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Phytochemical and antioxidant properties of date sweetened simulated milk powder from awara (soy curd)- a plant-based dairy

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Abstract
The phytochemical and antioxidant properties of date sweetened simulated milk powder (plant-based dairy source) from awara (soy curd) was studied. A total of five sample with ratio 100%, 75:25, 70:30, 65:35 and 60:40% for awara and date were generated and used for the formulation of the simulated milk based on mixture design. The simulated milk samples were subjected to phytochemical and antioxidant evaluation using standard procedures. The result reviewed the presence of total phenolic, total flavonoids, tannins, saponins and glycosides in both the sweetened and unsweetened simulated milk and values significantly $p<0.05$ ranged from 0.58-0.59mgGAE/100g, 0.90-2.07mgGAE/100g, 8.83-9.32, 1.42-3.32 and 2.64-4.05mg/100g, respectively except for total phenolic content. The DPPH radical scavenging activity assay for the sweetened and unsweetened simulated milk powder reviewed %inhibition values of 56.45-88.94, 65.31-91.20, 75.24-91.98, 80.96-92.17, 81.35-92.66% at 50, 100, 150, 200 and 250ug/ml, respectively with IC50 values of 90.50 (75:25), 91.67 (65:35), 93.67 (60:40), 107.50(70:30) and 112.67ug/ml (100% unsweetened simulated milk). All simulated milk powder with DPPH IC50 values below 100ug/ml means moderate antioxidant activity. The total antioxidant capacity assay of the sweetened and unsweetened simulated milk ranged from 63.50-89.40, 63.50-89.70, 64.83-89.74, 68.23-89.85, 70.33-93.32% for 50, 100, 150, 200 and 250ug/ml concertation with IC50 range from 104.50-185.50ug/ml (sweetened) indicating weak antioxidant capacity and 250.50ug/ml (unsweetened) indicating inactive antioxidant capacity. This inactive antioxidant capacity of the unsweetened simulated milk showed that the addition of date palm did not only enhance the taste but also its total antioxidant capacity. Thus, an addition to the healthy plant-based dairy powder and scalable opportunity for both small- and large-scale industry as soy bean is locally sourced.

Keywords: Simulated milk powder, awara, plant-based dairy, soybean, phytochemical and antioxidant capacity

Introduction

Phytochemicals are essential nutrients called natural bioactive compounds such as flavonoids, phenolic acids, tannins, carotenoids, saponins and alkaloids found in plants. They promote human health and prevents occurrences of diseases. They are commonly found in fruits, legumes, vegetable and nuts. It can also be found in soybean derived foods (Fatima *et al.,* 2025) [8]. The important functions of phytochemical is obtained from their antioxidant capacity. Antioxidants are compound that neutralize free radicals and reactive oxygen species (ROS) generated during metabolic processes or as a result of environmental stressors like radiation and pollution. Poor diet can as well led to the generation of free radicals and ROS. When the free radical and ROS becomes too much in the body, it causes cellular damage, protein degradation, DNA mutation and lipid peroxidation (Irondi *et al.,* 2024) [14]. The antioxidant capacity of phytochemicals make them essential in maintaining human health by supporting metabolic functions, against oxidative stress and reducing the risk of chronic diseases. Their addition in human diets through plant-based foods and functional products is crucial for overall well-being promotion.

There is an increase in the demand of plant-based milk alternative globally due to health, ethical concerns and environmental issues with animal source of milk. Plant-based milk analogue sourced from cereals, nuts and legumes are making waves as a functional food because of their rich bioactive compounds. Soybean (Glycine max) is one of the most commonly used amongst others as a source of plant-based dairy because of its high-quality protein, phytochemicals value and amino acid content with other ascertained health benefits (Fatima *et al.,* 2025) [8].

In the Northern part of Nigeria, West Africa country, awara a soy-curd from the coagulation of soymilk is a locally consumed plant-based dairy protein because of its affordability and accessibility (Bagirei *et al.,* 2021) [4]. Awara contains bioactive compounds such as phenolic, isoflavones and flavonoids compounds which gives its antioxidant, cardioprotective and anti-inflammatory properties (Fatima *et al.,* 2025) [8]. These are essential phytochemicals that mitigates oxidative stress through free radicals scavenging and regulation of metabolic process connected to chronic diseases.

The addition of date to plant-based dairy source is a healthier option that is getting more attention than refined sugar. Date palm is a rich source of simple sugar, minerals, dietary fiber, flavonoids and phenolic compound. These phytochemicals found in date contributes to their antioxidant capacity. Addition of date to plant-based dairy source does not only enhance its sensory acceptability but support overall health due to its bioactive compounds.

Irondi *et al.* (2024) and Awujo *et al*. (2023) [3, 14] noted that coagulation and fermentation process would affect the phytochemicals, bioavailability and enhance antioxidant activity through microbial transformation. Using fermented liquor from pap (akamu) fermentation as a coagulant could as well add or enhance antioxidant properties of the

simulated milk. Moreso, converting awara into milk powder alternative offers a convenient shelf-stable product for consumers.

Most studies available is focused on liquid soy milk or the full soybean powder with limited information on the phytochemical and antioxidant capacity of awara (soy curd) to dairy powder alternative. Thus, the evaluation of the phytochemical and antioxidant properties of simulated awara date sweetened simulated milk powder

Materials and methods

Experimental design

A simplex lattice mixture design was used and generated six formulation ratio such 100:0, 75:25, 70:30, 65:35, 60:40 using awara and date powder

Source of raw materials

Soybean (Glycine max), date fruit and mult-grains (maize, millet and guinea corn) were purchased from Eke-Awka market in Awka South Local Government Aera, Anambra State, Nigeria while the soy lectine was bought from an Instagram online vendor.

Production of coagulant (fermented multi-grain cereal grain waste liquor).

The waste liquor from akamu (pap) production was used as a coagulant. The coagulant was obtained according to the method of China and Amadi (2021) for akamu production with modification by using multi-grain instead of single grain. The three grains (maize, millet and guinea corn) were of equal ratio (1:1:1), was cleaned and soaked with water for 4 days at ambient temperature. The soaked water was drained and stored every 24h with replacement of fresh soaked water till the four days was complete. All the soaked fermented water stored inside freezer was brought out at the end of the fourth day, allowed to defrozed and then used as a coagulant.

Awara (soy curd) production

The awara production was done according to China and Amadi (2021) with modification. The soybean of 7000g was sorted, washed and soaked in 25 ^{0}C water for 1h before dehulling and grinding into thick paste. The paste was sieved with addition of water, to remove the chaff (okara) from the milk. The soymilk was boiled at 100 ^{0}C for 20minuets. The boiled soymilk was coagulated using the waste water from akamu (pap) production know as fermented liquor, by adding it gradually to the boiled soymilk at the ratio of 500ml (fermented liquor) to 1500ml (soymilk) and allowed to stand for 30min for coagulation to occur. After the coagulation, the formed awara (curd) and the whey were separated with cheese cloth. The awara inside the cheese cloth were squeezed to remove excess whey and was pressed further to semi-dryness by placing upon the tied cheesed cloth with the awara with heavy weight for over sometime. The semi-dried awara was subjected to further processing.

Date palm powder production

The date powder was produced according to the conventional method as described by Hemspriya (2018). The date was sorted to remove dirt and spoilt ones and washed with portable water. It was de-seeded, manually size reduced with kitchen knife, dehydrated with dehydrator (ST-01T) at 35 0C for 18h. it was milled with hammer mill (Honda GX200-6.5HP), sieved with wire mesh sieve of 125um to obtain the date powder and was packaged in an air-tight container till further use.

Awara-date simulated milk powder production

Based on the formulation ratio generated with simplex lattice mixture design, the semi-dried awara was combined with date powder and emulsifier (soy lectins) and was properly homogenized together. The homogenized awara-date-soy lectine was dehydrated using dehydrator at 60 ^{0}C for 18h and was further dried in oven at 65 ^{0}C for 10 min for minimal moisture residue. The oven dried awara-date-soy lectin was milled and sieved using 200um sieve to obtain a smooth and uniform powder which was then package as simulated awara-date milk powder.

Sample preparation and antioxidant determination

Sample preparation for antioxidant assay and antioxidant determination were according to Rumengan (2019) and Anokwah *et al.* (2022) [15], respectively.

Sample preparation for the determination of total phenolic, flavonoids and tannins were according to the method of Uddin *et al.* (2020) [29], Alshehri (2024) and Silva *et al.* (2019) [27]; with modification by using water instead of solvent (1g sample to 50ml water) while Uddin *et al.* (2020) [29] was used for the determination of total phenolic; flavonoids and saponin was as described by Alshehri (2024), tannins according to Folin-Dennis spectrophotometric method as described by Silva *et al.* (2019) [27] and glycoside by Oluwayemisi *et al.* (2023).

Results

Phytochemical composition of awara-date simulated milk powder

The Phytochemical composition of awara-date simulated milk powder is seen in Table 1. All the awara-date simulated milk powder samples as also seen in Figure 1 showed no significant $p>0.05$ difference in their total phenolic values, samples with ratio 70:30, 100:0 and 75:25 showed no significant $p>0.05$ difference in their total flavonoids values, sample 75:25 and 60:40 also showed no significant $p>0.05$ difference in their tannins content while every other sample showed significant $p<0.05$ difference. The awara-date simulated milk powder samples had total phenolic, total flavonoids, tannins, saponins and glycoside result range from 0.58-0.59mgGAE/100g, 0.90-2.07mgGAE/100g, 8.83-9.27, 1.42-3.32, 2.64-4.05mg/100g, respectively. Awara-date simulated milk powder with sample ratio 70:30 had the highest total phenolic and flavonoids value of 0.59 and 2.07mg/100g while 65:35 had the highest tannins and glycosides values of 9.32 and 4.05mg/100g and 75:25 with the highest saponin value of 3.32mg/100g.

Table 1: Phytochemical composition of awara-date simulated milk powder

Samples (Awara:date)	Total phenolic (mgGAE/100g)	Total flavonoids (mgQE/100g)	Tannin (mg/100g)	Saponin (mg/100g)	Glycosides (mg/100g)
100:0	$0.58^{a} \pm 0.00$	$2.03^{ab} \pm 0.00$	$9.12^{c} \pm 0.01$	$3.01^{b} \pm 0.02$	$2.64^{e} \pm 0.01$
75:25	$0.58^{a} \pm 0.00$	$2.02^{b} \pm 0.03$	$9.27^{b} \pm 0.00$	$3.32^{a} \pm 0.02$	$2.94^{d} \pm 0.01$

70:30	0.59[a] ± 0.00	2.07[a] ± 0.02	8.83[d] ± 0.01	2.41[c] ± 0.02	3.94[b]±0.01
65:35	0.58[a] ± 0.00	1.92[c] ± 0.04	9.32[a] ± 0.01	1.42[e] ± 0.00	4.05[a] ± 0.00
60:40	0.58[a] ± 0.00	0.90[d] ± 0.03	8.84[d] ± 0.01	2.19[d] ± 0.01	3.57[c] ± 0.01

Values are mean scores ± Standard deviation of three (3) replicates. Mean value with different superscript on each column is significantly different ($p < 0.05$).

DPPH (2,2-diphenyl-2-picrylhydrazyl) free radical scavenging activity assay of awara-date simulated milk powder

Table 2 shows the DPPH free radical scavenging activity assay of awara-date simulated milk powder samples. Generally, there was significant difference $p<0.05$ in the percentage inhibition of all the awara-date simulated milk powder at different concentration levels (50, 100, 150, 200 and 250µg/mL) when compared to the standard (ascorbic acid). The percentage inhibition values for the sample ratio 100:0, 75:25, 70:30, 65:35 and 60:40 at concentrations of 50, 100, 150, 200 and 250 µg/mL ranged from 76.10-81.35, 62.54-92.17, 56.45-82.11, 90.62-91.43 and 88.94-91.81%, respectively. The values of the percentage inhibition increased significantly $p<0.05$ with the increase in the concentration for all the samples. Sample ration 65:35, 75:25, 75:25,75:25 and 75:25 had the highest percentage inhibition of 90.62, 91.20, 91.98, 92.17 and 92.66% at 50, 100, 150, 200 and 250 µg/mL. Awara-date simulated milk powder had the overall highest inhibition value of 92.66% at 250 µg/mL, which is close to the highest value of inhibition value of 95.58% at the same concentration for ascorbic acid (standard).

Table 2: DPPH (2,2-diphenyl-2-picrylhydrazyl) free radical scavenging activity assay of awara-date simulated milk powder

% Inhibition						
Samples (Awara: date)						
Concentration (µg/mL)	100:0	75:25	70:30	65:35	60:40	Ascorbic acid
50	76.10[e] ± 0.02	62.54[e] ± 0.01	56.45[e] ± 0.05	90.62[e]± 0.02	88.94[e] ± 0.02	94.59[e] ± 0.02
100	76.39[d] ± 0.01	91.20[d] ± 0.02	65.31[d] ± 0.03	90.74[d] ± 0.01	89.14[d] ± 0.01	94.83[d] ± 0.02
150	77.63[c] ± 0.03	91.98[c] ± 0.01	75.24[c] ± 0.04	91.13[c] ± 0.01	90.72[c] ± 0.02	95.11[c] ± 0.02
200	80.96[b] ± 0.03	92.17[b] ± 0.01	82.11[b] ± 0.02	91.43[b] ± 0.01	91.81[b] ± 0.01	95.30[b] ± 0.01
250	81.35[a] ± 0.05	92.66[a] ± 0.01	87.46[a] ± 0.11	91.85[a] ± 0.04	91.93[a] ± 0.01	95.58[a] ± 0.02

Values are mean scores ± Standard deviation of three (3) replicates. Mean value with different superscript on each column is significantly different ($p < 0.05$).

DPPH (2,2-diphenyl-2-picrylhydrazyl) free radical scavenging (IC50 value) of awara-date simulated milk powder

The awara-date simulated milk powder DPPH free radical scavenging IC50 value is seen in Table 3. There was significant $p<0.05$ difference in the DPPH IC50 values of all the awara-date simulated milk powder and ranged from 90.50-112.67µg/mL. The simulated milk without date had the highest DPPH IC50 value of 112.67 µg/mL while sample ratio of 75:25 had the lowest value of 90.50 µg/mL.

Table 3: DPPH (2,2-diphenyl-2-picrylhydrazyl) free radical scavenging (IC50 value) of awara-date simulated milk powder

Samples (Awara:date)	DPPH IC50 (µg/mL)
100:0	112.67[e] ± 0.35
75:25	90.50[a] ± 0.50
70:30	107.50[d] ± 0.50
65:35	91.67[b] ± 0.42
60:40	93.67[c] ± 0.31

Values are mean scores ± Standard deviation of three (3) replicates. Mean value with different superscript on each column is significantly different ($p < 0.05$).

Total antioxidant capacity assay expressed as percent inhibition of awara-date simulated milk powder

Total antioxidant capacity assay of awara-date simulated milk powder is shown in Table 4.

The awara-date simulated milk powder with ratio 60:40 had significant $p<0.05$ difference in its percentage inhibition of the total antioxidant in all the concentration levels while some had no significant $p>0.05$ difference (100:0 at 50 and 100 µg/mL; 75:25 at 100 and 150 µg/mL; and 70:30 at 150 and 200 µg/mL) and some had significant $p<0.05$ difference (100:0 at 150-250 µg/mL, 75:25 at 50, 200 and 250 µg/mL; 70:30 at 50, 100 and 250 µg/mL; and 65:35 at 50-150 µg/mL). The total antioxidant percentage inhibition values for the sample ratio 100:0, 75:25, 70:30, 65:35 and 60:40 at concentrations of 50, 100, 150, 200 and 250 µg/mL ranged from 63.50-70.33, 89.40-93.32, 78.13-81.80, 81.28-82.41 and 71.62-80.48%, respectively. The values of the percentage inhibition increased with the increase in the concentration for all the samples. The awara-date sample with ratio 75:25 had the highest antioxidant capacity percentage inhibition of 89.40, 89.70, 89.74, 89.85 and 93.32% at 50, 100, 150, 200 and 250 µg/mL. Awara-date simulated milk powder had the overall highest antioxidant capacity inhibition value of 93.32% at 250 µg/mL, which is higher compared to the highest value of antioxidant capacity inhibition value of 90.48% at the same concentration for ascorbic acid (standard).

Table 4: Total antioxidant capacity assay expressed as percent inhibition of awara-date simulated milk powder

% Inhibition						
Samples (Awara:date)						
Concentration (µg/mL)	100:0	75:25	70:30	65:35	60:40	Ascorbic acid
50	63.50[d]±0.06	89.40[d]±0.02	78.13[d]±0.02	81.28[d]±0.02	71.62[e]±0.02	84.31[e]±0.10
100	63.50[d]±0.31	89.70[c]±0.03	79.12[c]±0.03	81.81[c]±0.10	72.53[d]±0.03	86.88[d]±0.01
150	64.83[c]±0.76	89.74[c]±0.01	80.42[b]±0.07	82.20[b]±0.02	77.04[c]±0.01	88.29[c]±0.13

200	68.23^{b}±0.15	89.85^{b}±0.02	80.43^{b}±0.03	82.37^{a}±0.04	80.14^{b}±0.01	89.57^{b}±0.15
250	70.33^{a}±0.10	93.32^{a}±0.07	81.80^{a}±0.10	82.41^{a}±0.02	80.48^{a}±0.08	90.48^{a}±0.02

Values are mean scores ± Standard deviation of three (3) replicates. Mean value with different superscript on each column is significantly different ($p < 0.05$).

Total antioxidant capacity IC50 of awara-date simulated milk powder

In Table 5 is the total antioxidant capacity IC50 of awara-date simulated milk powder. The awara-date simulated milk powder showed significant difference $p<0.05$ in their total antioxidant capacity IC50 values when compared with the control (100% awara simulated milk powder). Their values ranged from 104.50-250.50 µg/mL. The total antioxidant capacity IC50 of awara-date simulated milk powder increased as the ratio of date increased. However, the 100 percentage awara simulated milk powder had the highest value of 250.50µg/mL and decreased with inclusion of date powder.

Table 5: Total antioxidant capacity IC50 of awara-date simulated milk powder

Samples (Awara:date)	Total Antioxidant Capacity IC50 (µg/mL)
100:0	250.50^{e} ± 0.50
75:25	104.50^{a} ± 0.50
70:30	137.67^{b} ± 0.49
65:35	168.67^{c} ± 0.35
60:40	185.50^{d} ± 0.50

Values are mean scores ± Standard deviation of three (3) replicates. Mean value with different superscript on each column is significantly different ($p < 0.05$).

Fig 1: Packaged Awara-date simulated milk powder

Discussion

Phytochemical composition of awara-date simulated milk powder

The result shown in Table 1 reviewed that the awara-date simulated milk powder had relatively appreciable level of total phenolic, total flavonoids, tannins, saponnins and glycoside. This means that the simulated milk powder may have health benefits such as antioxidant or protective effects. Based on the interpretation given by Ziaul *et al.* (2019) [30], Manyou *et al.* (2021) and Lubria *et al.* (2023) [18] as been plant food with low total phenolic, total flavonoids, tannins and saponins as <500-1000mgGAE/100g, <500-1000mgGAE/100g, <10-20mgTAE/g and <5-10mg/g, it could be said that the ranges of 0.58-0.59mgQE/100g, 0.9-2.07mgQE/100g, 8.83-9.32mg/g and 1.42-3.32mg/g, respectively for awara-date simulated milk powder could be said to be low. This low level of phytochemicals content is an indication of weak antioxidant potential of the produced product. Agugo *et al*. (2025) [1] reported 5.59-9.99g/100g, 1.65-2.72g/100g and 2.95-4.96g/100g for saponins, tannins and flavonoids, respectively in indigenous plant-based powdered beverages from soybean, tigernut, ginger and date blends which is higher when compared with the awara-date simulated milk powder produced except for the tannin content (8.83-9.32mg/100g).

Rahat *et al.* (2022) [23] reported a total phenolic content of 12-34mg/g in soy derivatives extracted with methanol and this value is higher than the value reported. According to Lubna *et al.* (2023) low level of saponins means that it is present but not functionally dominant while Manyou *et al.* (2021) [5] stated that low level of tannins causes mild astringency and antinutritional load.

DPPH (2,2-diphenyl-2-picrylhydrazyl) free radical scavenging activity assay of awara-date simulated milk powder

DPPH is a stable free radical commonly used to evaluate the antioxidant ability of foods. It measures how effectively antioxidants in a sample can donate hydrogen or electrons to neutralize free radicals. High DPPH activity means strong antioxidant capacity with high ability to neutralize free radicals. It shows better functional and health promoting ability.

According to Table 2, the significant difference $p<0.05$ in the percentage inhibition of all the awara-date simulated milk powder at different concentration levels of 50, 100, 150, 200 and 250µg/ml is an indication that the free radical scavenging activity is concentration dependent. Thus, the reason for the percentage inhibition that increased with the increase in the concentration in all samples. The close range between the highest percentage inhibitions of 92.66% for awara-date at 250 µg/ml to 95.58% for ascorbic acid at the same concentration is an indication that the awara-dated simulated milk powder competed positively as it concerns free radical scavenging activity. It was also observed that even at the least concentration of 50µg/ml the percentage inhibition of all the simulated milk powder was all above average, showing the efficacy of the product in inhibiting oxidation.

DPPH is a screening tool for antioxidant potential and is a stable free radical (purple) that turns yellow when reduced by antioxidant (Sagar and Singh, 2011). Its decrease in absorbance indicates radical scavenging ability. According to Moeka *et al*. (2024), Krystyna and Anna (2013); and Fereidoon and Amal (2025), higher DPPH % of inhibition of >60-70% is an indication of strong antioxidant capacity, high ability to neutralize free radicals, indicates better functional and health promising potential, suitable for functional foods and nutraceuticals and usually associated with high phenolic and flavonoids contents; moderate DPPH activity % inhibition of 40-60% shows a moderate antioxidant protection, acceptable functional value and balance between health benefits and sensory quality while low DPPH % inhibition of <40% indicates weak antioxidant capacity, low free-radical scavenging ability, often due to low phenolic and flavonoids content or degradation during processing and more suitable as conventional beverage than a functional one. From the above standards and interpretation, it could be said that the range of DPPH % inhibition in this study (56.45—92.66% for sample ratio 70:30 and 75:25 at 50 and 250µg/ml concentrations, respectively) which falls within the high antioxidant capacity indicating strong antioxidant capacity and thus suitable to be called a functional beverage from plant-based.

DPPH (2,2-diphenyl-2-picrylhydrazyl) free radical scavenging (IC_{50} value) of awara-date simulated milk powder

DPPH IC_{50} measures the concentration of an antioxidant needed to reduce the initial concentration of DPPH radicals by 50%. The significant difference ($p<0.05$) of all the awara-date simulated milk powder as seen in Table 3 revealed that the ability to scavenge free radical at IC_{50} is ratio dependent. The lowest value of 90.50µg/ml (75:25 ratio), highest value of 90.50µg/ml (60:40 ratio- sweetened simulated milk powder) and highest value of 112.67µg/ml (100%- unsweetened simulated milk powder) indicated that A lower IC_{50} values indicates a higher antioxidant capacity, as less substance is needed to neutralize the free radicals

IC_{50} of <50µg/ml means strong antioxidant activity, 50-100µg/ml means moderate antioxidant activity, >100 µg/ml means weak antioxidant activity while >200 µg/ml means a very weak antioxidant activity. Based on the above standard it could be deduced that all the produced awara-date simulated milk powder falls within the 50-100µg/ml range denoting moderate antioxidant activity except the 100% awara simulated milk powder which had 112.67µg/ml and is within the range of >100µg/ml which indicates weak antioxidant activity. It can be seen from the immediate statement that the addition of date did not only sweeten the product but influenced the antioxidant activity positively.

Total antioxidant capacity assay expressed as percent inhibition of awara-date simulated milk powder

Total antioxidant capacity (TAC) refers to the overall ability of all rather than single antioxidant compound in a food sample to neutralize free radicals (Resat *et al.,* 2016) [25]. According to Hermsdorff *et al.* (2011) [13] in epidemiological studies, higher dietary TAC has been linked with lower markers of oxidative stress and lower risk of some chronic diseases. Higher dietary TAC has also shown association with lower risk of mortality and chronic conditions (Nicoletta *et al.,* 2020) it is also important to know that a higher TAC does not automatically translate to better health because bioavailability and metabolism of compound differ *in vivo* (Helmut 2007) [11]. An increase in the values of the percent inhibition with increase in the concentration as seen in Table 4, shows that total antioxidant capacity of the produced simulated milk powder is concentration dependent despite its formulation ratio. According to Maud *et al*. (2006), Refilda *et al.* (2024) and Biswas *et al*. (2021) [5, 21, 24] the total antioxidant capacity expressed as percentage inhibition of >70-90% is high, 50-70% is moderate and <50% is low, respectively. This indicate that when it is high it is of strong free radical scavenging capacity, when moderate- moderate radical scavenging ability and when low- lower free radical scavenging capacity (Saephan *et al.,* 2025) [26]. This means that the total antioxidant capacity expressed as percent inhibition obtained in this study (89.40-93.32% at 250µg/ml concentration) reviewed the simulated milk powder to have high total antioxidant capacity showing a strong free radical scavenging capacity of the product.

Total antioxidant capacity IC50 of awara-date simulated milk powder

The observation from Table 5 showed that the addition of date to the simulated milk powder caused a decreased in the values of the TAC IC50 from 250.50-104.50µg/ml showed that date raised the total antioxidant capacity IC50 of the product. Based on the interpretation given by Fidrianny *et al.* (2015) [9], IC50 <50µg/ml is very strong in antioxidant capacity, 50-100µg/ml is strong in antioxidant capacity (very potent free radical scavenging), 101-150µg/ml is moderate in antioxidant capacity and >150µg/ml is weak and ineffective at scavenging radicals (low free radical scavenging). The IC50 range of 104.50-185.50µg/ml for the awara-date simulated milk powder reviewed the product to having falling between moderate (104.50 and 137.67µg/ml for sample with ratio 75:25 and 70:30) and weak (168.67, 185.50 and 250µg/ml for sample 65:35, 60:40 and 100:0)

antioxidant capacity. The sample with moderate antioxidant capacity IC50 denoted moderate radical scavenging ability of the produced awara-date simulated milk powder with formulation ratio of 75:25 and 70:30 for awara and date, respectively. The 100%awara (unsweetened) simulated milk powder with the IC50 value of 250µg/ml reviewed its inactive antioxidant capacity which showed that the addition of date did not only enhance the taste but also its total antioxidant capacity.

Conclusion

The phytochemical findings showed that the simulated milk samples had relative appreciable level of total phenolic, total flavonoids, tannins, saponins with minimal glycoside content. This means that the simulated milk powder may have health benefits such as antioxidant or protective effects.

The DPPH %inhibition for the sample ratio 70:30 and 75:25 ranged from 56.45-92.66 at 50 and 250µg/ml. This falls within the high antioxidant capacity range and thus suitable to be called a functional beverage. The DPPH IC50 value for all the samples of the simulated milk fall within the 50-100µg/ml showing moderate antioxidant activity except for the 100% awara simulated milk which had 112.67µg/ml showing weak antioxidant activity.

Antioxidant capacity %inhibition ranged from 89.40-93.32 at 250µg/ml concentration which means high total antioxidant capacity, indicating a strong free radical scavenging capacity of the product. The antioxidants capacity express as IC50 ranged from 104.50-185.50µg/ml for simulated milk ratio 75:25 and 70:30, indicating moderate antioxidant capacity and 65:35, 60:40 and 100 showed weak antioxidant capacity. The 100%awara (unsweetened) simulated milk powder with the IC50 value of 250µg/ml reviewed its inactive antioxidant capacity which showed that the addition of date did not only enhance the taste but also its total antioxidant capacity. Conclusively, all the simulated milk formulation competed closely with each other in its antioxidant capacity with the exception of 100% awara simulated milk which had weak antioxidant properties, but sample ratio 75:25 was outstanding in performance as regards antioxidant capacity. Thus, recommended that simulated milk with sample ratio 75:25 which ranked best in the antioxidant capacity at 250µg/ml should be considered.

List of abbreviation

TAC = Total Antioxidant Capacity

Author contributions

Ngozi Eunice Odoh initiated the research idea, design, literature review, supervised data collection and statistical analysis, manuscript writing and submission for review and publication

Ifunanya Cynthia Okpala participated in literature review, methodology sourcing, laboratory data collection and analysis, result presentations and discussion

Chisom Chimdi Ojiabor participated in the literature review, data collection and manuscript preparation

Consent for publication

We the authors give our consent for the publication of the above titled research as an original and not published in another Journal yet

Conflict of interest

All authors declares no conflict of interest

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