

RESEARCH ARTICLE

MANUFACTURING THERAPEUTIC YOGHURT FORTIFIED WITH TWO TYPES OF RICE AND STUDY PHYSICOCHEMICAL AND MICROBIAL PROPERTIES

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ABSTRACT

The paper involved the manufacture of a dairy product with therapeutic properties fortified with amber rice flour and basmati rice flour at an addition rate of 3 and 5%. The product was fermented using a mixture of two starter cultures of therapeutic lactic acid bacteria, *Lactobacillus plantarum* and *Lactobacillus acidophilus* (Probio-Tech-5), in addition to a control sample. The product was stored for 14 days. The results showed increasing the rate of total solids when adding Amber rice flour and Basmati rice flour in comparison to the controlling sample. The highest growth in solids was in the Basmati rice treatment at the 5% addition rate, reaching 18.0% at the launch of the trial. The increase continued until the end of storage, reaching 20.11%. The differences were significant between the samples. The results showed an increase in acidity in the Amber and Basmati rice treatments compared to the control sample. An increase in the viscosity rate was observed with an increase in the Amber and Basmati rice addition rate in comparison to the controlling sample. The highest increase was in the Amber rice treatment at a 5% addition rate, reaching (5112, 6230 centipoise) at the beginning and end of the experiment, respectively. An increase was observed in the number of lactic acid bacteria with an increase in the Amber and Basmati rice addition rate compared to the control sample. The highest increase was in the Basmati rice treatment at a 5% addition rate, reaching (20.80 x 10⁶ CFU/ml) at the beginning and end of the experiment, respectively. While there was a decrease in the total bacterial count was observed with an increase in the percentage of added amber and basmati rice in comparison to the controlling sample. The largest decrease in bacterial counts was observed when treating basmati rice with an addition rate of 5%, reaching (20.80 x 10⁶ CFU/ml) at the beginning and end of the experiment, respectively. While there was a decrease in the total bacterial count with an increase in the percentage of added amber and basmati rice compared to the control sample, reaching (25, 20 x 10⁶ CFU/ml) at the beginning and end of the experiment, respectively. No growth of coliform bacteria was observed, with a slight appearance of yeast and mold. Regarding the sensory evaluation, it was noted that the basmati rice treatment was superior in terms of texture and general appearance compared to the amber rice treatment, while the latter was superior in terms of flavor.

KEYWORDS

Yogurt, Dairy product, Rice, Therapeutic

1. INTRODUCTION

Probiotics appear Nowadays they are available in various forms including fermented products and nutritional supplements, as well as pharmaceutical forms (capsules or tablets), and their markets have expanded throughout the world. Probiotics have been known as microorganisms or their derivatives, which when ingested lead to beneficial effects on the health of the consumer and as cultures of microorganisms. Live organisms (single or mixed) have positive impacts on the health of the host (human or animal) by enhancing the microbial balance of the intestinal flora (Youssef, 2017 ;Liong 2011). *Lactobacillus* ferments are among the most acceptable products to consumers in the market and have historically had health benefits The method of trading and storing these products contributes to maintaining the appropriate numbers of probiotics to perform their therapeutic action (Abdullah and Ismail, 2018; Mhan, 2008; Zhao et al., 2016).

Therefore, therapeutic lactic acid bacteria are generally employed in the manufacture of fermented milk in order to obtain food products with therapeutic value that improve consumer health (Gahrue et al., 2015). In order what the consumers needs for healthy foods and the nutritional recommendations issued by health authorities, as well as the nutritional importance of yogurt and the essential nutritional elements it contains, there is a need to fortify it with alternative plant ingredients. (Macwan et al., 2016; Aboukila et al., 2018; Pontonio et al., 2020).

No necessity needed for novel plant-centered dairy substitutes in the food market due to lactose intolerance and dairy allergens (Morris et al., 2025). The integration of functional ingredients resulted to improving the content of phenolics and flavonoids, increasing its water capacity of 20-25%, improving the number of live cells of lactic acid bacteria, reducing fat loss, and also improving the apparent viscosity and sensory properties of texture and consistency (Rashwan et al., 2023). Rice is considered the

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most vital grain in the humane diet and is consumed by 75% of the world's populace (Al-Battah and Sultan, 2014; Anjum et al., 2007). It has a high nutritional value as the main component of rice is starch. In addition to its richness in carbohydrates and it contains a balanced protein because it contains essential amino acids and it is unique among grain proteins and The germ contains vitamins, minerals, and a small amount of protein and fat (Cantral and Reeves, 2002; Cáceres et al., 2019; Tagliapietra et al., 2024). In addition the digestibility coefficient of rice is higher than that of other grains compared to other food grains and it is rich in minerals such as calcium phosphorus and magnesium with traces of ferritin, copper, zinc, and manganese (Yousaf, 1992; Mahmood, 2025).

Legumes, grains, and rice have many nutritional uses, including breakfast foods, baby foods, milk fortification, and frozen foods. Plant-made yogurt substitutes are gaining traction in the market, while sales of dairy-only yogurt are stagnant or even declining. Rice is known for its high nutritional content and its ability to crystallize when fermented with lactic acid bacteria (Gallagher et al., 2004; Boeck et al., 2021; Tashakori et al., 2013). Using a mixture of the two materials dried whey proteins and starch and adding them to the milk gave a product with high degrees of sensory evaluation. The study aimed to produce yogurt with healthy specifications using therapeutic lactic acid bacteria with fortification rice flour to raise the nutritional value of the milk and improve the texture and taste.

2. METHODS AND MATERIALS

The study included to use of two types of therapeutic lactic acid bacteria *Lactobacillus acidophilus* (Probio-Tech-5) attained in lyophilized form a company of chr. Hansen Danish and *Lactobacillus plantarum* Which was obtained from the laboratories of the College of Science University of Mosul and a mixture of both types was used with an addition of 5% .

2.1 Basic materials used

New cow's milk was attained from Al-Jazeera Dairy Factory located in Mosul, the rice was attained from the home markets of the city of Mosul Long-grain basmati rice the (Mahmoud) brand of Emirati origin was used and Short-grain amber rice the (Nebras) brand of Turkish origin was also used, Boil the rice at a temperature of 110 degrees Celsius for 20 minutes then cool it and mash by a blender and dry it in the microwave then grind it.

2.2 How to make Yogurt

Use the method described by some researcher (Tamime and Robinson, 1985).The milk was treated at 85 degrees Celsius for 15 mins after that was cooled to a temperature of 42 degrees Celsius and amber and basmati rice flour were added separately with addition rates of 3% and 5% then the activated starter mixture was added at a rate of 5% and Incubation for 4 hours then cryopreservation for 14 days.

The total solids and acidity was measured based on the method described in a studies and viscosity capacity was specified based on the method (Donkor et al., 2007; A.O.A.C., 2008).The numbers of lactic acid bacteria were estimated by the pouring plate method and using the Deman Rogosa Sharp (MRS) nutrient medium as stated and the numbers of total bacteria coliform bacteria yeasts and molds were expected as reported in (Speak, 1984; Andrews, 1992). The sensory evaluation was conducted according to the questionnaire provided by (Nelson and Trout, 1964). The data were analyzed statistically by a fully random design based on (Al-Rawi and Abdul Aziz, 1980).

3. RESULTS AND DISCUSSION

Figure 1. Indicates a total rise in the total solids for the fortified Amber and Basmati rice yogurt and that Total solids increase with increasing rice addition ratio. as noticeable differences were noticed between the T and the rest of the treatments , the highest percentage of total solids at the beginning of the experiment was in the basmati rice sample followed to T2 compared to the comparison sample and reached (18.00, 17.30, 14.00%) respectively.

The reason is due For rice to absorb water so the percentage of total solids increases for all treatments, as well as because Basmati rice contains the highest percentage of total solids compared to the rest of the samples, An increase in total solids was observed for all samples after storage for 14 days and the greatest rise was in the basmati rice sample with an addition rate of 5% and amounted to (20.11%). The storage period led to a reduction in humidity Which caused an increase in total solids for all treatments and this agrees with (Malki et al., 2021).

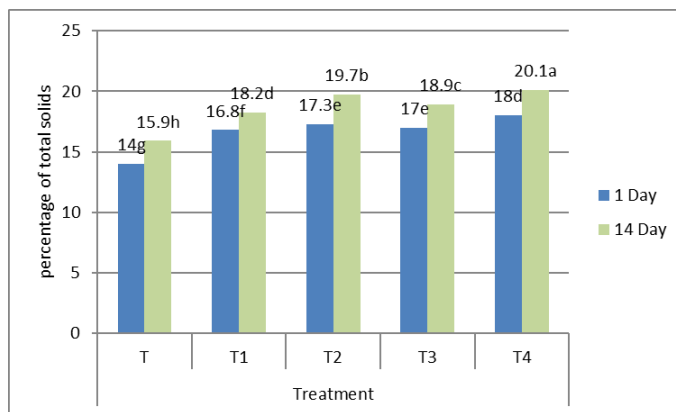


Figure 1: Effect of adding two kinds of rice flour upon the total solids content of yogurt

T: Comparative treatment, T1: contains 3% milled Amber rice, T2: contains 5% milled Amber rice, T3: contains 3% milled Basmati rice, T4: contains 5% milled Basmati rice

In the table, the various letters point out to the significant differences at ($P \leq 0.05$) level. Figure 2. shows the increase in the physical acidity when adding amber and basmati rice to the yogurt compared to the T, as significant differences were observed between the treatments , the highest percentage of the acidity at the beginning of the experiment was in the basmati rice sample followed by the T2 compared to the comparison sample that was (1.00, 0.95, 0.80%) respectively, and this acidity was normal and consistent with what was found (Caplice and fitzgerald, 1999). At the end of the experiment there was an increase in the acidity of all treatments and the greatest growth occurred in the basmati rice sample with an addition rate of 5% amounting to (1.35%), The storage period led to increasing the lactic acid bacteria leading to increasing the acidity of the milky product and this is consistent with the note of (Ghalib, 2008; Jamalullail et al., 2023).

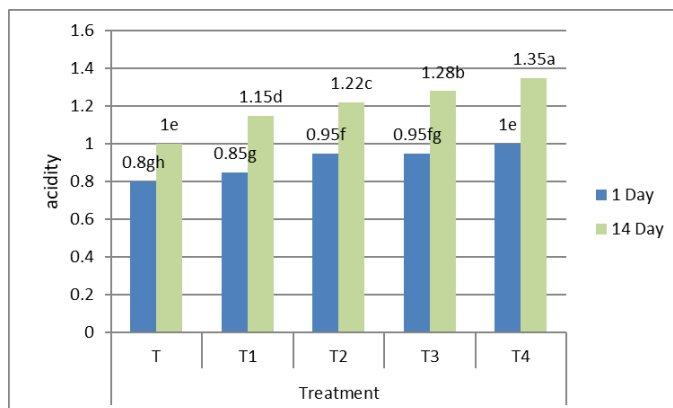


Figure 2: Impact of adding two types of rice flour upon the acidity of yogurt

T: Comparative treatment, T1: contains 3% milled Amber rice, T2: contains 5% milled Amber rice, T3: contains 3% milled Basmati rice, T4: contains 5% milled Basmati rice

In the table, the various letters point out to the significant differences at ($P \leq 0.05$) level. Figure 3. shows the increase in centipoise viscosity when adding amber and basmati rice to the yogurt compared to the T as significant differences were observed between the treatments , the greatest viscosity at the end of the experiment was in the T2 and amounted to (5112cp) It is attributed to the high total solids and the increase in protein, which in turn forms a strong protein network that helps increase viscosity by binding with milk protein.

At the end of the storage period it was observed that an increase Viscosity for all treatments, The greatest increasing occurred in the Anbar rice sample with an addition rate of 5% and reached (6230 cp) The reason is that the storage period leads to an increase in acidity which leads to larger protein clusters, thus increasing the gel strength and increasing viscosity (Ozdal et al., 2013). While other researcher mentioned The viscosity of yogurt fortified with brown rice decreases with storage (Morris et al., 2024).

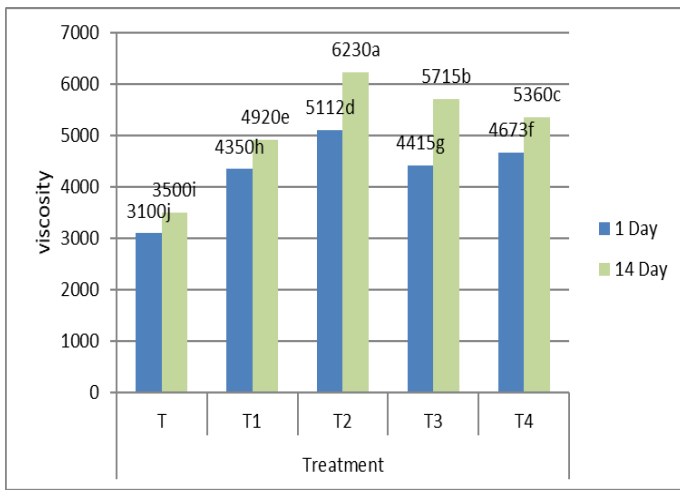


Figure 3: Impact of adding two types of rice flour upon the viscosity of yogurt

T: Comparative treatment, T1: contains 3% milled Amber rice, T2: contains 5% milled Amber rice, T3: contains 3% milled Basmati rice, T4: contains 5% milled Basmati rice

In the table, the various letters point out to the significant differences at ($P \leq 0.05$) level. Table 1. indicates the microbial content in the fortified yogurt, notice a continued rising in the lactic acid bacteria As the storage period increases, The maximal number was reached in the basmati rice treatment followed by the T2 it reached ($80, 77 \times 10^6$ cfu/ml) respectively The number of bacteria was within the internationally accepted limits throughout the time of storage and was close what to found (Ali, 2012). This is consistent with (Wongsa et al., 2022). It is consistent with what was indicated by who supported yogurt with legumes and noted the survival of therapeutic bacteria until the end of storage (Jamalullail et al., 2023). As for the total bacterial counts significant differences were noticed, as the overall bacterial increased after two weeks of storage in the T and reached (51×10^6 cfu/ml), while there was a decrease in the total bacterial counts in the fortified product treatments. The Basmati rice treatment recorded the lowest decrease, followed by the T2, reaching ($20, 23 \times 10^6$ cfu/ml) respectively Agrees with the cause is ascribed to the activity of the therapeutic bacteria which work to impede undesirable bacteria by secreting substances that thwart competing bacteria like bacteriocins (Morris et al., 2024; Al-Rawi, 2005). We note that all treatments were void of coliform bacteria and from yeasts and molds except for the T containing (5×10^4 cfu/ml) of yeasts and molds after 14 days of storage. The reason for the non-appearance of coliform bacteria is attributed to the action of lactic acid bacteria to inhibiting other organisms as well as to the acidity that they produce and makes the medium unsuitable for the growth of coliform bacteria yeasts and molds (Robinson, 1990; Ahmed, 2022).

Table 1: The effect of adding amber and basmati rice flour on the total lactic acid bacteria and total bacteria (10^6 cfu/ml) and coliform bacteria yeasts and molds (10^1 cfu/ml) in yogurt.

Type	Treatment	Storage time/day	
		1	14
Lactic acid bacteria	T	8h	12g
	T1	16 f	60 d
	T2	19 e	77b
	T3	17 f	65c
	T4	20 e	80a
Total bacteria	T	44b	51a
	T1	30 ed	29 d
	T2	27 e	23 fg
	T3	32c	27 e
	T4	25 f	20 g
Coliform bacteria	T	.....	.....
	T1	.....	.....
	T2	.....	.....
	T3	.....	.....
	T4	.....	.....
Yeasts and Molds	T	.....	5
	T1	.....	.....
	T2	.....	.....
	T3	.....	.....
	T4	.....	.....

T: Comparative treatment, T1: contains 3% milled Amber rice, T2: contains 5% milled Amber rice, T3: contains 3% milled Basmati rice, T4: contains 5% milled Basmati rice

In the table, the various letters point out to the significant differences at ($P \leq 0.05$) level.

Table 2 shows the sensory evaluation and contrast in the sensory traits at the beginning of the experiment, where the treatment of an amber rice obtained the best evaluation degree in the characteristic of flavor at the addition of 5% and reached (51%), As for the adjective of Texture and

general appearance, Basmati's rice was able to get the highest evaluation degree at a rate of 5% and reached (28, 8%) respectively It agrees with who supported yogurt with rice and it was sensory acceptable (DeBruyne and Hekmat 2024).

With the progress of the storage, the sensory evaluation of all transactions decreased but the treatment of an amber rice-maintained excellence in the characteristic of the flavor and was (49 %), the treatment of Basmati's rice maintained excellence in the characteristic of the Texture and the general appearance and reached (25, 7 %) respectively and this is consistent (Cham and Suwannaporn, 2010).

Table 2: Impact of adding ground two kinds of rice upon the total number of lactic acid bacteria, total bacteria (106 cfu/ml), coliform bacteria, yeast and mold (101 cfu/ml) in yogurt.

Storage time/day	Treatment	Flavor	Texture	general look 10%
		%60	%30	
1	T	41	20	6
	T1	45	22	6
	T2	51	24	7
	T3	43	25	6
	T4	48	28	8
14	T	39	18	5
	T1	43	20	5
	T2	49	23	6
	T3	42	23	5
	T4	46	25	7

T: Comparative treatment, T1: contains 3% milled Amber rice, T2: contains 5% milled Amber rice, T3: contains 3% milled Basmati rice, T4: contains 5% milled Basmati rice

In the table, the various letters point out to the significant differences at ($P \leq 0.05$) level.

Table (5) Impact of adding ground rice of two types upon the sensory evaluation of yogurt.

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DECLARATION OF CONFLICT OF INTEREST

No conflict of interest is declared by the authors.

AUTHORS CONTRIBUTION

The first and second researchers participated in designing the research and made the practical part. The third researcher achieved statistical analysis, making tablet, and writing.

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