Effect of chufa flour addition on characteristics of yoghurt quality

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Abstract

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Introduction. The purpose of the research is to determine the effect of the addition of chufa flour on the characteristics of yoghurt quality.

Materials and methods. The yoghurt has been prepared by respecting the classic technological process, with the difference that chufa (*Cyperus esculentus*) flour has been added in different proportions (sample ICO3–0.3%, ICO5–0.5%, ICO7–0.7%). The yoghurt samples have been kept at a temperature of 2–4 °C for 15 days. Diacetyl has been determined by gas chromatography method, titratable acidity of yoghurt samples – by titration with 0.1N NaOH and syneresis – using the methodology of Barkallah.

Results and discussion. After the first day of storage, the diacetyl content is low in all the analyzed samples, but the ICO5 sample showed a higher diacetyl content of 6.5 µg/g. After 15 days of storage, the diacetyl content increased in all samples analyzed, so so diacetyl content of control sample is 6.4 µg/g, ICO3 – 15 µg/g, ICO5 – 16.2 µg/g and ICO7 18.8 mg/g. The high content of diacetyl is found in ICO7, which means that the addition of chufa flour has a positive effect for lactic acid bacteria used in the fermentation process. The acidity increases in all yoghurt samples analyzed from day 1 to day 15. The control sample shows lower acidity values between 80 and 108 °T, compared to the other samples, but the sample with a chufa flour in the proportion of 0.7% has acidity values between 87 and 125 °T, which indicates that the addition influences this characteristic analyzed. The highest removal of the serum was observed for control sample in 1 and 15 days, compared to the samples ICO3, ICO5 and ICO7. The ICO7 sample shows a lower syneresis, respectively on the first day of 9%, and the on 15th day of 32%.

Conclusions. The addition of chufa flour improves the quality of yoghurt, which is of particular importance to the consumer in choosing these dairy products.

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1. Introduction

Consumption of yoghurt has several benefits for human health, such as protection against gastrointestinal upsets, enhanced digestion of lactose by maldigestion, decreased risk of cancer, lower blood cholesterol, improved immune response and help the body assimilate protein and calcium [2–4]. The demand for dairy products with functional properties leads to the promotion of added-value products: fermented dairy drinks, probiotic and other functional yoghurts, reduced-fat and enriched milk products and other [26]. Another important trend is the increasing demand for consumer convenience. Consumers prefer foods that promote good health and prevent diseases [27].

Many researchers have conducted studies on improving the composition of yoghurt by using it with milk proteins or vegetable proteins [5–8]. One of the ways to improve the nutritional value of yoghurt is to use the chufa (*Cyperus esculentus*). The chufa has been shown to have various beneficial health effects such as preventing obesity and lowering cholesterol and triglycerides. [9, 28] Its chemical composition includes fibre, protein and natural sugars. Moreover, chufa has a high content of soluble glucose and oleic acid, along with high energy content (starch, fats, sugars and proteins), are rich minerals such as phosphorous, potassium and in vitamins E and C [10]. The chufa flour can also be considered an excellent source of natural antioxidants (mainly flavonoids) and a natural food additive [11]. These numerous nutritional advantages and health benefits associated with chufa makes it more attractive for dairy products.

The sample of application of chufa flour in food technology is the production of “Horchata de chufa” (“tiger nut” or “chufa” milk), is a sweetened water extract of chufa tubers, which is popular in Spain [29]. Adgidzi et al. [30] investigated yoghurt-like products from chufa. The use of chufa and cow milk composite to prepare yoghurt reduces the cost of yoghurt production without compromising its nutritional composition and therapeutic effects. It is possible to manufacture probiotic yoghurt using chufa extract as a functional dairy food [31]. A product known as cypher-coconut yoghurt can be prepared using coconut milk blended with chufa milk, and the commercially available starter used as a source of lactic acid bacteria [32]. It is also used as a flavouring agent in ice cream [33]. Ice cream production from a blend of chufa and cow milk was subjected to proximate, physicochemical and sensory evaluation by Umelo et al [33]. Flour of roasted chufa is sometimes added to bakery products [34], as well as in making oil, starch extracts and soap [35].

However, it's not enough nutritional advantages and health benefits of the product for successful commercial promotion, and it's necessary to supply good sensory properties of new a product. Generally lactic acid gives fermented milk their slightly tart taste. Other typical flavours and aromas are additional results of LAB metabolism [36]. Thus, more than 100 chemical compounds was isolated from yoghurt and other fermented milk, but only a few (ethanol, diacetyl, acetaldehyde, acetone and butanone-2) influence on the desired product flavour [37, 38, 39].

Acetaldehyde provides the typical aroma of yoghurt [25]. The *Streptococcus* may form acetaldehyde from lactose via pyruvate, but only trace amounts are formed by this way and by *Lactobacillus delbrueckii subsp. bulgaricus*. Optimum aroma and flavour are obtained between 23 and 41 ppm acetaldehyde. Diacetyl and acetoin result from the metabolic activity of *Streptococcus thermophilus* are very low – 0.5 ppm. Diacetyl is produced by *Lactococcus lactis subsp. lactis biovar. diacetylactis* and *Lactococcus lactis subsp. cremoris*. The presence of diacetyl contributes to the delicate, full flavour and aroma of yoghurt and is especially important, if acetaldehyde is low because it can enhance yoghurt flavour [25].

Note, in the available scientific literature there are insufficient data about the effect of the addition of chufa flour on the characteristics of yoghurt quality.

Therefore, the purpose of the research is to determine the effect of the addition of chufa flour on the characteristics of yoghurt quality. Also, an important task is to study the degree of syneresis in the product to ensure uniform consistency during storage.

2. Materials and methods

2.1. Materials and sample preparation

For yoghurt preparation, cow milk has been used. Used milk has a fat content of 1.5% because it takes into account the consumer's preference to consume dairy products with low-fat content [12, 13].

The technological scheme is identical to the classic one concerning the technological parameters [14]. For inoculation, a specific culture for the processing of yoghurt from CHR HANSEN has been used in the proportion of 0.075 g/L milk [15].

Different percentage of chufa (*Cyperus esculentus*) flour has been added before homogenization, in the following proportions: 0.3%, 0.5% and 0.7%, and the mixture obtained has been packed in glass jars with lids, placed under thermostat at a temperature of 42 °C for 3.5 hours and cooled to 20 °C for one hour. Yoghurt has been stored at a refrigeration temperature of 2–4 °C [16].

The yoghurt samples have been analyzed after two storage periods 1 day (**T1**) and 15 days (**T15**) at 4 °C.

The analyzed samples were marked as follows:

1. Control sample, yogurt with 1.5% fat: **IM**;
2. Yoghurt with a chufa flour addition of 0.3%: **IC03**;
3. Yoghurt with a chufa flour addition of 0.5%: **IC05**;
4. Yoghurt with a chufa flour addition of 0.7%: **IC07**.

2.2. Methods of analysis

2.2.1. Preparation of samples for GLC analysis

Diacetyl extraction has been performed using high purity acetone. Approximately 2 g of the sample has been accurately weighed, 2 mL of acetone and 2 mL of 2,3-pentandione of 50 µg/mL were added as internal standard and stirred vigorously for 30 seconds. After the samples were centrifuged at 4000 rpm for 5 minutes, the supernatant has been filtered through a 0.20 µm disposable syringe membrane filter and then injected directly into the gas chromatography apparatus. The final diacetyl concentration (expressed as µg of diacetyl per gram of sample) has been calculated using the following formula [11]:

$$\text{Diacetyl } (\mu\text{g/g}) = \frac{wIS \cdot AD \cdot P \cdot 0,5}{AIS \cdot Ws \cdot 25}$$

where:

- w_{IS} – internal standard (2,3 pentanedione), μg ;
- A_D – diacetyl peak area;
- A_{IS} – the peak area of the internal standard;
- W_s – sample table, g;
- P – purity of the standard, %;
- 0,5 – dilution factor;
- 25 – dilution factor.

2.2.2. Gas-chromatographic analysis

Diacetyl gas chromatographic analysis has been performed by manual injection using an Agilent Technologies Model 7890A gas chromatograph equipped with a flame ionization detector. A sequence has been created using Chem Station software to analyze the samples and quantify the results.

A 30 m YB WAX capillary column (Phenomenex, Torrance, CA, USA) with a diameter of 0.32 mm, a particle size of 0.5 μm and a composition of 100% polyethylene glycol has been used. The following parameters have been used for the analysis:

- Carrier gas, a combination of nitrogen and hydrogen at a flow rate of 50 kPa (7.25 psi);
- Injection volume: 1 μl ;
- Injection ratio at injection, 1:15;
- Injector temperature: 250 $^{\circ}\text{C}$;
- Detector temperature: 260 $^{\circ}\text{C}$;
- The oven temperature increases progressively by 7 $^{\circ}\text{C}/\text{min}$ from 50 $^{\circ}\text{C}$ to 240 $^{\circ}\text{C}$.

The diacetyl peak recognition has been performed by comparing its retention time with that of the relative standard. The quantitative measurement of diacetyl has been calculated from the diacetyl peak area compared with that of the 2,3-pentanedione. Some samples of the gas chromatography profiles for yoghurts enriched with chufa are presented in Figures 1 and 2:

Figure 1. GC chromatogram of yoghurt with 0.3% chufa (T1):
1-Solvent; 2, 3, 4, 5-Solvent impurities; 6-Yoghurt component;
7-Diacetyl; 8-Internal standard 2,3 Pentanedione

Figure 2. Gc Chromatogram of Yoghurt with chufa 0.7% (T15):
1-Solvent; 2,3,5,6-Solvent impurities; 4,7-Yoghurt components;
8-Diacetyl; 9-Internal standard 2.3 Pentanedione

2.2.3. Titrable Acidity

Titration acidity of yoghurt samples has been determined by titration with NaOH 0.1N solution using phenolphthalein as an indicator and expressed in Thörner degrees [20].

2.2.4. Susceptibility to Syneresis

Syneresis of the different yoghurt samples has been determined according to the methodology proposed by Barkallah et al [21] by placing 100 mL of each sample in a funnel lined with Whatman filter paper number 1. After 6 h of drainage, the volume of whey has been measured and the following formula has been used to calculate susceptibility of syneresis:

$$\text{Syneresis} = \frac{V_1}{V_2} \cdot 100$$

where,

V_1 = volume of whey collected after draining, ml;

V_2 = the volume of the yoghurt sample, ml;

3. Results and discussions

3.1. Determination of diacetyl

Figure 3 shows the results obtained for the determination of diacetyl of the samples obtained during the analyzed period.

Figure 3. Evolution of diacetyl content in yoghurt samples

The diacetyl content analyzed in 1 day shows different values, so the control sample, the sample with an addition of 0.3 and the sample with 0.7% chufa between 4.4 and 4.8 µg/g, and the sample with a chufa of 0.5 has a content higher than 6.5 µg/g.

After 15 days of storage, the diacetyl content of the samples increased considerably, so the control sample has a value of 13.1 µg/g, and the sample with 0.7% chufa has the highest diacetyl content of 18.8 µg/g compared to the samples by 0.3% (15 µg /g) and the sample by 0.5% (µg/g).

The results of diacetyl content during storage are in agreement with Vahcic and Hruskar (2000) [25], in which diacetyl was found to increase slightly almost linearly on the lowest temperature (4 °C), but significantly on higher temperature levels (20 and 37 °C) during 25 days of storage (Figure 4 [25]). Our obtained higher levels of diacetyl may be explained by the adding of chufa, which components may enhance the production of diacetyl by starter organisms.

El-Shenawy et al. (2012) [31] studied the diacetyl content of probiotic yoghurt made with chufa extract, stored at 4 ±2 °C for 10 days. It was observed a gradual increase in the concentration of diacetyl until day 10, that is similar to our results. However, the initial diacetyl content of our samples is lower than obtained results by El-Shenawy et al [31]. This may be due to the different composition of the starter microorganisms. It is well known, that different starter microorganisms influence the flavour as well as the texture of the final product [25, 36].

Figure 4. Diacetyl content in samples during storage [25].
Temperature: 1 – 4 °C; 2 – 20 °C; 3 – 37 °C.

3.2. Determination of acidity

The acidity of a food product is one of the first quality indices that demonstrate its freshness [22]. The results obtained for the determination of the acidity of the analyzed yoghurt samples are presented in Figure 5.

Figure 5. The evolution of the acidity of yoghurt samples

Following the determination, an increase in acidity is observed in all yoghurt samples, from day 1 to day 15. The IM sample shows acidity values between 80°T and 108°T. In the case of samples IC03, IC05 and IC07, the addition of chufa flour contribute to the variation of the titratable acidity, the values being between 81, 84 and 87 °T on day 1 and 119, 121 and 125 °T for day 15. The evolution of the acidity for the samples with the addition of the chufa is higher than the control sample, and the sample with the highest quantity of the chufa, respectively of 0.7% presents the highest acidity for the analyzed period.

One explanation for this is that the chufa used improves the growth of bacteria contained in yoghurt samples. This increase of lactic acid bacteria may be due to the presence of some growth promoter, such as salts, free amino acids, or vitamins present in chufa [40]. Also, it has been found, that starch and fibre content of chufa presumably provides prebiotic properties for colon bacteria, as well as, yoghurt microorganisms [41]. Ire F.S., Maduka N. and Njoku H.O (2017) [42] reported that chufa milk was a possible culture medium to cultivate probiotic lactic acid bacteria such as *Lactobacillus plantarum*, *Lactobacillus acidophilus*, *Streptococcus thermophilus* and *Lactobacillus brevis*.

A similar observation was reported by [21], who reported that the acidity of the yoghurt increased due to the type of added plants. R.E.Sanful (2009) [43] obtained similar results during the investigation of chufa, cow milk and their compositions as substrates for yoghurt production.

3.3. Determination of syneresis

Syneresis is considered by many researchers as one of the most important parameters that indicate the quality of yoghurt during storage [23]. The following figure shows the changes in the syneresis rates of the yoghurt samples analyzed during the storage period.

Figure 9. The evolution of the syneresis of yoghurt samples

The control sample showed a higher syneresis compared to the yoghurt samples with different levels of added chufa so that after 15 days of storage it shows elimination of whey of 44% because the dry matter content also has an influence.

In the case of samples IC03, IC05 and IC07, the addition of chufa contribute to the syneresis process, the values being between 12, 10 and 9% respectively on day 1 and 39, 35 and 32% for day 15. The lowest syneresis after 15 days of storage was observed for chufa yoghurt with an addition of 0.7%, which demonstrates that the addition of chufa flour improves the texture of the yoghurt, and thus reduces the process of syneresis. And for this studied feature there is a similar observation which shows that syneresis is influenced by the amount of additive used [24].

The ability of yoghurt to retain whey depends on structure and pore size of protein gel [44]. It appears that supplementation with a low level of chufa may contain some polysaccharides which enhance the water holding capacity, while supplementation with the high level impaired the yoghurt structure, thereby decreased whey syneresis. Folkenberg et al. (2006) [45] observed that syneresis was more pronounced in EPS containing yoghurts. They have suggested that yoghurts should have a structure with medium size pores containing polysaccharides to provide a stable structure with minimum syneresis. A similar observation during storage was made by Doleyres et al. (2005) [46] in yoghurts prepared using EPS-producing cultures, as well as, El-Shenawy et al. (2012) [31] in yoghurts with chufa extracts.

Conclusions

1. The characteristics of the yoghurt quality with the addition of a chufa flour were improved compared to the control sample.
2. The use of a larger amount of chufa positively influenced the parameters analyzed during storage.
3. The addition of chufa shows that it improves the quality of the yoghurt and implicitly the requirements of the consumers.

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