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THE EFFECTS OF FERMENTATION ON THE NUTRITIONAL AND MEDICINAL IMPROVEMENT OF GREEN AND OOLONG TEA WINE

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ABSTRACT

Purpose: This experiment involved fermentation processes of infusions of oolong and green tea into a low alcohol wine, and the evaluation of its nutritional, total polyphenol, antioxidant and sensory properties.

Design/methodology/Approach: Materials for the oolong wine were obtained from the open market, while green tea was produced from leaves harvested by hand plucking and machine. The wines were produced by yeast fermentation using standard methods. Wines produced were evaluated for nutritional properties and the sensory characteristics were measured.

Findings: Hand plucking of tea leaves seemed to reflect greater protein conservation than wines from tea harvested with machines. This is shown in the significant differences between GTW1 and GTW2 in their protein content, 0.87% for GTW1 and 0.98% for GTW2. The effect of tea type is also reflected in the protein level, as oolong tea contained 1.26% protein, which is higher than the two wines produced from green tea. Significant differences were also found in the percentages of ash, crude fat, pH and total soluble solids; there was no difference in their percentage of alcoholic content and titratable acidity as tartaric acids. Tea type did not have any effect on the percentage of alcohol, which fell within $8 \pm 0.2\%$. Significant differences were found in the caffeine content of the tea wines. The potassium values (K) for OOT, GTW1, and GTW2 also differed significantly at ($p < 0.05$) respectively, while the phosphorous (P) for the wines also varied significantly. Sensory evaluation showed that there were significant differences in attributes of taste, odour, brilliance and general acceptability among the wine samples and the control non-tea processed wines. The taste, colour, brilliance and aroma of the oolong tea was superior to green tea wines, although the green tea wines, irrespective of the method of processing, were not significantly different in any of the attributes evaluated, except in protein content.

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Originality: This study is the first of producing wine from both green tea and oolong tea

Conclusion: This study established that oolong tea wine was higher in protein, caffeine, vitamins A, C, and E, potassium and phosphorous, as well as having greater sensory values than the green tea wines.

Keywords: Oolong, green tea, nutritional, sensory, vitamins, minerals

INTRODUCTION

The production of wines has mostly been reported from grapes (Tofalo et al., 2009; La Jeune et al., 2006; Monk and Cowley, 1984; Martini and Martini, 1990; Mallouchos et al., 2002). There has been much research into alternative raw materials for wine production; many new materials have been used from tropical crops. Notable among wines from tropical fruits were orange (Okunowo et al., 2005), mango (Reddy and Reddy, 2005a, 2005b, 2011), kiwifruit (Towantakavanit et al., 2011; Jang et al., 2007), and loose tea infusions (Aroyeun et al., 2005; Jayasundara et al, 2008). Often the quality of wines produced from all these fruits have been comparable to the quality obtained from grape wines. Tea and herb teas are popular beverages worldwide because of their refreshing and mildly stimulating actions (Hamilton-Miller, 1995). The increase in diversification into the utilisation of tea has necessitated the development of wine from infused black tea (Aroyeun et al., 2005).

Many studies have been undertaken on wine production from grapes and other fruit musts, and several physicochemical analyses have been undertaken.

Wines with other moderately alcoholic beverages have been associated with a reduced risk of cardiovascular disease and other sicknesses because of their antioxidant properties. Substances that perform an antioxidant action are of increasing clinical and nutritional interest (Simonetti et al., 1997); this is because they are capable of neutralizing the harmful effects of free radicals that generally have a very high chemical reactivity (Roberfroid and Calderon, 1995). Foods that have potential or definite antioxidant activities are mainly vegetables and fruits, as well as beverages such as wine, tea and beer. Wine is well appreciated because of its organoleptic qualities, and is also a source of antioxidant substance such as flavonoids (anthocyanins, flavanols, catechins and leucoanthocyanins) and resveratrol (Natella et al., 2001; German and Walzem, 2000). The experiment described in this paper was therefore designed to produce wine from an oolong tea and green tea infusion, using hand plucked tea leaves and machine harvested tea leaves. In this work, therefore, we have reported the effects of both the tea type (oolong and green) and the processing method (hand and machine processing of green tea) on the nutritional, alcoholic, caffeine and sensory profiles of the wine produced from all these materials.

MATERIALS AND METHODS

Source of Raw Materials

Green tea is processed using a standard Chinese method that involved plucking, fixing, rolling and drying. GT1 represented hand processed green tea while (GT2) represented machine processed green tea. Oolong tea (OOT) was kindly provided by Professor Peng Jinguan of the Hunan Tea Research Institute, P.R. China. From the sample, 2g of each was infused in 100ml of water boiled to 86–90^{o}C, then cooled and labelled accordingly and reserved for analysis.

Preparation of Yeast Starter

The starter culture was prepared using 1g/litre of baker's yeast, which was made into slurry with some of the aliquots to be fermented. This was mixed thoroughly into the main portion to which sugar had already been added at 28^{o} Brix sugar level. The fermenting vessel was filled to about a quarter full, plugged with cotton wool with cork through which the fermenting lock was inserted. Following this, 450ppm of sodium metabisulphite, 0.67% ammonium sulphate, and 1g/litre of citric acid were added to the extract. Fermentation was allowed to proceed in the room at a fixed temperature of 30^{o}C for 120 hours in an anaerobic system to avoid fluctuation in temperature.

Maturation of Wine

The fermented liquor was racked into a clean bottle up to the neck and lightly covered with cotton wool. This was allowed to age for about 52 weeks,

during which racking was carried out at intervals of three months at a temperature of 28°C. After six months of storage, physicochemical parameters were carried out in duplicate, and mean values were recorded respectively.

Physicochemical Analysis

The pH was determined using Kent EIL 7020 model pH meter. The pH of the musts was taken at two hour intervals of 24 hours for two-days during the fermentation. Specific gravity and soluble solids were determined at 20°C using a hydrometer and Lombe Abbe refractometer. Titratable acidity as a percentage of v/v citric acid was determined according to standard AOAC (2005) methods. Potassium and phosphorous were determined by atomic absorption spectrophotometer.

Sensory Analysis

A sensory evaluation of the wine was carried out using taste panels from the Cocoa Research Institute of Nigeria, Ibadan. Five different coded samples were presented to the panels. The samples were OOT, GT1, GT2 and reference samples of cocoa wine and apricot wine. Other protocols of the sensory analysis were carried out in accordance with the methods described by Aroyeun et al. (2005).

Results and Discussion

The fermentation process by *Saccahromyces cerevisiae* species has many benefits. Earlier reports have established the formation of nutritionally important vitamins, such as Riboflavin, β-carotene, Thiamine and ascorbic acid during fermentation (Chand and Gopal, 2005). According to Table 1, the proximate composition of the different tea samples showed significant differences, OTW being higher significantly than both GTW1 and GTW2 in the percentage of protein, ash and caffeine, with values of 0.87±0.31 (GTW1), 0.78±0.02 (GTW2) and 1.26±0.21 (OOT) for protein, and 0.75±0.05 (GTW1), 0.71±0.03 (GTW2) and 0.78±0.02 (OOT) for ash, while the caffeine content also varied significantly, with the values obtained being 80.0±0.03µg (OOT), 60.00±0.22µg (GTW1) and 40.00±0.04 µg (GTW2) respectively.

Significant differences also occurred in pH, percentage of crude fat, percentage of titratable acidity, specific gravity, total soluble solids (TSS) and percentage of alcohol (see Table 2). Vitamins C, A

Table 1 Proximate Composition of Tea Wines from Oolong, GTW1 and GTW2

Samples	*% Prot*	*% Fat*	*% CHO*	*% Ash*	*% DM*	*Caffeine*
OOT	1.26±0.01	0.36±0.00	1.62±0.11	0.78±0.03	36±0.12	80±0.03
GT1	0.87±0.31	0.35±0.01	1.22±0.00	0.75±0.05	6.22±0.05	60±0.22
GT2	0.98±0.02	0.44±1.01	1.42±0.09	0.71±0.03	6.19±0.22	40±0.04

± Standard deviation; Prot-protein, CHO-carbohydrate, DM-dry matter
OOT – Oolong Tea; GT1 – Hand Processed Green Tea; GT2 – Machine Processed Green Tea
Source: Devised by author.

Table 2 Some Physicochemical Parameters of Wines from OOT, GTW1, GTW2

Wine	*Specific gravity*	*pH*	*% Total solid*	*% Acidity*	*% Alcohol*
OOT	1.033±0.04	3.20±0.22	6.50±0.5	1.04±0.21	8.0±0.03
GTW1	1.030±0.21	3.40±0.00	5.20±0.02	1.00±0.02	8.2±0.12
GTW2	1.032±0.13	3.25±1.11	6.00±0.04	1.00±0.23	8.0±0.31
Cocoa wine	0.990±0.11	3.70±0.31	5.00±0.22	0.89±0.07	10.0±0.22
Apricot	1.040±0.33	3.10±0.12	9.00±0.01	1.07±0.44	7.0±0.00

± Standard deviation; Prot-protein, CHO-carbohydrate, DM-dry matter
OOT – Oolong Tea; GT1 – Hand Processed Green Tea; GT2 – Machine Processed Green Tea
Source: Devised by author.

Table 3 Effects of Tea Type and Processing Methods on Potassium, Phosphorous, Vitamin C, A and E on Tea Wine

Wine samples	*Vitamin C*	*Vitamin A*	*Vitamin E*	*Potassium*	*Phosphorous*
OOT	13.23±0.03	24.2±0.20	0.08±0.00	9.80±0.11	1.28±0.05
GTW1	10.62±0.02	18.6±0.01	0.03±0.03	7.20±0.01	0.70±0.41
GTW2	12.67±0.02	21.5±0.12	0.06±0.41	9.50±0.21	0.96±0.03

± Standard deviation; Prot-protein, CHO-carbohydrate, DM-dry matter

OOT – Oolong Tea; GT1 – Hand Processed Green Tea; GT2 – Machine Processed Green Tea

Source: Devised by author.

Table 4 Sensory Evaluation of Wine from OOT, GT1 and GT2

Wine	*Colour*	*Taste*	*Brilliance*	*Aroma*	*Overall Acceptability*
OOT	7.2±0.08b	7.0±0.04d	8.4±0.13b	8.7±0.25a	8.2±1.11b
GTW1	7.6±0.01a	7.6±0.21b	8.6±0.01a	8.0±0.01b	8.0±0.03c
GTW2	7.2±0.11b	7.6±0.31b	8.0±0.00c	7.9±0.00b	8.0±0.05c
Cocoa wine	5.4±0.11d	7.2±0.10c	7.61±0.21d	4.50±0.01c	6.80±13d
Apricot	6.9±0.33c	8.1±1.11a	8.1±1.21b	7.8±1.11b	8.7±0.18a

± Standard deviation; Prot-protein, CHO-carbohydrate, DM-dry matter

OOT – Oolong Tea; GT1 – Hand Processed Green Tea; GT2 – Machine Processed Green Tea

Source: Devised by author.

a, b, c…Means along the same column with same alphabets are not significantly different at $p<0.05$

and E also varied significantly ($p<0.05$). The values obtained for vitamin C of OOT, was 13.23±0.02µg/100g, vitamin A, 24.2±0.01µg/100g, and vitamin E of 0.08±0.00µg/100g. GTW1 contained 10.62±0.00µg/100g of vitamin C, 18.60±0.11µg/100g vitamin A, and 0.03±0.00µg/100g vitamin E. GTW2 contained 12.67±0.01mg/100g of vitamin C, 21.5±0.05mg/100g vitamin A and 0.06±mg/100g of vitamin E. The potassium levels of OOT, GTW1 and GTW2 were 9.8±0.11, 7.20±0.01 and 9.5±0.21 respectively, while the phosphorous levels differed significantly and contained 1.28±0.05 for OOT, 0.70±0.41 for GTW1 and 0.96±0.03 for GTW2 respectively.

In this study we established that wines made from green tea plucked using different methods (hand and machine) were significantly different ($p<0.05$) from each other in all the evaluations.

Nutritional parameters were also different from oolong tea wine. Oolong tea wine contained more protein than the two wines produced from green tea. However, this was expected as oolong tea is an example of fermented tea, and earlier reports had confirmed that fermentation had a significant effect on the nutritional and medicinal improvement of fermented tea (Chand and Gopal, 2005). Tea type did not have any significant effect on the percentage of alcohol, which fell within 8.0±0.2% and conformed to the study carried out by Aroyeun et al. (2005) on wine developed from infused tea leaves. The percentage alcohol was higher than those reported by Jayasundara et al. (2008).

This experiment is one of the reported projects involving yeast fermentation to modify the value of tea (Chand and Gopal, 2005). Tea has high levels of phenolic compounds. Various populations consume different fermented tea in which microorganisms, as a consortium, are used for fermentation (Chen and Liu, 2000).

The importance of tea for its nutritional and medicinal values has been reported in the literature (Wu and Wei, 2002; Hamilton-Miller, 1995;

Mitscher et al., 1997; Wei et al., 1999; Yoshizawa et al., 1987; You, 1993), and its harmful effects on health (Hattori et al., 1990; Ohta et al., 2002; Schenker, 2001; Woodward and Tundstall-Pedoe, 1999; Zhang and Kashket, 1998) is well documented. In general, a person drinks two to four cups of tea per day (Graham, 1978; Weidner and Istvan, 1985), 1 cup = 200ml (Hallberg and Hulthén, 2000). If an average of three cups (600ml) of fermented Oolong tea wine and green tea 1 and 2 wine are taken daily, its nutritional improvement is progressive. Daily intake of oolong tea wine provides more vitamin C, A, and E, as well as more potassium and phosphorous than GTW1 and GTW2. The presence of more vitamin A in oolong tea wine indicated the possibility of more iron metabolism in consumers of oolong tea wine than other tea wines. Reports have shown that vitamin A can play a very significant role in iron metabolism. The provision of vitamin A together with iron, however, can reduce anaemia in wine consumers when compared with those who consumed ordinary unfermented beverages (Allen and Casterline-Sabel, 2001).

According to our study, since ascorbic acid (vitamin C) is an essential component of the diet, more vitamin C enhances iron absorption (Cook and Reddy, 2001; Hallberg and Hulthén, 2000) and is important in preventing megaloblastic anaemia of infants (Jacob, 1994); it also reduces stomach cancer (Hemilia and Herman, 1995). Our reports have shown that daily intake of oolong and green tea wine provides more vitamin C than the one reported by Chand and Gopal (2005), who reported 7.8mg vitamin C as a result of fermentation. Our results did not support these findings, probably because the type used by the authors was different from the types used in this experiment: only oolong tea and green tea were used in our study while Chand and Gopal (2005) used black tea. One would have expected changes in their components as a result of different processing methods. The caffeine contents of the tea wines were far lower than the amount reported by Chand and Gopal (2005); this is desirable as earlier reports had shown that it is better to reduce the daily intake of caffeine.

Sensory evaluation results showed that there were significant differences in the attributes of taste, colour, brilliance and general acceptability of the wines and the non-tea processed wines available at the markets. The taste, colour and aroma of the oolong tea wine seemed to be superior to those produced from green tea, although the two wines, GT1 and GT2, were not significantly different in all the organoleptic attributes evaluated.

CONCLUSION

This study established that oolong tea wine was higher in the percentage of protein, caffeine, vitamin A, C and E, potassium and phosphorous as well as good sensory values than the green tea wines (GTW1 and GTW2). Apart from this, the processing of tea wines from machine harvested fresh tea leaves reduced the nutritional values of the wines when compared to wine produced from hand plucked leaves, especially in the percentage of protein content, vitamin C, A and E and minerals such as phosphorous and potassium. However, although the wine processed from hand plucked tea leaves was better in nutritional values than the wine produced from machine harvested tea leaves, it was found that the former is more labour intensive, more costly and has a lower output than the latter, which is faster, cheaper and required fewer people to produce. The option of vitamins C, A and E may be necessary in a situation for the large scale production of tea wine. Tea wine from hand-plucked tea leaves may be appropriate only for home use.

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