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Abstract

Nowadays, food industry developing a range of plant-based milk as alternatives to cow milk in order to meet the requirement of protein in developing countries mainly for individuals suffering from lactose intolerance. Rice, oat and coconut milk are a plant–based milk alternative, which are rich in nutritional value. White chocolate was prepared from cow, rice, oat and coconut milk. The result of chemical composition of cow white milk chocolate showed no significant difference in the protein contents compared to white chocolate prepared from plant based milk. Coconut chocolate contains the highest percent of fat (58.30%) and fiber (5.40%) compared to white milk chocolate which showed (54.7%) of fat and non-fiber. The oat chocolate has the highest percentage of carbohydrates (44. 0%).Minerals results showed that calcium was high in cow and rice white milk chocolate and coconut white milk chocolate was high in potassium. The pH values of plant based milk were close to cow milk. Antioxidants activity of coconut white milk chocolate was the highest (64.60%) compared to other prepared chocolate. HPLC analysis of sugar profile extracted from cow milk chocolate showed the presence of lactose sugar at a rate of 3.90%, and its absence in chocolate prepared from plant-based milk. The sensory evaluation of white chocolate revealed that the overall acceptability of coconut chocolate, was more followed with oat, rice and the cow milk chocolate. This study provides new visions for plant-based milk alternatives which have high nutrients values to meeting the needs of lactose intolerant people.

Keywords: plant-based milk, lactose intolerance, White Chocolate, Sensory evaluation

Introduction

Cow's milk has important benefits for health of body and bones. However, there are some pitfalls and side effects for certain people including but not limited to the allergy towards the milk and the intolerant distribution of lactose enzymes **(Aydar *et al.*, 2020)**. Whereas the allergy towards cow's milk affected children and infants in a high scale

(Lifschitz and Szajewska, 2015), lactose intolerance impacts nearly 65 % of the world's population **(Katoch *et al.*, 2022)**. Therefore, there are some beneficial alternatives which resemble the cow's milk features and can give guaranteed benefits. These alternatives are the plant-based milk which is defined as fluids that are extracted from the breakdown of homogenized plants' fluids such as buts, oats, pseudo-cereals and oilseeds **(Özbal *et al.*, 2022)**.

Oat milk is considered the trendiest alternative in the current markets based on its therapeutic merits. On one hand, it contains high-nutritional substances, dietary fibers and phytochemicals **(Syed *et al.*, 2020)**. On the other hand, it contains β-glucan, lipid and phytochemicals which provides the body with health benefits **(Srikaeo, 2022)**. These substances assist the body in digesting the food faster than the cow's milk with zero lactose sugar **(Aydar *et al.*, 2020)**.

Another important alternative is coconut which spreads widely in the south-east Asian region **(Syed *et al.*, 2020).** Attention has recently been paid to coconut' milk because of its rich substances such as fat and protein **(Aydar *et al.*, 2020)**. The emulsion of milk in coconut is a natural process in which albumin and globulin play an important role in stabilizing this process **(Lu *et al.*, 2019)**.

Also, Coconut milk is very popular and is available in the market. It is made from the white pulp of mature coconuts. Coconut milk is a high-calorie milk had many nutrients and its consumption is rarely associated with allergenic reactions. Therefore, it is considered a vegan alternative to animal milk, as it is lactose-free and ideal drink for those who suffer from lactose intolerance **(Sekar *et al.*, 2020)**.

As for rice milk, it is characterized with containing adequate amounts of low fat and carbohydrates which are necessary for our body building **(Padma *et al.*, 2019)**. Rice milk is prescribed especially for those who suffer from the lactose intolerance of cow's milk because its hypoallergenic structure and zero cholesterol fat **(Abou-Dobara *et al.*, 2016)**.

Regarding chocolate's milk, it is one of the most preferred alternatives particularly in the cases of fatigue and anxiety. It is easily digested and contains various polyphenol compounds, minerals and vitamins which improve our health**(Aranguren and Marcovich, 2023)**.

Some derivatives can be formed from the chocolate's milk such as white chocolate's milk which is extracted also from other alternatives such as sugar, cocoa butter and cow's milk. It is worthy to mention that cow's milk is one of the basic ingredients for white chocolate and plays a role in maintaining its texture, which boosts its economic advantages in the recent market **(Bianchi *et al.*, 2021)**. To maximize the advantages of chocolate's milk and eradicate the lactose intolerance, producers have to substitute the cow's milk substances with other plant-based substances such as coconut, rice and oat.

Based on the previous facts, this research aims to formulate white chocolate from rice, oat and coconut milk as alternatives to cow milk. Chemical analysis and physical properties were performed for rice, oat and coconut milk beside the prepared white chocolate. Sensory evaluation of prepared white chocolate was also done.

Materials and Methods

Materials

Samples of Coconut (*Cocos nucifera*), Oats (*Avena sativa*) , rice (*Oryza sativa*), Cocoa butter, coconut oil, honey, vanilla and chia were obtained from Fathallah markets in Alexandria, Egypt. Cow milk was obtained from Dairy Pilot Plant - Dairy Science and Technology Department, Faculty of Agriculture, Alexandria University, Alexandria Egypt.

Reagents, and solvents

All reagents and solvents used were purchased from Sigma–Aldrich Chemical (St. Louis, MO, USA) and El- Gomhoria Company, Alexandria, Egypt.

Chemical analysis

Samples of cow milk, plant–based milk (coconut, oat and rice) and prepared white chocolate were analyzed to determine, protein, moisture, ash, fat and fiber using **(Özbal *et al.*, 2022)** method. Total carbohydrate content was calculated by difference according to **Pearson (1976)**. The pH value was determined by using a digital pH meter according to **Leahu *et al.* (2022)**.

Mineral’s analysis

Previous samples of cow milk, plant–based milk and prepared White chocolate were analyzed to determine K, Ca, Fe and Zn using Atomic Absorption Spectrophotometer (Shimadzu model AA- 6650) **(Latimer, 2016)**.

Physical properties

Viscosity of cow milk, plant–based milk and white chocolate samples were determined using the Brookfield viscometer **(Srianta *et al.*, 2011)**. Whiteness of all samples will determined using a HUNTERLAB Colorimeter **(Hunter and Harold, 1987)**.

Hardens and Springiness

Brookfield Texture Analyzer was used to measure the chocolates hardness and springiness at room temperature according to **Dicolla (2009)**.

Anti-oxidant activities.

The free radical scavenging capacity of white chocolate samples were measured using a stable 2, 2 diphenyl-1-picrylhydrazyl (DPPH) radical according to **Wronkowska *et al.* (2010)** with some modifications.

Methods

Preparation of coconut and oat milk

Coconut or Oat (400g) was placed in a bowl contain 2L of warm water and left over night. The resultant solution was dumped into a blender on high speed for 1 minute then the bowl was heated until reached the desired consistency, then filtered using gauze and residues pieces of oat or coconut were discarded. The filtrate was used as coconut or oat milk **Figre1**. Pour the Coconut milk or oat milk was poured into an empty container then stored in the fridge until used to prepare the white chocolate **(Bernat *et al.*, 2015)**.

Preparation of rice milk

Rice (400g) was placed in a bowl contain 2L of warm water and was cooked until the water dries up. Then rice placed in the blender and one liter of water was added and heated well until reached the desired consistency, then filtered using gauze and residues were discarded. The filtrate was used as rice milk **Figre1**. rice milk was poured into an empty container then stored it in the fridge until used to prepare the white chocolate **(Adewale *et al.*, 2013).**

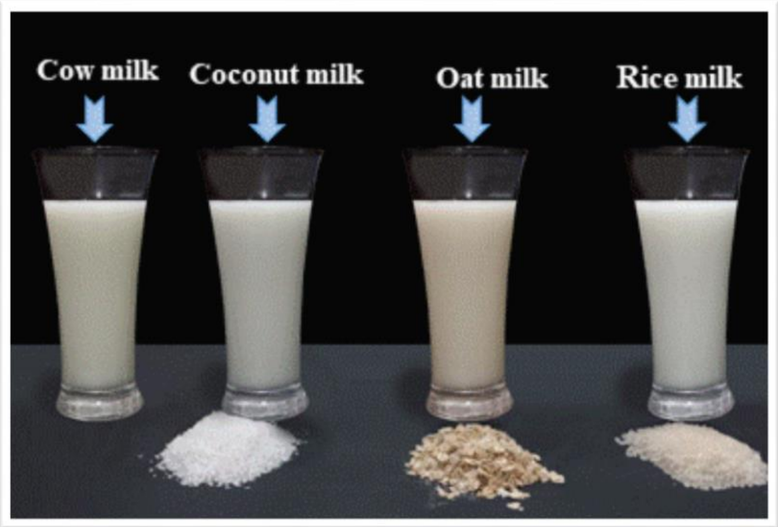


Figure (1): cow and plant based milk

Preparation of white chocolate

White chocolate was prepared by placing the Cocoa butter and coconut oil in a bowl, then the mixture was heated in water bath and stirred until the Cocoa butter and coconut oil melted then sweetener (honey), vanilla, chia, and cow or plant based milk were added and stirred until became soft (**Table 1 and Figre2)**. After that the bowl removed from the water bath and allowed to cool. The mixtures poured into flexible silicone moulds and placed on fridge until hard end then removed from the moulds and served **(Ţiplea *et al.*, 2019)**.

Figure (2): white chocolate of cow and plant based milk

Table (1): Ingredients of white chocolate formulation

Chocolate Formulation	Cocoa butter	Coconut oil	Honey	Vanilla	Chia	Milk
	gm					ml
Cow's milk Chocolate	**٤50**	**10**	**40**	**5**	**5**	**٢٠٠**
Coconut milk Chocolate	**٤50**	**10**	**40**	**5**	**5**	**٢٠٠**
Oat milk Chocolate	**٤50**	**10**	**40**	**5**	**5**	**٢٠٠**
Rice milk Chocolate	**٤50**	**10**	**40**	**5**	**5**	**٢٠٠**

High-performance liquid chromatography Analysis

Sugars of white chocolate samples were extracted by dipping 0.1 gram of sample, in 10 ml of deionized water. The resultant solutions placed in a water bath for 15 minutes, then cooled and filtered using 0.2 mm filter. HPLC analysis was carried out using a Shimadzu C196-E039A apparatus, which was outfitted with a CARBOSepCoregel 87P column 8 m (7.8 x 300 mm) (Transgenomic, USA). RID-10A refractive index dedector was employed. The data was processed using the LC solution programme. DI H2O was used as the mobile phase, with a flow rate of 1 mL min-1. The temperature in the column was 85°C **(Sungur and KIlboz, 2016)**.

Sensory evaluation

The sensory evaluation of prepared white chocolate was carried out using 9 points hedonic scale **(Gatade *et al.*, 2009)**. Forty persons from staff and students of Faculty of Agriculture, Department of Food Technology Sciences Alexandria University were chosen for pilot study to select the highest acceptability score fore samples. The sensory attributes were evaluated color, tast, texture, odour and overall acceptability of the product.

Statistical analysis of the data

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). Quantitative data was expressed as mean and standard error of mean One way ANOVA test was used for comparing the four studied groups and followed by Post Hoc test (LSD) for pairwise comparison between each two groups. Significance of the obtained results was judged at the 5% level.

Results and dissection

Chemical composition of cow and plant based milk

The chemical composition of different milk was analyzed to determine their nutrient profile which include, protein, fat, fiber and carbohydrates. The gross chemical composition of cow and plant based milk is shown in **Table 2**. The results showed that the percentages of protein contents were higher in cow milk (3.5%) compared with rice milk (1.0%). While no significant variation in the protein contents between cow milk and coconut or oat milk. In the case of fat the coconut milk contains the highest percent 13.40% compared with cow or other plant based milk. The percentage of fiber content was higher in plant base milk compared with cow milk which showed non-fiber. The oat milk had the highest percentage of carbohydrates (34.70%) while the lowest percentage in the coconut milk (4.0%). Moreover, no significant variation in the percentage of ash between cow and plant based milk. The moisture content was higher in cow milk (86.0%) compared with oat milk (59.7%) or other plant based milk.

Our results showed that coconut milk had 2.5% of protein milk which play an important role on the stability of the emulsion The results consistence with that reported **(Alyaqoubi *et al.*, 2015),** in which coconut milk samples that collected from different countries varied in total protein content ranged between (2.06- 3.5%). The fat percentage was the highest in coconut milk compared with cow or plant based milk. Fat content played an important role in the flow property of coconut milk **(Brown, 2014),** The percentage of carbohydrate in coconut milk was (4.0%) which close to that reported by **Shameena Beegum *et al.* (2022)** (5.6%). The current results showed that oat milk was lower in protein compared to cow milk. The results matched with that reported by **Gupta and BISLA (2019)**. The results were also agreed with **Syed *et al.* (2020)** in which oat milk contains the highest carbohydrate content 34.03%, protein 0.96%, and fibers 3.2%. The results in contrast with that reported by **Rasane *et al.* (2015)** in which the moisture content of oat milk was found to be higher than cow milk**.** The percentage of rice protein was (1.0%), to that reported by **Abou-Dobara *et al.* (2016)**, Who showed that rice milk is low in protein (0.6%).

Table (2): Chemical composition of cow, coconut, oat and rice milk

Samples	Protein	Fats	Fiber	Ash	Carbohydrates	Moisture content
	(%)					
Cow milk	3.50^{a} ± 0.38	3.60^{b} ± 0.30	0.0^{c} ± 0.0	0.81^{a} ± 0.07	6.10^{c} ± 0.96	86.00^{a} ± 1.20
Coconut milk	2.50^{ab} ± 0.33	13.40^{a} ± 0.32	3.70^{a} ± 0.29	0.66^{a} ± 0.47	4.00^{c} ± 0.65	75.80^{b} ± 0.78
Oat milk	1.70^{bc} ± 0.37	2.00^{c} ± 0.25	2.60^{b} ± 0.36	0.47^{a} ± 0.03	34.70^{a} ± 0.75	59.7^{d} ± 0.70
Rice milk	1.00^{c} ± 0.14	0.71^{d} ± 0.40	1.90^{b} ± 0.31	0.23^{a} ± 0.11	25.60^{b} ± 0.37	69.20^{c} ± 0.69
F	10.56*	319.91*	31.96*	1.08	440.48*	163.69*
P	0.004*	<0.001*	<0.001*	0.413	<0.001*	<0.001*
LSD 5%	1.05	1.05	0.90	0.79	2.33	2.82

*Data was expressed as Mean ± SE.
Statistically significant at $p \leq 0.05$
Means for each column with the same letter are not significantly different according to the $LSD_{0.05}$

Chemical composition of white chocolate

The prepared white chocolate from cow milk and plant based milk were analyzed to determine their nutrient profile which include, protein, fat, fiber and carbohydrates. The gross chemical composition of white chocolate is shown in **Table 3**. The results showed no significant difference in the protein contents between white chocolate prepared from cow milk and white chocolate prepared from plant based milk. In the case of fat the coconut chocolate contains the highest percent 58.30% compared with cow or other plant based chocolate. The percentage of fiber content was higher in plant base milk chocolate compared with cow milk chocolate which showed non-fiber. The oat chocolate has the highest percentage of carbohydrates (44.0%) while the lowest percentage in the coconut chocolate (30.2%). Moreover, no significant variation in the percentage of ash between cow and plant based chocolate. The moisture content was higher in rice chocolate compared with white chocolate prepared from other plant based milk. Our results matched with **Marsh *et al.* (2017),** who showed that the protein in white chocolate was 4.9%. While in contrast with the percentage of fat 34.1% and carbohydrate 44.1%

The current results in consistent with that reported by **Chandan (2017)** in which protein content was 4.6 g/100 g for plant-based yogurts. **Belewu *et al.* (2005),** stated that Coconut milk is rich in iron; the thus supplies the body with nearly a quarter of daily value of iron thereby resulting in the prevention of anemia**.** Milk and milk products from nuts, seeds and grains, may also be used as an alternative to cow milk. These alternatives have been characterized by a profile of healthy fatty acids and carbohydrates with low glycemic index **(Onweluzo and Nwakalor, 2009).** Furthermore, oat milk and oat-based products preserve the stomach walls and lower the acidity of gastric juice, which is beneficial for persons with gastrointestinal illnesses. **(Khrundin *et al.*, 2021).** Rice milk is said to be the most hypoallergenic type of milk. If you are allergic to cow milk, you should consume rice milk instead. Rice milk is recommended for those who are lactose intolerant because it is cholesterol-free and high in unsaturated fat **(Adewale *et al.*, 2013).**

Table (3): Chemical composition of white chocolate prepared from cow milk and plant based milk

Samples	Protein	Fats	Fiber	Ash	Carbohydrates	Moisture content
	(%)					
Cow milk chocolate	4.50[a] ± 0.70	54.7[b] ± 0.80	00[d] ± 0.00	1.80[a] ± 0.48	37.50[b] ± 0.27	1.60[ab] ± 0.18
Coconut milk chocolate	3.50[ab] ± 0.31	58.3[a] ± 1.2	5.40[a] ± 0.08	1.84[a] ± 0.33	30.20[c] ± 0.65	0.84[b] ± 0.12
Oat milk chocolate	3.00[ab] ± 0.55	50[c] ± 1.1	3.80[b] ± 0.68	1.85[a] ± 0.08	44.00[a] ± 2.4	0.93[b] ± 0.06
Rice milk chocolate	2.40[b] ± 0.39	48.9[c] ± 0.60	2.40[c] ± 0.22	2.60[a] ± 0.22	41.1[ab] ± 0.60	2.60[a] ± 0.75
F	2.989*	21.304*	40.812*	22.522*	14.143*	4.104*
p	0.046*	<0.001*	<0.001*	<0.001*	0.001*	0.049*
LSD 5%	1.66	3.05	1.16	1.02	4.11	1.28

Data was expressed using Mean ± SE.

F: **F for One way ANOVA test**, Pairwise comparison bet. each 2 groups was done using **Post Hoc Test (LSD)**

p: p value for comparing between the four studied groups

*: Statistically significant at $p \le 0.05$

Means for each column with the same letter are not significantly different according to the LSD0.05

Mineral composition of milk

The mineral composition of cow and some plant based milk is shown (Table 4) The cow milk showed the highest content of Ca (338.00mg/100ml), followed by rice milk (240.90mg/100ml), while the coconut milk has the lowest Ca content (16.70mg/100ml). No significant variation in the iron (Fe) contents between cow milk and plant based milk. However, the potassium content in coconut milk was (260.50mg/100ml) higher than cow milk and other plant-based milk. In the other hand, the zinc content showed the highest percentage in oat milk was (10.20mg/100ml) compared to the cow milk and other plant-based milk.

Cow milk considered as one of the potential sources of minerals in the diet. The current results showed that cow milk was rich in Ca contents compared to the tested plant based milk, and that matched with that reported by **Meisel and FitzGerald (2003)** in which the highest level of calcium in milk and dairy products thought to be due to the phosphorylated sequences in the caseins. Moreover, coconut milk was high in potassium, calcium and iron **(Kartz *et al.*, 2014).** Calcium content in oat milk was close to that reported by **Ahmad *et al.* (2014)** (49.1 mg/100ml) and that was lower than the standard cow's milk that contain (112 mg/100ml), while they found that iron content of oat milk was 0.65 mg/100ml which was higher than the standard cow's milk.

Table (4): Mineral composition of cow, coconut, oat and rice milk

Samples	Calcium	Iron	Potassium	Zinc
		(mg/100ml)		
Cow milk	338.00^{a} ± 1.2	2.60^{a} ± 0.53	146.00^{b} ± 1.6	0.48^{b} ± 0.06
Coconut milk	16.70^{d} ± 1.8	3.20^{a} ± 0.06	260.50^{a} ± 1.7	0.52^{b} ± 0.11
Oat milk	48.70^{c} ± 1.1	2.30^{a} ± 0.23	0.76^{c} ± 0.17	10.20^{a} ± 0.64
Rice milk	240.90^{b} ± 2.5	2.40^{a} ± 0.20	2.40^{c} ± 0.22	0.43^{b} ± 0.19
F	8052.524*	9.052*	11194.30*	207.054*
P	<0.001*	0.006*	<0.001*	<0.001*
LSD 5%	5.59	1.00	3.86	1.09

Data was expressed using Mean ± SE.
F: **F for One way ANOVA test**, Pairwise comparison bet. each 2 groups was done using **Post Hoc Test (LSD)**
p: p value for comparing between the four studied groups
*: Statistically significant at $p \le 0.05$
Means for each column with the same letter are not significantly different according to the LSD0.05

Mineral Composition of white chocolate

The mineral composition of prepared white chocolate of cow and plant based milk is shown in (Table 5). The cow milk chocolate had the highest content of Ca (338.30mg/100g), followed by rice milk chocolate (241.70mg/100g). While the amount of Ca in oat milk and Coconut milk chocolate were 49.50mg/100g and 16.71mg/100g. No significant variation in the iron (Fe) contents between cow milk chocolate and plant based milk chocolate. However, the potassium content in coconut milk chocolate was (270.00mg/100g) higher than cow milk and other plant-based milk chocolate. In the other hand, the zinc content showed the highest percentage in oat milk chocolate was (11.00mg/100g) compared to the cow milk chocolate and other plant-based milk chocolate.

The current results in consistence with**Belewu and Azeez (2008),** who reported that calcium content was higher in cow milk compare with coconut milk chocolate. While, potassium content in cow milk was less than coconut milk chocolate.

Cinquanta *et al.* (2016), reported that the amount of calcium, iron, potassium and zinc were (180.4, 1.19, 198.9 and 0.94 mg/100 g, respectively in cow milk chocolate. compared to all the other types of investigated chocolate. Our results showed that cow milk chocolate was high in Ca and iron (338.30 and 2.50 mg/100 g).

Potassium is essential for maintaining membrane potentials, thus playing a role in the pathways related to cardiovascular health **(Strazzullo *et al.*, 2009).**

Moreover, zinc has a considerable influence on the immune system **(Tuerk and Fazel, 2009).**The deficiency of zinc cause global health problem **(Sandstead, 2012)**. The content of zinc in the chocolate contributes nearly one third of the nutritional requirement by consuming 100 g of chocolate.

Table (5): Mineral composition of white chocolate prepared from cow, coconut, oat and rice milk

Samples	Calcium	Iron	Potassium	Zinc
	(mg/100g)			
Cow milk chocolate	338.30[a] ± 0.50	2.50[a] ± 0.38	146.20[b] ± 1.9	0.51[b] ± 0.02
Coconut milk chocolate	16.71[d] ± 1.2	3.20[a]± 0.08	270.00[a] ± 1.7	0.59[b] ± 0.06
Oat milk chocolate	49.50[c] ± 0.48	2.40[a] ± 0.29	0.84[c] ± 0.04	11.00[a] ± 0.86
Rice milk chocolate	241.70[b] ± 2.8	2.50[a] ± 0.16	2.60[c] ± 0.16	0.56[b] ± 0.17
F	9510.429*	14.690*	9775.926*	126.985*
P	<0.001*	0.001*	<0.001*	<0.001*
LSD 5%	5.15	0.82	4.13	1.42

Data was expressed using Mean ± SE.

F: **F for One way ANOVA test**, Pairwise comparison bet. each 2 groups was done using **Post Hoc Test (LSD)**

p: p value for comparing between the four studied groups

*: Statistically significant at $p \le 0.05$

Means for each column with the same letter are not significantly different according to the LSD0.05

Physical properties of milk

The physical properties of cow and plant based milk includes, values of pH, viscosity and whiteness index of cow and plant based milk is shown in **Table (6).** The pH values of Coconut, rice and cow milk were 6.9, 6.9 and 6.6 respectively. While the lowest pH for oat milk 5.5 values. The highest viscosity was for coconut milk 46.5 values, while the lowest viscosity was for cow milk and rice milk 2.8 and 2.9mPas. The highest whiteness index value was 75.6 for cow milk followed by coconut milk 67.7 and rice milk 66.6. While the lowest whiteness index value for oat milk 54.9. The current results close to that reported by **Syed *et al.* (2020)**

in which the pH values of cow milk, coconut and oat milk were 6.68, 6.70 and 5.92. In contrast **(Ladokun and Oni, 2014),** found that the pH was higher in cow milk than that of coconut milk. **Khuenpet *et al.* (2016),** found that the viscosity of coconut milk samples were in the range between **12.8-33.6.** Moreover, **Zheng *et al.* (2021),** showed that the viscosity of oat milk was higher than cow milk. The carbohydrate contents of oat being relatively higher than other cereals, which contributed to their high viscosity **(Ahmadi-Abhari *et al.*, 2013).**

The Whiteness Index is one of the most important quality parameters for milk **(Saha and Bhattacharya, 2010).** The Whiteness Index for cow milk is the highest with 81.89 and all plant-based milk substitutes appeared darker **(Cadwallader, 2010).** Oat milks may have a slight brownish color due to the presence of natural pigments **(McClements *et al.*, 2019).**

Table (6): Physical properties of cow, coconut, oat and rice milk

Samples	pH values	Viscosity[mPa s]	Whiteness index
Cow milk	6.6[a] ± 0.24	2.8[c] ± 0.15	75.6[a] ± 1.7
Coconut milk	6.9[a] ± 0.15	46.5[a] ± 0.74	67.7[b] ± 1.3
Oat milk	5.5[b] ± 0.27	6.3[b] ± 0.36	54.9[c] ± 1.9
Rice milk	6.9[a] ± 0.12	2.9[c] ± 0.31	66.6[b] ± 1.2
F	10.512*	2272.43*	29.746*
p	0.004*	<0.001*	<0.001*
LSD 5%	0.66	1.45	5.09

3 replica for each group Data was expressed using Mean ± SE.

F: **F for One way ANOVA test**, Pairwise comparison bet. each 2 groups was done using **Post Hoc Test (LSD)**

p: p value for comparing between the four studied groups

*: Statistically significant at $p \leq 0.05$

Means for each column with the same letter are not significantly different according to the LSD0.05

Physical properties and texture of white chocolate

The physical properties and texture of cow and plant based milk white chocolate are shown in (Table 7). The highest viscosity was for coconut milk chocolate (782.3mPas), while the low viscosity was for cow milk chocolate 41.3mPas. The highest whiteness index value was 68.3 for cow milk chocolate followed by coconut milk chocolate 63.8 and rice milk chocolate 57 while the lowest whiteness index value for oat milk chocolate 48.7, that may due to slight brownish color of natural pigments.

The highest hardness was for rice milk chocolate 11083g, while the lowest hardness was for oat milk chocolate 6948g. The highest springiness were for coconut and oat milk chocolate (2.51 and 2.41mm), while the lowest springiness were for cow and rice milk chocolate (0.52

and 0.46 mm). The current results showed that the viscosity of plant based milk was less than white chocolate. **Lopes *et al.* (2020)**, found that the viscosity of plant milk increased with increasing heat treatments. Also**, Yao *et al.* (2022),** reported that the viscosity of affected by heat treatment.

The whiteness index of various plant-based milks shows that the plant-based milks have less white appearance than cow milk **(Jeske *et al.*, 2017). Ayah *et al.* (2022),** reported that, the texture parameter (springiness) of **c**hocolate made from cow's milk and some vegan milks exhibited the significantly highest values of the textural parameter.

Table (7): Physical properties and texture of white chocolate cow, coconut, oat and rice milk

Samples	Physical properties		texture	
	Viscosity mPa s	Whiteness index	Hardness (g)	Springiness
Cow milk chocolate	41.3[d] ± 0.41	68.3[a] ± 0.35	9883.3[c] ± 1.2	0.52[b] ± 0.04
Coconut milk chocolate	782.3[a] ± 1	63.8[b] ± 1.8	10705[b] ± 2.3	2.51[a] ± 0.02
Oat milk chocolate	404.8[c] ± 2.5	48.7[d] ± 1.5	6938.7[d] ± 2.9	2.41[a] ± 0.21
Rice milk chocolate	449.7[b] ± 0.27	57[c] ± 1.1	11083[a] ± 1.2	0.46[b] ± 0.05
F	49042.15*	43.160*	868953.03*	110.796*
p	<0.001*	<0.001*	<0.001*	<0.001*
LSD 5%	4.46	4.25	6.56	0.35

Data was expressed using Mean ± SE.

F: **F for One way ANOVA test**, Pairwise comparison bet. each 2 groups was done using **Post Hoc Test (LSD)**

p: p value for comparing between the four studied groups *: Statistically significant at $p \leq 0.05$

Means for each column with the same letter are not significantly different according to the LSD0.05

ntioxidant activity of white chocolate

The results showed significant differences in the antioxidant activity between the cow chocolate and the other white chocolate prepared from some plant based milk (Table 8). The lowest antioxidant activity was observed in rice chocolate 16.70% and the highest percentage 64.60% was recorded in coconut chocolate. The antioxidant activity in cow and oat chocolate were 22.30 and 52.60 %, respectively. The current results in the line with that reported by **Brown (2014)** in which coconut milk had antioxidants activity, that might prevent free radical damage due to the abundance of phenolic compounds in the coconut oil. Also, **Karunasiri *et al.* (2020),** found that DPPH content in coconut milk was higher than the cow milk. Moreover, **Seneviratne *et al.* (2009) and García-Lafuente *et al.* (2014),** stated that phenolic compounds present in coconut oil and coconut milk give the coconut tast. However, **Cooper *et al.* (2008),** showed that dark chocolate has the greatest phenolic content, followed by milk and white chocolates.

Table (8): Antioxidant activity of white chocolate prepared Cow and plant based milk

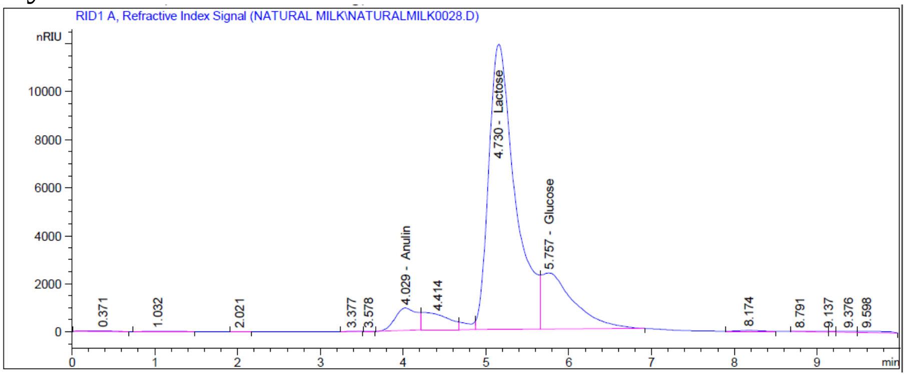
Samples	DPPH(%)
Cow chocolate	22.30[c] ± 1
Coconut chocolate	64.60[a] ± 1.7
Oat chocolate	52.60[b] ± 0.28
Rice chocolate	16.70[d] ± 1.1
F	401.458*
P	<0.001*
LSD 5%	3.77

Data was expressed using Mean ± SE.
F: **F for One-way ANOVA test**, Pairwise comparison bet. each 2 groups was done using **Post Hoc Test (LSD)**
p: p value for comparing between the four studied groups
*: Statistically significant at $p \leq 0.05$
Means for each column with the same letter are not significantly different according to the LSD0.05

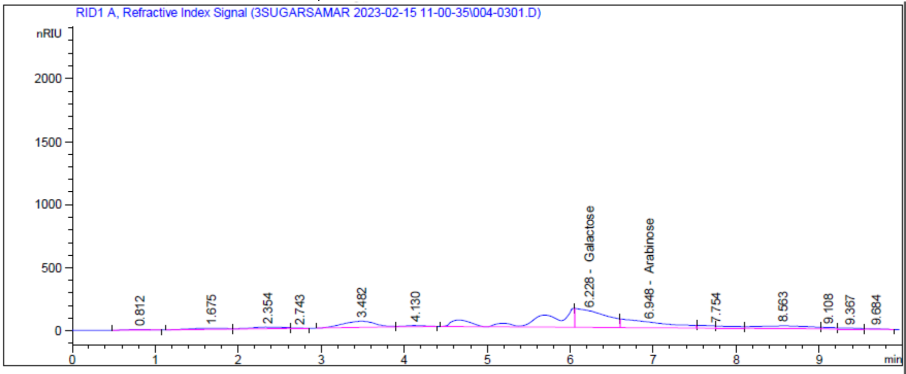
HPLC profile of white chocolate sugar

The HPLC profile of sugars extracted from cow white chocolate and the other white chocolate prepared from some plant based milk is shown in **(Table 9 and Figure ٣)**. The analysis of sugars in cow's milk chocolate showed the presence of lactose sugar at a rate of 3.90%, and its absence in chocolate prepared from plant-based milk. The analysis also showed the presence of glucose sugar in cow, oat and rice milk chocolate. Moreover, galactose sugar is presence in coconut, rice and oat milk chocolates, and its absence in cow milk chocolate. Further, some other sugars were presence in a minor percent in the samples of plant based chocolate. The current and earlier studies showed that lactose is a major sugar present in cow milk. The other remaining sugars are mono-saccharides, such as glucose and galactose **(Trani *et al.*, 2017).** The prevalence of lactose intolerance around the world makes lactose analysis particularly crucial. Usually, a lack of the lactase enzyme is the cause of such intolerance. This deficit prevents the body from fully digesting lactose, which results in a multitude of symptoms that have an adverse effect on health **(Romero-Velarde *et al.*, 2019).**

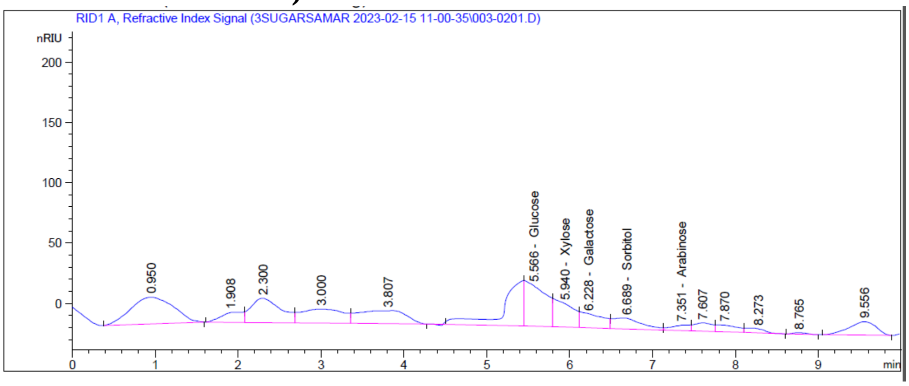
The oat- based milk and rice based milk contained high amounts of maltose and glucose while cow milk contained about 3.33 % lactose and 0.05 % galactose **(Jeske *et al.*, 2017).** Moreover, **Sethi *et al.* (2016)**, reported that the levels of sugars in plant based milk depend on the efficiency of extraction of milk.



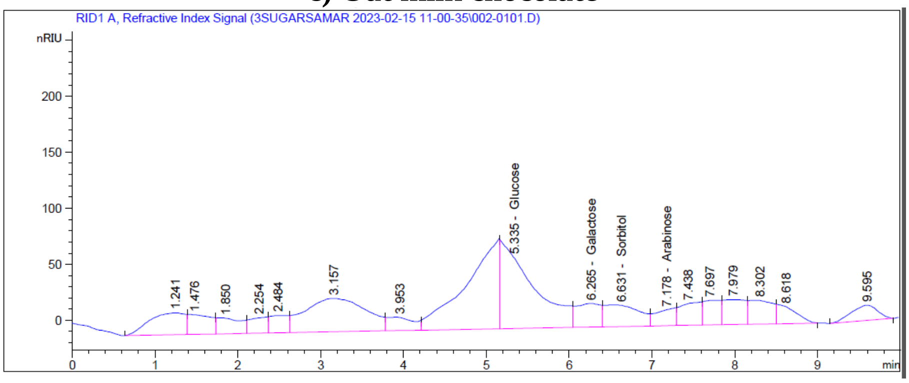
a) Cow milk chocolate



b) Coconut milk chocolate



c) Oat milk chocolate



d) Rice milk chocolate

Figure (٣): HPLC Separation of sugars from cow and plant based milk white chocolate

Table (9): Linearity parameters of white chocolate sugar analyzed by HPLC

Samples	Sugars	R^2	(g /100g) %	RT*	Equation
Cow milk chocolate	Lactose	0.983	3.90	4.730	y = 8328.36x -38.91
	Glucose	0.983	1.20	5.566	y = 8908370x +6504.11
	Anuline	0.983	0.44	4.029	y = 430.921x -141.20
Coconut milk chocolate	Galactose	0.983	0.20	6.228	y = 2143590x - 218580
	Arabinose	0.983	0.15	6.948	y = 8908370x +6504.11
Oat milk chocolate	Glucose	0.983	0.50	5.566	y = 8908370x +6504.11
	Galactose	0.983	0.10	6.228	y = 2143590x - 218580
	Xylose	0.983	0.20	5.940	y = 9852000x + 16970.21
	arabinose	0.983	0.03	7.351	y = 8908370x +6504.11
	Sorbitol	0.983	0.80	6.689	y = -157832x + 81238.56
Rice milk chocolate	Glucose	0.983	0.30	5.566	y = 8908370x +6504.11
	Galactose	0.983	0.20	6.265	y = 2143590x - 218580
	Sorbitol	0.983	0.26	6.631	y = -157832x + 81238.56
	Arabinose	0.983	0.10	7.178	y = 8908370x +6504.11

* **Retention time**

Sensory evaluation of white chocolate

The data in **(Table 10),** showed the sensory properties of white chocolate of cow and plant based milk. The data revealed variation between the prepared chocolate. Moreover, significant differences in overall acceptability was estimated between the four prepared samples of white milk chocolates. The data also, showed that coconut white milk chocolate was more preferable for panelists compared with cow white milk chocolate. The sensory scores of overall acceptability was 8.0 out of nine for white coconut milk chocolate followed by 7.2 and 6.6 for white oat milk chocolate and rice milk chocolate, respectively compared with cow white milk chocolate was 6.0. The current results point to the importance of plant based milk chocolates of coconut, oat and rice for lactose intolerance. Among the prepared chocolate, coconut milk chocolate was preferable due to the fascinating odour of coconut milk which enhanced the panel mood. The improved flavour and taste of coconut milk chocolate confirmed the results of **Thompson *et al.* (2004).** Moreover, **Belewu and Azeez (2008),** reported that the overall acceptability results favoured coconut milk chocolate compared to cow milk chocolate. The study of **Suri *et al.* (2019)**, showed that the use of coconut milk is a viable alternative as it is a non-dairy product, thus meeting thereby satisfying the demands of lactose intolerant persons.

There are some factors that attract consumers towards certain types of milk such as physical appearance and color **(El-Bialy *et al.*, 2020)**. Coconut appeals to a big scale of consumers because it is distinguished by its flavor which is tastier than cow's milk **(Beegum *et al.*, 2021)**

Table (10): Sensory evaluation of white chocolate of cow and plant based milk.

Samples	Color	Taste	Odor	Textures	Acceptance
Cow chocolate	$7^{b} \pm 0.25$	$5.9^{d} \pm 0.24$	$7^{b} \pm 0.34$	$7.1^{a} \pm 0.33$	$6.0^{d} \pm 0.20$
Coconut chocolate	$8^{a} \pm 0.12$	$8.4^{a} \pm 0.22$	$8.2^{a} \pm 0.07$	$7.72^{a} \pm 0.20$	$8.0^{a} \pm 0.10$
Oat chocolate	$5.9^{c} \pm 0.20$	$7.5^{b} \pm 0.18$	$7.2^{b} \pm 0.31$	$7.5^{a} \pm 0.25$	$7.2^{b} \pm 0.17$
Rice chocolate	$7.6^{a} \pm 0.21$	$6.6^{c} \pm 0.22$	$7.2^{b} \pm 0.29$	$7.5^{a} \pm 0.24$	$6.6^{c} \pm 0.28$
F	21.076*	24.686*	3.571	0.924	19.722*
p	<0.001*	<0.001*	0.017*	0.433	<0.001*
LSD 5%	0.56	0.61	0.76	0.72	0.55

Data was expressed using Mean ± SE.

F: **F for One way ANOVA test**, Pairwise comparison bet. each 2 groups was done using **Post Hoc Test (LSD)**

p: p value for comparing between the four studied groups

*: Statistically significant at $p \le 0.05$

Means for each column with the same letter are not significantly different according to the LSD0.05

Conclusion

This study sheds new light on some plant sources for plant-based milk alternatives. Plant-based white milk chocolate is differentiated by its rich mineral, fat, fibre, and antioxidant content. Plant-based milk is lower in cholesterol than cow milk and may be a better option for people who are lactose intolerant or have low cholesterol. Data of the present study showed that coconut, rice and oat extracts (milk) could be used successfully in producing chocolate free lactose. Further study will be needed in the future to examine the biological aspects of such products.

Data of the present study showed that coconut, rice and oat extracts could be used successfully in producing chocolate free lactose. Further study will be needed in the future to examine the biological aspects of such products.

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تحضير تجهيزات الشيكولاتة البيضاء الخالية من اللاكتوز من حليب جوز الهند، الشوفان والأرز: دراسات كيميائية وغذائية

الملخص:

في الوقت الحاضر ، تقوم صناعة الأغذية بتطوير مجموعة من الالبان النباتية كبدائل للحليب البقري من أجل تلبية متطلبات البروتين في البلدان النامية خاصة للأفراد الذين يعانون من عدم تحمل اللاكتوز. يعتبر حليب الأرز ،الشوفان وجوز الهند من البدائل الغنية بالقيمة الغذائية. تم تحضير الشيكولاتة البيضاء من حليب البقر ،الأرز ،الشوفان وجوز الهند. أظهرت نتيجة التحليل الكيميائي للشوكولاتة البيضاء عدم وجود فروق معنوية في محتوى البروتين بين الشوكولاته البيضاء المحضرة من حليب البقر والشيكولاتة البيضاء المحضرة من الحليب النباتي. كما بينت النتائج أن شيكولاتة جوز الهند تحتوي على نسب اعلى من الدهون (٥٨,٣٠٪) والألياف (٥,٤٠٪) مقارنة بشيكولاتة الحليب البقري التي أظهرت نسبة قدرها (٥٤,٧٪) من الدهون ولم يوجد بها الياف. تحتوي شيكولاتة الشوفان على أعلى نسبة من الكربوهيدرات (٤٤,٠٪). أظهرت نتائج تقديرالمعادن أن الكالسيوم كان مرتفعًا في شيكولاتة حليب البقري والأرز ، وكان شيكولاتة جوز الهند تحتوي على نسبة عالية من البوتاسيوم. كما كانت قيم الأس الهيدروجيني للحليب النباتي قريبة من قيمة الحليب البقري. كان نشاط مضادات الأكسدة في شيكولاتة جوز الهند أعلى (٦٤,٦٠٪) مقارنة بالشيكولاتة الأخرى. أظهر تحليل HPLC للسكريات تواجد سكر اللاكتوز بنسبة ٣,٩٠٪ في شيكولاتة حليب البقر ، وغيابه في الشيكولاتة المحضرة من الحليب النباتي. كما أظهر التقييم الحسي للشيكولاتة البيضاء أن التقبل العام لشيكولاتة جوز الهند كان الأفضل يلية شيكولاتة الشوفان ، الأرز ثم الحليب البقري. تقدم هذه الدراسة رؤى جديدة لبدائل الحليب النباتية التي تحتوي على قيم غذائية عالية لتلبية احتياجات الأشخاص الذين يعانون من عدم تحمل اللاكتوز.

الكلمات المفتاحية: الحليب النباتي ، عدم تحمل اللاكتوز ، شيكولاتة ، التقييم الحسي