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NUTRITIVE ATTRIBUTES OF COCONUT FRUIT JUICE AS ADDITIVE TO YOGHURT

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ABSTRACT
The enhancement of yoghurt quality and nutritional attributes through additives is increasingly important in functional dairy products. This study evaluated the phytochemical contents of coconut fruit juice (CFJ) and its effect on the proximate composition and fatty acid profile of yoghurt. Fresh cow milk was inoculated with standard yoghurt starter cultures (*Lactobacillus bulgaricus* and *Streptococcus thermophilus*) and treated with five CFJ inclusion levels (0, 5, 10, 15, and 20 ml per 100 ml yoghurt) in a Completely Randomised Design. Parameters assessed included physicochemical, proximate, vitamin, and fatty acid properties. Results showed that CFJ is rich in phenols, flavonoids, saponins, alkaloids, glycosides, and anthocyanins, with phenols most abundant. Proximate analysis indicated that moisture and crude protein increased significantly with higher CFJ inclusion, while crude fat, carbohydrate, fibre, and ash decreased ($P < 0.05$). Physicochemical evaluation revealed progressive reductions in titratable acidity and free fatty acids with CFJ addition ($P < 0.05$). These findings suggest that CFJ fortification improves yoghurt's nutritional balance by lowering fat and enhancing protein and hydration, while providing antioxidant phytochemicals with potential health benefits. The 15 % CFJ inclusion level achieved the best balance between nutritional enhancement and product stability. Beyond macronutrient improvement, CFJ incorporation is expected to confer antioxidant protection, improved hydration, reduced fat, and enhanced protein availability, aligning with consumer demand for healthier dairy products. In conclusion, CFJ fortification is a promising strategy for producing value-added yoghurt with improved nutritional quality and functional benefits, with 15 % inclusion recommended as optimal for production and processing.

Keywords: Additive, Nutrient content, Fatty acid profile, Yoghurt, Coconut fruit juice

INTRODUCTION
Yoghurt, a fermented culture of cream, whole milk or skimmed milk with a characteristic bacterial culture of lactic acid bacteria (Tamime & Robinson, 2007) has numerous health benefits associated with its consumption including improved gut health and digestive enhancement due to the pro-biotic bacteria content in it (Selhub *et al.*, 2014). The reduced risk of type 2 diabetes (Gijsbers *et al.*, 2016), decreased blood pressure (Drouin-Chartier *et al.*, 2015) better bone health and reduced risk of osteoporosis (Moschonis *et al.*, 2013), weight management and appetite control (Tremblay *et al.*, 2017) are derived merits of yoghurt consumption. Yoghurt is considered as a nutrition-dense food and a rich source of calcium which provides calcium in its bio-available form (Chandan, 2006). The need to enhance the value of this globally acceptable beverage cannot be over stressed. Earlier studies to improve the value of yoghurt by adding açai (*Euterpe oleracea*) juice and passion fruit (*Passiflora edulis*) peel powder not only enhanced its antioxidant properties but also improved colour stability during storage while extending its shelf life (Coisson *et al.*, 2005; DoEspírito-Santo *et al.*, 2012).

The value addition of yoghurt is a recurring and perpetual necessity. Yoghurt value addition by Coconut fruit juice (CFJ), also known as coconut water appears promising. CFJ is a clear liquid found inside young, green coconut fruits and is a popular beverage and health drink, particularly in tropical regions where coconuts are abundant (Saat *et al.*, 2002; Patel, 2018). Coconut fruit juice contains high sucrose and other nutrient that are suitable for growth of bacteria and yeast; potent for producing pro-biotic drink such as yoghurt. There are numerous health benefits attributed to coconut fruit juice. It is low in calories, fat-free, and rich in several important nutrients and electrolytes, its high moisture content also gives re-hydration (Saat *et al.*, 2002; Palaniswamy *et al.*, 2011). Thus, this study investigated the effects of incorporating coconut fruit juice as an additive to yoghurt in relation toits influence on phytochemicals, fatty acid and nutritive value.

MATERIALS AND METHODS
Preparation of Coconut Fruit Juice (CFJ)
Fresh, young and green coconut fruits were obtained from Ganmo market, Ilorin. They were cleaned, split and the juice in them stored in a bottle and kept in room

temperature. They were transported to University of Ilorin's Main Laboratory where analysis was done.

Phytochemical Composition of the Juice
Different phytochemicals were tested using different methods. Tannins, Flavonoid, Saponins and Alkaloids were determined using Lead sub-acetate test, Aluminum chloride test, Frothing test and Mayer's reagent test respectively (Pius, 2011).

Preparation of Yoghurt
Fresh cow milk from fifty cows at Fulani station in Lajiki village, adjacent to University of Ilorin, Kwara State, Nigeria, was transported to Animal Production Laboratory in an ice jacket to maintain a low temperature and prevent microbial spoilage before processing. The milk was pasteurized for 85 °C for 30 minutes to eliminate pathogenic microorganisms. After pasteurization, the milk was mixed and cooled to 42 °C. The yoghurt starter culture of *Lactobacillus bulgarius* and *Streptococcus thermophilus* were added at a rate of two teaspoons per cup of milk and the specified quantity (0, 5, 10, 15, and 20 ml) of CFJ (according to the treatment plan) was added to and stirred with the rest of the milk. The milk is incubated at 42 °C for 12 hours at a pH 4.5 for the fermentation. The yoghurt was cooled to 4 °C to stop the fermentation process, labelled and placed in a refrigerator. The entire experimental procedure was carried out in triplicate to ensure reliability and statistical validity of results. The method followed the procedure of Aforijiku (2020) with slight modifications to accommodate CFJ inclusion levels.

Yoghurt Parameters Evaluated
These include proximate composition of coconut fruit juice fortified yoghurt, (moisture content, crude protein, crude ash, crude fat, crude fibre and carbohydrate), the Fatty Acid profile and the Total Titratable Acidity. The procedures and subsequent analysis were done in triplicates and the mean value taken for precision. A Completely Randomized Design (CRD) was used.

Table 1: The treatment plan for coconut fruit juice inclusion in yoghurt

Treatment	Coconut Fruit juice (ml/100 ml)
1	0
2	5
3	10
4	15
5	20

Proximate Composition
The proximate composition of the yoghurt samples was determined using the methods of AOAC (2010).

Total Titratable Acidity Composition
The total titratable acidity was determined for all samples according to the Ca 5a-40 method (AOCS, 2004).

Free Fatty Acid Composition
The free fatty acids in the oils were analysed by gas chromatography-mass spectrometry in a device equipped with a Split/Split less injector with an automatic injector.

Statistical Analysis
Data obtained from the quality assessments were analyzed by one-way analysis of variance (ANOVA), and mean differences were separated using Duncan's Multiple Range Test (DMRT) at a 5 % significance level ($P< 0.05$). All statistical procedures were conducted using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA).

RESULTS AND DISCUSSION

Phytochemical Composition
It was observed that phenols, tannins, flavonoids, saponins, alkaloids, glycoside and anthocyanin were present in the coconut fruit juice extract while terpenoids, phlobatanins and steroids were absent. Phenols, anthocyanin and saponins contents were high as shown in Table 2. Earlier studies showed that these phytochemicals are beneficial as anti-aging, anti-inflammatory, anti-oxidant, anti-proliferative, virucidal and antifungal agents **(**Olatunde, 2021). They also contain several anti-oxidant enzymes. Prado *et al*. (2015) and Reddy *et al*. (2018) reported that phenolic compounds contain gallic acid, chlorogenic acid, and ferulic acid which have all been associated with several beneficial antimicrobial properties which makes coconut fruit juice a potent preservative material. Blending of yoghurt with CFJ is expected to confer these benefits to yoghurt.

Table 2: Phytochemical composition of coconut fruit juice

Phytochemical	Status	Value (mg/100 g)
Phenols	+	0.768
Tannins	+	0.299
Flavonoids	+	0.222
Saponins	+	0.315
Alkaloids	+	0.127
Glycoside	+	0.012
Terpenoids	-	0.000
Anthocyanin	+	0.464
Phlobatanins	-	0.000
Steroids	-	0.000

– Absent, + = Present

Nutritive Value
Results of proximate composition of yoghurt with different coconut juice inclusion levels revealed that Yoghurt with 20 ml CFJ inclusion was highest in moisture content, but lowest in crude fat and crude fibre (Table 3). Crude fat and carbohydrate were reduced with increasing CFJ inclusion. The moisture content

values increased when the CFJ inclusion level was increased. Increasing moisture content with the increasing inclusion level shows that there is plenty of water in the coconut juice enhanced yoghurt. The reducing ash content (Table 3) shows that there is reducing volatility present as the inclusion level increases and that the inorganic matter of the sample keeps reducing with the increasing inclusion level. Both crude fat and crude fibre decreased with the increase in the inclusion of coconut juice. The inclusion of coconut juice in yoghurt can potentially lead to an increase in the carbohydrate content of the final product. There are many implications to this, including increased energy content (Yong *et al*., 2009; Chowdhury *et al*., 2022), potential impact on glycemic response (Tan *et al*., 2014), sweetness and sensory values (Faria-Tischer *et al*., 2016) and potential impact on fermentation (Sah *et al*., 2016).

Table 3: Proximate composition of blended yoghurt samples

Sample	Moisture	Ash	Fat	Fibre	CP	Carbohydrate
F_0	86.43±0.162^{d}	0.67±0.019^{b}	2.87±0.015^{b}	0.35±0.005^{b}	2.93±0.095	6.75 ±.0.03^{b}
F_1	86.88±0.005^{a}	0.54±0.095^{a}	2.59±0.014^{c}	0.31±0.002^{a}	2.82±0.005	6.87 ±.0.013^{c}
F_2	87.08±0.027^{bc}	0.60±0.005^{c}	2.52±0.01^{a}	0.30±0.001^{a}	2.87±0.010	6.65 ±0.004^{a}
F_3	87.31±0.011^{b}	0.50±0.007^{d}	2.52±0.005^{a}	0.29±0.002^{c}	2.84±0.009	6.55 ±0.02^{a}
F_4	87.24±0.045^{c}	0.55±0.003^{a}	2.50±0.006^{a}	0.28±0.002^{d}	2.88±0.001	6.56 ±0.05^{a}

F_0: Fresh yoghurt + 0 ml coconut juice inclusion level; F_1: Fresh yoghurt + 5 ml coconut juice inclusion level; F_2: Fresh yoghurt + 10 ml coconut juice inclusion level; F_3: Fresh yoghurt + 15 ml coconut juice inclusion level; F_4: Fresh yoghurt + 20 ml coconut juice inclusion level; C_P: Crude Protein; Means having the same letter in the same column are not significantly different at $p < 0.05$,

Physico-chemical Parameters

Table 4 shows the quantitative analysis of the free fatty acid and total titratable acidity of yoghurt with different coconut juice inclusion levels. It was observed that the treatment with 0 ml (control) inclusion level had the highest mean titratable acidity and free fatty acid values while the lowest values were observed in treatment with 5 ml CFJ inclusion level (F1).

Table 4: Physico-chemical attributes of yoghurt samples

Sample	TTA (% Lactic acid)	FFA (mmol/100g)
F_0	0.181±0.002^{b}	0.173±0.001^{b}
F_1	0.149±0.001^{c}	0.170±0.001^{c}
F_2	0.161±0.002^{a}	0.167±0.002^{d}
F_3	0.160±0.001^{a}	0.163±0.00^{a}
F_4	0.164±0.001^{a}	0.1620±0.001^{a}

F_0 = Fresh yoghurt + 0 ml coconut juice inclusion level; F_1 = Fresh yoghurt + 5 ml coconut juice inclusion level; F_2 = Fresh yoghurt + 10 ml coconut juice inclusion level; F_3 = Fresh yoghurt + 15 ml coconut juice inclusion level; F_4 = Fresh yoghurt + 20 ml coconut juice inclusion level; TTA = Total Titratable Acidity; FFA = Free Fatty Acid; Means having different letters in the same column are significantly different ($P< 0.05$).

Incorporating ingredients like coconut water can have implications for both the nutritional composition of the yoghurt itself and its potential impact on human health, which can include: reduced total fat and saturated fat content (Chowdhury *et al*., 2022), altered fatty acid profile (Faria-Tischer *et al*., 2016), potential impact on nutrient density (Srisuvor *et al*., 2013), potential benefits for weight management (Chowdhury *et al*., 2022), improved cardiovascular health (Faria-Tischer *et al*., 2016) and potential impact on nutrient absorption (Srisuvor *et al*., 2013). Fat content of beverages has become a strong nutritional consideration and the choice of fatty acid profile of yoghurt with coconut water inclusion may vary depending on factors such as the initial milk source, processing methods, and the overall dietary pattern of the individual consuming the yoghurt.

CONCLUSION

The inclusion of coconut fruit juice into yoghurt enhances the beneficial attributes of yoghurt, making the healthy drink food to be healthier. Phytochemicals in coconut fruit juice exerted an immunity enhancer effect to yoghurt and also as anti-oxidants expected to extend the shelf life of yoghurt. The reduction in the fat content of yoghurt when coconut fruit juice is included as an additive makes it wholesome and highly desirable for consumers interested in reduced fat consumption. The inclusion of coconut fruit juice at 15 % level is hereby recommended for enhanced yoghurt properties. Further research should be conducted on reducing the lactose content of yoghurt, thereby making it consumable to lactose intolerant people. The antimicrobial effect of phytochemicals in the blended yoghurt should be studied as well as multiple additive blending of yoghurt with other fruit juices.

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