]. The bacteria used to make yoghurt are known as "yoghurt cultures". Fermentation of lactose by these bacteria produces lactic acid, which acts on milk protein to give yoghurt its texture and characteristic tart flavour [3]. It is the most widely available fermented milk in western world where its popularity derives more from its flavour and versatility [4]. Yoghurt is a dairy product produced by bacteria fermentation of milk sugar (lactose) into lactic acid [5]. This gives yoghurt its gel-like texture and characteristics taste. It is often sold with a fruit vanilla or chocolate flavour but can be unflavoured.

The nutritional and therapeutic functions of yoghurt have been known in the Middle East, Far East and Eastern Europe for hundreds of years, but it has only been appreciated in the west in the last decades [6]. Yoghurt is made by introducing two bacteria: *Lactobacillus bulgaricus* and *Streptococccus thermophilus* into either whole or skimmed milk. The milk is first heated to a temperature between 85 to 95 °C for 30 min for pasteurization and proper viscosity and cooled to incubating temperature before inoculating the starter culture. These bacteria feed on milk, sugar, producing an acid in return, which coagulates the milk protein, resulting to a semi-solid consistency and a flavour [3, 7].

Milk formula is usually made from cow's milk and represents the first food introduced into an infant's diet when breastfeeding is either not possible or insufficient to cover nutritional needs [8]. Cow's milk and dairy are commonly consumed foods in the human diet and contribute to maintaining a healthy nutritional state, providing unique sources

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of energy, calcium, protein, and vitamins, especially during early childhood. Water is the main component in all milks, ranging from an average of 68% in reindeer milk to 91% in donkey milk [9].

The main carbohydrate in milk is lactose, which is involved in the intestinal absorption of calcium, magnesium and phosphorus, and the utilization of vitamin D in brain development and is a source of energy [10]. Lactose also provides a ready source of energy for the neonate, providing 30% of the energy in bovine milk, nearly 40% in human milk and 53–66% in equine milks [11]. Cow milk accounted for 83% of global milk production in 2010. Cow milk contains more protein and minerals, especially calcium and phosphorus, than human milk. This is because a young calf grows faster than a child and hence has higher nutritive demands: on average, a calf takes only 10 weeks to double its birth weight, compared with 20 weeks for a human baby [12]. The protein in cow milk is of high-quality (defined as protein that supports maximal growth), containing a good balance of all the essential amino acids, including lysine [8].

Thermization is a method of sanitizing raw milk with low heat. It is generic description of a range of sub-pasteurization heat treatments that markedly reduce the number of spoilages in milk with minimal heat damage and its temperature ranges from 57 to 68 °C [13]. There are two main temperature categories employed in thermal processing: pasteurization and sterilization. The basic purpose for the thermal processing of foods is to reduce or destroy microbial activity, reduce or destroy enzyme activity and to produce physical or chemical changes to make the food meet a certain quality standard for example, gelatinization of starch and denaturation of proteins to produce edible food [14].

Today, yoghurt remains a milk-based fermented milk that is presented to the consumer in either a gel form (set yoghurt) or as a viscous fluid (stirred yoghurt) but, as figures for consumption have risen, so manufacturers have expanded the market by introducing an ever-wider range of fruit flavours and/or changing the image of the product, e.g., by raising the total solids and fat contents of a standard stirred yoghurt to give a product with a luxury image. Nevertheless, despite these and other innovations, the method of manufacture is still based on the system employed by nomadic herdsmen many centuries ago and the effect of temperature (thermization) on the quality and storability of the yoghurt was not spelt out e. g. the majority of yoghurts consumed worldwide are manufactured with cultures of bacteria with growth optima of 37–45 °C and this characteristic derives from the fact that the species in question, namely *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus*, evolved in the Middle East where the ambient temperature in the summer months is often well in excess of 35 °C. Similarly, the universal method of manufacturing satisfactory yoghurt is based on the traditional process expanded but this method does not put into consideration the possible effect of this processing (especially, thermization) on the quality and storage period of yoghurt [15]. However, an indication of possible effect of this on the quality parameters of yoghurt which is of great importance has not been researched on. Hence, the need for this study.

2 Material and methods

2.1 Materials

Milk, starter culture and sweeteners were obtained at Agbeni-Ogunpa Market, Ibadan, Nigeria. Other equipment such as refrigerator, boiler and thermometer were provided by the Department of Livestock Feeds and made use of at Livestock Feeds Analytical Laboratory, Institute of Agricultural Research and Training, Ibadan, Nigeria.

2.2 Preparation of Yoghurt

Four kilograms (4 kg) of powdered milk was weighed and heated to 82 °C for 17 min. Then, it was cooled to 46 °C. Three percent (3%) of yoghurt culture was added to the milk and mixed well [3]. The milk was kept in clean container to ferment for 20 h. sweeteners were added and mixed very well before filling in a well sterilized container.

2.3 Procedure of Thermization and Storage

The yoghurt sample was divided into six (6) portions in which five (5) portions were thermized at five (5) different thermization temperatures (50, 55, 60, 65 and 70 °C) and the sixth portion is unthermized (control). The samples were then stored at room temperature (25 °C) for a month and check every 7 days to determine the effect thermization and storage period on its quality parameters after the initial analysis has been carried out [3].

2.4 Chemical Analysis

Samples of yoghurt were analyzed for the following parameters, fat, protein, moisture, crude fiber and ash content using AOAC [16] methods. The carbohydrate content was determined by difference between 100 and total sum of the percentage of moisture, protein, fat, crude fibre and ash. The pH and percentage titratable acidity were determined according to Adegoke [17].

2.5 Sensory Evaluation

An organoleptic analysis of the yoghurt from each day that sample was taken for analysis was carried out for comparison. 15 panelists were selected among staffs, students and people in IAR&T, Apata, Ibadan and its environs who was accustomed with the product and terminology. The yoghurt samples were assessed using nine-point hedonic scale ranging from 9 = like extremely to 1= dislike extremely for the following attributes: taste, colour, texture, odour and overall acceptability [1].

2.6 Statistical analysis

Statistical analysis of all the data was done with all experiments were done in three replicates. The statistical significance differences were evaluated by one-way analysis of variance (ANOVA) using the statistical package for social sciences (SPSS version 16.0) at the 5% significance level.

3 Results and discussion

3.1 Chemical analysis

The result of the proximate composition obtained on yoghurt with different thermization temperatures are as shown in Tables 1 – 5. Moisture content of the sample ranged from 86.28 to 89.03%, 86.15 to 89.57%, 86.43 to 89.71%, 86.54 to 89.80% and 86.72 to 89.94%, respectively for 0, 1, 2, 3 and 4 weeks with control sample having the highest value and yoghurt sample thermized at 70 °C having the lowest value. There were significant differences ($p<0.05$) among all the samples but it was observed that all samples thermized are drastically lower than the control samples in which similar observation was made by Obi *et al*. [1] whose range of yoghurt sample was 85.55 to 87.50%. Also, low moisture content in foods retard the growth of mould and other biochemical reactions and also enhances storage stability [18]. High moisture products greater than 12% usually have short shelf stability compared with lower moisture products with less than 12% [19].

Ash content is the measure of the total amount of minerals present within a food (a reflection of the mineral element) [20]. Ash content of the yoghurt samples ranged from 0.60 to 0.89%, 0.51 to 0.86%, 0.41 to 0.80%, 0.34 to 0.71% and 0.25 to 0.63%, respectively for 0, 1, 2, 3 and 4 weeks. The control samples having the lowest value and yoghurt samples 70 ^{0}C had the highest value with significant differences ($p<0.05$) among all samples. It was observed that thermization and storage period contributed to total ash content which is in conformance with Andleeb *et al*. [21] that ranged from 0.74 to 0.86% who worked on the assessment of the quality of conventional yogurt as affected by storage.

Fat content ranged between 3.30 to 3.83%, 3.25 to 3.80%, 3.17 to 3.72%, 3.10 to 3.67% and 2.98 to 3.58%, respectively for 0, 1, 2, 3 and 4 weeks. Thus, control samples had the lowest value and yoghurt sample thermized at 70 °C had the highest value in which there was no significant difference ($p>0.05$) among all samples except for the control sample been significantly different from all other samples. The fat content increases with increase in the thermization and decreases with increase in the storage (the higher the thermization, the higher the fat content but the higher the storage period, the lower the fat content). A similar result was obtained in the finding of Bibiana *et al*. [22]. This favours the flow properties of yogurt which will enable the formation of more stable viscoelastic gel networks according to Vasileana *et al*. [23]. Ikuomola [24] reported that fat is able to provide thrice the amount of energy needed by the body. It also plays a role in determining the shelf-life of foods.

Protein content of yoghurt sample ranged from 3.53 to 4.74%, 3.44 to 5.08%, 3.37 to 4.46%, 3.28 to 4.27% and 3.21 to 4.10%, respectively for 0, 1, 2, 3 and 4 weeks with significant differences ($p<0.05$) among all samples in which control samples had the lowest values and the yoghurt samples T_{70} had the highest values similar to the values obtained in Obi *et al*. [1] findings, which ranged from 2.97 to 3.95%. It was reported by Mahan and Escott-Stump [25] that proteins act as carriers for other nutrients such as vitamin A, lipids, iron, potassium and sodium and also by Anuonye *et al*. [26] that foods high in protein are of great nutritional importance in developing countries such as Nigeria where there is a prevalence of protein malnutrition.

According to Iqbal *et al.* [27], the only deficiency in yoghurt is a fibre and most time may call for incorporation of vegetable for fibre enrichment. Crude fibre was not present in all the yoghurt samples (0.00%). Carbohydrate content with significant differences ($p<0.05$) ranged from 3.55 to 4.64%, 3.25 to 4.67%, 3.35 to 4.75%, 3.48 to 4.84% and 3.63 to 5.07%, respectively for 0, 1, 2, 3 and 4 weeks in which control samples had the lowest values compared to the yoghurt samples (65 °C) with the highest values which was in conformity with Obi *et al.* [1] ranging between 6.68 to 4.40%. The carbohydrate content of the sample tends to increase with increase in storage period and decreases with temperature that is, temperature and storage period are key factor affecting the carbohydrate content of yoghurt samples [28].

Table 1 Proximate composition of yoghurt at 0 week

Sample	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Crude fibre (%)	Carbohydrate (%)	Total solid (%)
T_{50}	87.73^{b}	0.69^{c}	3.61^{a}	3.63^{c}	0.00	4.14^{b}	12.27^{e}
T_{55}	87.74^{b}	0.73^{cd}	3.58^{a}	4.19^{b}	0.00	3.99^{bc}	12.60^{d}
T_{60}	86.51^{c}	0.78^{c}	3.71^{a}	4.38^{b}	0.00	4.64^{a}	13.50^{c}
T_{65}	86.41^{c}	084^{b}	3.78^{a}	4.57^{ab}	0.00	4.42^{ab}	13.59^{b}
T_{70}	86.28^{d}	0.89^{a}	3.83^{a}	4.74^{a}	0.00	4.27^{b}	13.73^{a}
Control	89.03^{a}	0.60^{e}	3.30^{b}	3.53^{d}	0.00	3.55^{c}	10.98^{f}

Mean along the column with superscripts are significantly different ($p \leq 0.05$); T_{50} = yoghurt thermized at 50 °C; T_{55} = yoghurt thermized at 55 °C; T_{60} = yoghurt thermized at 60 °C; T_{65} = yoghurt thermized at 65 °C and T_{70} = yoghurt thermized at 70 °C.

Table 2 Proximate composition of yoghurt at 1 week

Sample	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Crude fibre (%)	Carbohydrate (%)	Total solid (%)
T_{50}	87.62^{b}	0.66^{c}	3.58^{a}	4.07^{c}	0.00	4.09^{c}	12.38^{d}
T_{55}	87.23^{c}	0.70^{bc}	3.53^{a}	4.53^{bc}	0.00	4.02^{d}	12.78^{c}
T_{60}	86.30^{de}	0.74^{b}	3.67^{a}	4.64^{b}	0.00	4.67^{a}	13.71^{ab}
T_{65}	86.37^{d}	0.81^{ab}	3.73^{a}	4.83^{ab}	0.00	4.27^{b}	13.64^{c}
T_{70}	86.15^{e}	0.86^{a}	3.80^{a}	5.08^{a}	0.00	4.12^{bc}	13.85^{a}
Control	89.57^{a}	0.51^{d}	3.25^{b}	3.44^{d}	0.00	3.25^{e}	10.43^{e}

Mean along the column with superscripts are significantly different ($p \leq 0.05$); T_{50} = yoghurt thermized at 50 °C; T_{55} = yoghurt thermized at 55 °C; T_{60} = yoghurt thermized at 60 °C; T_{65} = yoghurt thermized at 65 °C and T_{70} = yoghurt thermized at 70 °C.

Table 3 Proximate composition of yoghurt at 2 weeks

Sample	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Crude fibre (%)	Carbohydrate (%)	Total solid (%)
T_{50}	88.13^{b}	0.62^{c}	3.54^{a}	3.65^{d}	0.00	4.07^{bc}	11.88^{e}
T_{55}	87.94^{c}	0.66^{bc}	3.47^{a}	4.03^{c}	0.00	3.91^{c}	12.06^{d}
T_{60}	86.81^{d}	0.70^{b}	3.61^{a}	4.14^{bc}	0.00	4.75^{a}	13.24^{c}
T_{65}	86.63^{de}	0.76^{ab}	3.68^{a}	4.26^{b}	0.00	4.68^{ab}	13.37^{b}
T_{70}	86.43^{e}	0.80^{a}	3.76^{a}	4.46^{a}	0.00	4.60^{abc}	13.57^{a}
Control	89.71^{a}	0.41^{d}	3.17^{b}	3.37^{e}	0.00	3.35^{d}	10.30^{f}

Mean along the column with superscripts are significantly different ($p \leq 0.05$); T_{50} = yoghurt thermized at 50 °C; T_{55} = yoghurt thermized at 55 °C; T_{60} = yoghurt thermized at 60 °C; T_{65} = yoghurt thermized at 65 °C and T_{70} = yoghurt thermized at 70 °C.

Table 4 Proximate composition of yoghurt at 3 weeks

Sample	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Crude fibre (%)	Carbohydrate (%)	Total solid (%)
T_{50}	88.40^{b}	0.55^{cd}	3.45^{a}	3.45^{cd}	0.00	4.16^{bcd}	11.61^{c}
T_{55}	88.11^{c}	0.60^{c}	3.63^{a}	3.90^{bcd}	0.00	4.03^{cd}	11.89^{bc}
T_{60}	87.00^{d}	0.63^{bc}	3.50^{a}	4.00^{bc}	0.00	4.53^{bc}	13.10^{ab}
T_{65}	86.80^{de}	0.68^{b}	3.58^{a}	4.12^{ab}	0.00	4.84^{a}	13.21^{b}
T_{70}	86.54^{e}	0.71^{a}	3.67^{a}	4.27^{a}	0.00	4.82^{ab}	13.46^{a}
Control	89.80^{a}	0.34^{d}	3.10^{b}	3.28^{d}	0.00	3.48^{d}	10.21^{d}

Mean along the column with superscripts are significantly different ($p \leq 0.05$); T_{50} = yoghurt thermized at 50 °C; T_{55} = yoghurt thermized at 55 °C; T_{60} = yoghurt thermized at 60 °C; T_{65} = yoghurt thermized at 65 °C and T_{70} = yoghurt thermized at 70 °C.

Table 5 Proximate composition of yoghurt at 4 weeks

Sample	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Crude fibre (%)	Carbohydrate (%)	Total solid (%)
T_{50}	88.58^{b}	0.48^{d}	3.37^{a}	3.27^{c}	0.00	4.31^{b}	11.43^{e}
T_{55}	88.36^{bc}	0.51^{c}	3.30^{a}	3.71^{bc}	0.00	4.13^{c}	11.64^{d}
T_{60}	87.15^{cd}	0.55^{bc}	3.42^{a}	3.82^{b}	0.00	5.07^{a}	12.85^{c}
T_{65}	86.95^{d}	0.58^{b}	3.50^{a}	3.93^{ab}	0.00	5.05^{a}	13.06^{b}
T_{70}	86.72^{e}	0.63^{a}	3.58^{a}	4.10^{a}	0.00	4.98^{ab}	13.28^{a}
Control	89.94^{a}	0.25^{e}	2.98^{b}	3.21^{c}	0.00	3.63^{d}	10.07^{f}

Mean along the column with superscripts are significantly different ($p \leq 0.05$); T_{50} = yoghurt thermized at 50 °C; T_{55} = yoghurt thermized at 55 °C; T_{60} = yoghurt thermized at 60 °C; T_{65} = yoghurt thermized at 65 °C and T_{70} = yoghurt thermized at 70 °C.

3.2 Physio-chemical properties

The result of physio-chemical properties on the yoghurt is shown in Table 6. The result of the analysis shows that pH ranged from 5.30 to 6.70, 4.60 to 6.50, 3.90 to 6.30, 4.30 to 6.10 and 4.90 to 6.60, respectively for 0, 1, 2, 3 and 4 weeks with significant difference ($p<0.05$) in which the controls sample had the highest value compared to the yoghurt sample 70 °C with the lowest value. It was observed that the pH of the yoghurt sample is affected mostly by storage period and thermization temperature. The pH decreases with increase in the storage period and thermization temperature.

Additionally, titratable acidity ranged from 0.53 to 0.78%, 0.53 to 0.81%, 0.54 to 0.84%, 0.55 to 0.83% and 0.53 to 0.81%, respectively for 0, 1, 2, 3 and 4 weeks with significant difference ($p<0.05$). Hence, yoghurt samples had the highest titratable values compared to control sample which had the lowest value. The values of the titratable acidity of the yoghurt samples are affected by the thermization temperature and the storage period which means the higher the thermization temperature and storage period, the higher the total titratable acidity.

3.3 Sensory Evaluation

The result obtained from the sensory evaluation of the yoghurt samples are shown in Table 7. The results from Hedonic test for the sensory properties (colour, taste, texture, flavour and general acceptance) ranges from 6.13 to 8.25, 6.33 to 7.87, 6.00 to 8.27, 5.47 to 8.00 and 5.07 to 8.33 (from extremely like to dislike very much) for taste, texture, odour, appearance and overall acceptability, respectively. The result also showed that the yoghurt produced can also be sold since it gave a better sour taste as compared with control (yoghurt produced with commercially made starter culture). There is significant difference ($p<0.05$) among all the samples in terms of taste, appearance, texture, odour and overall acceptability. The yoghurt samples had favourable odour compared to control samples along with the texture, taste, appearance and overall acceptability. It was observed that yoghurt sample thermized at 65 °C had the most acceptable sensory property.

Table 6 Physio-chemical properties of yoghurt

Samples	0 week		1 week		2 weeks		3 weeks		4 weeks	
	pH	%TTA	pH	%TTA	pH	%TTA	pH	%TTA	pH	%TTA
T_{50}	6.20^{ab}	0.60^{d}	5.70^{b}	0.61^{d}	5.20^{b}	0.65^{de}	5.80^{ab}	0.62^{d}	6.12^{b}	0.60^{e}
T_{55}	6.10^{b}	0.61^{cd}	5.30^{c}	0.64^{cd}	4.90^{c}	0.66^{c}	5.50^{bc}	0.64^{de}	5.90^{c}	0.62^{d}
T_{60}	5.80^{b}	0.66^{c}	5.10^{d}	0.70^{c}	4.60^{cd}	0.71^{bc}	5.10^{cd}	0.69^{c}	5.60^{d}	0.68^{c}
T_{65}	5.60^{c}	0.73^{b}	4.80^{e}	0.79^{b}	4.20^{de}	0.83^{ab}	4.80^{de}	0.80^{b}	5.30^{e}	0.79^{b}
T_{70}	5.30^{d}	0.78^{a}	4.60^{f}	0.81^{a}	3.90^{e}	0.84^{a}	4.30^{e}	0.83^{a}	4.90^{f}	0.81^{a}
Control	6.70^{a}	0.53^{e}	6.50^{a}	0.53^{e}	6.30^{a}	0.54^{e}	6.10^{a}	0.55^{e}	6.60^{a}	0.53^{f}

Mean along the column with superscripts are significantly different ($p \leq 0.05$); T_{50} = yoghurt thermized at 50 °C; T_{55} = yoghurt thermized at 55 °C; T_{60} = yoghurt thermized at 60 °C; T_{65} = yoghurt thermized at 65 °C and T_{70} = yoghurt thermized at 70 °C.

Table 7 Sensory evaluation of yoghurt sample

Sample	Taste	Texture	Odour	Appearance	Overall Acceptability
T_{50}	6.13^{a}	7.13^{a}	6.00^{a}	6.27^{a}	7.67^{a}
T_{55}	7.06^{a}	7.27^{a}	5.13^{a}	8.00^{b}	8.33^{a}
T_{60}	8.25^{b}	7.87^{a}	8.27^{b}	7.73^{ab}	7.87^{a}
T_{65}	6.31^{ab}	7.40^{a}	6.93^{ab}	7.33^{ab}	8.13^{a}
T_{70}	6.81^{a}	7.80^{ab}	7.13^{ab}	7.00^{ab}	6.53^{ab}
Control	6.13^{ab}	6.33^{ab}	6.60^{a}	5.47^{a}	5.07^{b}

Mean along the column with superscripts are significantly different ($p \leq 0.05$); T_{50} = yoghurt thermized at 50 °C; T_{55} = yoghurt thermized at 55 °C; T_{60} = yoghurt thermized at 60 °C; T_{65} = yoghurt thermized at 65 °C and T_{70} = yoghurt thermized at 70 °C

4 Conclusion

Quality yoghurt in conjunction with the effect of thermization and storage period was developed. The result of the proximate contents showed that the yoghurt with the use of thermization as a preservative technique prior to storage is a good source of moisture, fat, protein and carbohydrate. After production, the yoghurt continued to ferment and forming clotting and it was discovered its taste slightly changed as well as the texture but the odour/flavour as well as the colour and sweetness does not change, it has some water particles at the bottom of the can and deteriorate little by little until after five days (5) and oxygen in the yoghurt can which causes busting of the stored yoghurt while storing at room temperature (ambient) in which there is microbial growth (manifestation of micro-organisms) which causes the sudden deterioration/spoilage of the yoghurt.

It was therefore concluded that the thermization reduces the content of the yoghurt sample and the higher the thermization temperature, the lower the degree of deterioration and also, that storage of yoghurt has adverse effect on the storability and therefore, slightly reduces the quality parameters/attributes of the yoghurt hence makes the yoghurt unsuitable/unfit for consumption.

Compliance with ethical standards

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Disclosure of conflict of interest

This work was carried out in collaboration, among the three authors. All authors read and approved the final manuscript.

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