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Sensory and Physicochemical Properties of Pasteurized Coconut Water from Two Varieties of Coconut

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Abstract
Coconut water is traditionally consumed fresh and is widely patronized by all and sundry. Storage of coconut water has however become a challenge due to it susceptibility to microbial attack coupled with several biochemical changes that takes place to alter it properties. Pasteurization is a mild thermal process used for fruit juice and beverage preservation. The objective of this study was to investigate the effects of pasteurization on the qualities of coconut water. Coconut water was extracted from two varieties, Malayan Green and Malayan Yellow and each variety was pasteurized at 90^{o}C for 5 minutes, 80^{o}C for 15 minutes and 70^{o}C for 25 minutes. Sensory evaluation was conducted and the most preferred pasteurized sample for each variety was selected. Total soluble sugars (TSS), pH, titratable acidity (TA), total phenols and vitamin C of the most preferred pasteurized sample and the control for each variety were determined. Findings from the study revealed that, panellists mostly preferred the Malayan Green and Malayan Yellow samples pasteurized at 90^{o}C for 5 minutes and 80^{o}C for 15 minutes respectively. A higher TSS of 5.8 ^{o}Brix and pH of 4.78 were recorded for unpasteurized Malayan Yellow sample. The Malayan Green recorded higher values in all the other physicochemical properties analyzed. It recorded 0.14% of TA, 95.15 mg/L for total phenols and 30.18 µg/mL for vitamin C content. Reduction in the properties occurred in pasteurized samples of both varieties. This indicates that pasteurization had a reducing effect on microbes, sensory and nutritional value of coconut water. However, the Malayan Green variety was found to be more stable to pasteurization conditions compared to the Malayan Yellow variety.
Keywords: Malayan Yellow coconut, Malayan Green coconut, pasteurized coconut water, sensory evaluation, physicochemical properties

1. Introduction

The coconut palm (*Cocos nucifera*) is a very important cash crop mostly grown along the coastal belt of Ghana. Coconut cultivation in Ghana is a great source of employment to individuals in the rural areas since it helps in income generation that contributes to the improvement in their livelihood (Adams *et al*., 1996). Ghana produces a total of 224,000 tons of coconut annually from 43,000 hectares of land (Ofori and Nkansah-Poku, 1995). Coconut varieties fall under two broad groups, Tall and Dwarf. Tall and Dwarf coconut types may hybridize to produce intermediate forms. The traditional commercial coconuts are the Tall varieties which are preferred over the Dwarf varieties because of the quality and quantity of copra they produce (Woodroof 1970).

Coconut water is the liquid endosperm of *Cocos nucifera* and is accumulated in large amounts over periods of a year or more in its life cycle. The greatest amount of coconut water is found in young, green coconuts and provides nourishment for the growth of the solid endosperm (coconut meat) inside the hard shell of the fruit (Maciel *et al.*, 1992). When the fruit matures, both the solid endosperm and the remaining coconut water serve as nutrients for the developing embryo and seedling. Thus coconut water serves as a natural reservoir of nutrients to promote tissue growth (Rursegloove, 1992). Coconut water has long been a popular drink in the tropics. It is naturally fat-free, and low in food energy (16.7 calories or 70 kJ per 100 g). A suitable pH, high mineral and sugar contents as well as the sterile nature of coconut water has made it possible for it to be used in intravenous therapy in emergency situations (Campbell-Falcket *et al*., 2000). Coconut water contains a host of nutrients including sugars, sugar alcohols, lipids, amino acids, nitrogenous compounds, organic acids and enzymes (Arditti, 2008), and they play different functional roles in plant and human systems due to their distinct chemical properties. Vitamins, which are essential for the normal functioning of the human body, are also found in coconut water. It contains the B vitamins. The B vitamins are water-soluble and are required as coenzymes for enzymatic reactions essential for cellular function (Depeint *et al.,* 2006). Coconut water is also marketed as a sports drink because of its high potassium and mineral content which helps the body recover from rigorous exercise (Kuberski *et al*., 1979). It has a therapeutic effect by acting as an anticarcinogenic agent (Sylianco *et al*., 1992). Research studies have suggested that coconut water can be used for electrolyte replacement in a wide range of situations.

Coconut water contains many enzymes including acid phosphatase, catalase, dehydrogenase, diastase, peroxidase and RNA polymerase (Jean *et al.*, 2009). It also contains oxidoreductase enzymes; polyphenoloxidases and peroxidases. These enzymes can be inactivated by pasteurization, sterilization and other heat treatment processes (Queiroz *et al.,* 2008). Coconut water is traditionally consumed fresh, directly from the fruit at

production regions. In order to allow its consumption in other regions, its industrialization demands a conservation process able to maintain its physicochemical and sensory properties (Nakono *et al.,* 2012). The water inside the fruit is sterile but when it is extracted and exposed to air, it becomes subjected to quick oxidation and microbial contamination leading to depletion of nutrients and spoilage (Matsui *et al*., 2008).

Pasteurization is a mild thermal process performed below 100 ºC and generally carried out to preserve food through the mechanism of enzyme inactivation and the destruction of relatively heat–sensitive microorganisms. The heating process causes minimal changes in the sensory characteristics and nutritive value of the food (Matsui *et al*., 2008). However, it extends the shelf life of foods for several days or for some months. Pasteurization can be achieved by a combination of time and temperature such as heating at a relatively low temperature and maintaining for a longer time or heating food to a higher temperature and holding it for a short time (Campos *et al*., 1996).The use of adequate pasteurization conditions for preserving coconut water will ensure its shelf-life extension, and consequently lead to the availability of the water at all times. The aim of the study was to investigate the sensory and physicochemical properties of pasteurized coconut water from two varieties of coconut.

2. MATERIALS AND METHODS

2.1 Source of Raw Materials

About 120 fresh coconuts were acquired from a coconut farm in Offinso Nnamon, in the Ashanti Region of Ghana. The coconuts were carefully selected and washed carefully and thoroughly with tap water. Selection criteria for the selection of the fresh coconuts included variety (Malayan yellow and Malayan green), age or maturity (34 weeks to 38 weeks or about 9 months old), absence of defects and uniformity of shell.

2.2 Extraction and Pasteurization of Coconut Water

A stainless steel knife was used to cut a small incision for the extraction of the coconut water. The fresh coconut water was strained using a muslin cloth into a sterilized plastic container. It was then dispensed into sterilized plastic bottles, sealed immediately and then, pasteurized at 90ºC for 5 minutes, 80ºC for 15 minutes and at 70ºC for 25 minutes in water bathes and then refrigerated at 4ºC until required for analyses.

2.3 Sensory Evaluation of Coconut Water

The sensory evaluation was carried out in the Sensory Laboratory of Food Science and Technology Department of the Kwame Nkrumah University of Science and Technology (KNUST), Ghana. The 50 panellists were recruited from students and workers from KNUST as well as patients of the Clinical Analysis Laboratory, KNUST. The panellists assessed the pasteurized and unpasteurized coconut water using the 9 point hedonic scale with 9 representing like extremely and 1 denoting dislike extremely. The acceptability test was used to evaluate samples of coconut water pasteurized at the three different pasteurization conditions mentioned earlier and unpasteurized coconut water as control. The test was performed on both varieties. Panellists were served with the coconut water samples and each labeled with a three digit code. Water was provided to be used as a palate cleanser. Acceptability test was done using a sensory score sheet to evaluate the clarity, aroma, mouthfeel, aftertaste and overall acceptability of the samples. Each panellist was served with 40 mL of each sample.

2.4 Analyses of Pasteurized and Unpasteurized Coconut water

2.4.1 pH and Total Soluble Sugars

The pH was directly measured in triplicates with the Mettler Toledo pH meter (FE 20; GB/T111165). The total soluble sugar was measured with the Reichert Digital refractometer (AR 200) at a temperature of 25ºC in triplicates (AOAC 2000).

2.4.2 Determination of Vitamin C Using the Spectrophotometer

About 0.5 mL of the coconut water was added to 1.5 mL of 10 % trichloroacetic acid (TCA). The mixture was vortexed and allowed to stand for 5 minutes at room temperature. The mixture was then centrifuged at 2000 rpm for 5 minutes. About 1 mL of the supernatant was then added to 0.4 mL of DNPH reagent and incubated at 37ºC for 3 hours. A 1.6 mL of 65 % H_2SO_4 was added and vortexed. The mixture was incubated for another 30 minutes after which the wavelength was read on a spectrophotometer at 520 nm against a reagent blank. A serial standard of 10, 20, 50, 80 and 100 mg/L were also prepared from pure ascorbic acid and treated under the same condition as stated above. The Vitamin C content was subsequently calculated using a Vitamin C standard curve (Benderitter *et al*., 1998).

2.4.3 Determination of Titratable Acidity

Ten (10) mL of the coconut water was pipetted into a conical flask and diluted to about 80 mL with distilled water. About three drops of phenolphthalein indicator was added and titrated to a faint pink end point with 0.1M NaOH solution. The titre value was recorded. The test was done in triplicates. The calculation of the titratable acidity was based on malic acid (Nielsen, 1998).

2.4.4 Determination of Total Phenols

A mass of 20 g of anhydrous sodium carbonate (20% w/v) was dissolved in 80 mL of distilled water and continuously stirred to dissolve. This was topped up with distilled water to give a final volume of 100 mL. A 500 mg of dry gallic acid was weighed and dissolved in 10 mL ethanol in a beaker. This was transferred into a 100 mL volumetric flask and diluted to volume with distilled water. In the preparation of standard curve 0, 1, 2, 3, 5 and 10 mL of the gallic acid stock solution prepared above was placed into separate 100 mL volumetric flasks and then diluted to volume with distilled water to give a standard gallic acid solution of 0, 50, 100, 150, 250 and 500 mg/L respectively. An amount of 0.1 mL of the standard gallic acid was pipetted into a 10 mL volumetric flask and 6.0 mL distilled water added. A 0.5 mL Folin Ciocalteau reagent (2N) was then added. The solution was well mixed and left for 5 minutes after which 1.5 mL of 20 % sodium carbonate solution was added. Finally the solution was topped with distilled water to the 10 mL mark and mixed thoroughly. The resulting solution was then incubated at room temperature for 2 hours. About 0.1 mL of sample or blank (distilled water) was pipetted into a 10 mL volumetric flask and 6.0 mL of distilled water added. This was followed by adding 0.5 mL of Folin-Ciocalteau reagent (2N). It was well mixed and then left for 5 minutes after which 1.5 mL of 20% sodium carbonate solution was added. The solution was made up to the 10 mL mark with distilled water and mixed thoroughly. The resulting solution was then incubated at room temperature for 2 hours after which absorbance readings were taken at 765 nm using Shimadzu UV-VIS 1240 spectrophotometer. Duplicate absorbance readings were taken for each of the duplicate determinations for each sample. The results were expressed as concentration of Gallic acid equivalent (GAE, mg/L) using equation of line of best fit obtained from the standard calibration curve (Spencer *et al.,* 2008).

2.5 Microbiological Analysis

2.5.1 Enumeration of Yeast and Moulds

One milliliter (1 mL) of the sample was pipetted into 9 mL of ringer solution and serial dilutions up to 10^{-6} were made. From the dilutions, 1 mL was inoculated into sterile petri dish and 10 to 15 mL of molten media (malt extract agar) was added, swirled to mix and allowed to set. The petri dishes were then incubated in Gallenkamp Model IH-150 at 25^{o}C for 5 days. The colonies formed in serial dilution 10^{-1} were enumerated using a Colony Counter.

2.6 Statistical Analyses

Mean value and standard deviation were calculated for the results of each test and the sensory evaluation using Microsoft excel. One way analysis of variance (ANOVA) using Statistical Package for Social Scientists (SPSS) was also performed. Tukey's test was used to compare the mean values and establish significance differences at $p<0.05$.

3. RESULTS AND DISCUSSION

3.1 Sensory evaluation of pasteurized coconut water from Malayan Green and Malayan Yellow

The Malayan Green showed significant differences ($p<0.05$) between sample code 575 pasteurized at 70^{o}C for 25 minutes and the other pasteurized and unpasteurized (control) samples when assessed by panellists using the attributes clarity, mouthfeel, aftertaste and overall acceptability as seen in Table 1. In terms of clarity, there was a significant differences between product 575 and the other three samples. Product 575 with the lowest mean score of 5.46 indicate that the panellist neither liked nor disliked the product. The clarity of the control with a mean score of 7.28 indicate that it was the most liked sample. In terms of aroma, there was a significant difference ($p<0.05$) between samples 575 and 807 (80^{o}C for 15 minutes) and the other samples 698 (pasteurized at 90^{o}C for 5 minutes) and 213 (control). The latter samples with a mean score of 6.20 shows that their acceptability by panellists were higher than the samples 575 and 807. There is a small loss of volatile aroma or flavour compounds during pasteurization of juices and this causes a reduction in quality (Fellows, 2000). Hence, under all the parameters evaluated for the Green Malayan variety, the control was not significantly different ($p>0.05$) from the sample pasteurized at 90^{o}C for 5 minutes (698). Therefore, the panellists liked the sample 698 almost as much as they liked 213 (the control). Implying sample 698 was more accepted than 575 and 807.

Panellists stated that sample 213 had the fresh coconut taste, aroma and the sweetest. They also stated it had a nice aftertaste, a crystal clear and attractive clarity. The overall mean score of 5.22 of sample 575 shows that the panellist neither liked nor disliked the product. A few panellists commented that sample 575 tasted good and had a good flavour.

Table 2 shows the sensory properties of pasteurized Malayan Yellow coconut water. It can be seen that panellists preferred the control (fresh unpasteurized coconut water with code 876) over the other samples in terms of all the evaluated properties. Significant differences ($p<0.05$) existed between the sensory parameters of the control and the other pasteurized samples 209, 976 and 621. Sample 876 (control) recorded the highest overall acceptability of 7.20 followed by sample 621 which recorded a mean value of 6.18. Panellists indicated that sample 621 had an appealing aroma, fresh taste and mouthfeel. They also stated that sample 876 was the sweetest, clear,

had a good aftertaste and tasted like natural coconut water. Heating causes caramelization of the sugars which induces a cloudy appearance of the coconut water. Also maillard reactions are initiated during the heating process (Ros-Chumillas *et al.,* 2007) which also contributed to the cloudy or opaque nature of the pasteurized samples. These reactions also altered the aroma, aftertaste and mouthfeel of the coconut water.

Figure 1 shows the overall mean scores of all the samples. It can be observed that, for the Malayan Yellow variety, as the pasteurization temperature increased the overall mean score decreased. Heating process causes minimal changes in the sensory characteristics and nutritive value of foods (Matsui *et al*., 2008). As the temperature increases, the titratable acidity, vitamin C content and phenol composition of the coconut water is depleted. This results in the changes of the sensory characteristics Heat processing of food results in alteration in the components of foods that are responsible for the individual flavour, colour, taste or texture (Fellows, 2000).

In the case of Malayan Green variety, as the pasteurization temperature increased, the overall mean score of the pasteurized samples also increased. The short duration of the pasteurized samples at high temperatures allowed for a less depletion in the nutritional value of the coconut water. Hence, the pasteurized samples of the Malayan Green will depict higher sensory characteristics resulting in the high mean values observed in Figure 1.

3.2 Physicochemical Properties of Coconut Water

The control and the second most accepted samples based on the overall acceptability scores in Tables 1 and 2 were chosen for the physicochemical and microbial analyses. Malayan green pasteurized at 90ºC for 5 minutes (698 or MG 90 ^{O}C) and Malayan Yellow pasteurized at 80ºC for 15 minutes (621 or MY 80 ^{O}C) were chosen.

Physicochemical properties of unpasteurized Malayan Green sample was higher than that of the unpasteurized Malayan Yellow sample except for total soluble sugars. From the results shown in Table 3, the unpasteurized Malayan Yellow (MY), had a higher total soluble sugar (TSS) content compared to the unpasteurized Malayan Green (MG). This agrees with the findings of Raissa *et al*. (2007), who stated high yields of sugar for dwarf yellow varieties. TSS values for both pasteurized and unpasteurized samples of the two varieties were within the TSS average range for tender coconut water ranging from 4.5 to 6.5 ºBrix (Jean *et al*, 2009). MG (90^{O}C) recorded lower pH value than MY (80^{O}C). There were significant differences ($p< 0.05$) between the pH values of all the samples.

After pasteurization, both varieties experienced slight reduction in titratable acidity (TA) and significant decrease ($p<0.05$) in the total phenols. Generally the Malayan Green (MG) had higher values of total phenols than Malayan Yellow (MY). MG (control) recorded 95.15 mg/L of total phenols whilst MY (control) recorded 46.85 mg/L. A reduction in the total phenol content was observed in both Malayan Green and Malayan Yellow coconut water after pasteurization. Significant difference ($p<0.05$) existed between the total phenols of all four samples MG (control), MY (control), MG (90^{O}C) and MY (80^{O}C). Nakano *et al*., (2012) reported changes in some nutritional content of coconut water after being pasteurized at 90ºC for 20seconds. Phenolic compounds, ubiquitous in fruits and vegetables are the most abundant antioxidants in the human diet, and are of considerable interest due to their antioxidant properties (Saci *et al*., 2015). Most phenols are also heat labile (Turkmen, 2005). Heat application reduces or depletes the phenols in coconut water. The decrease in phenols could be attributed to oxidation of these compounds and polymerization with proteins (Liu *et al*., 2014). Also, Klimczak *et al*. (2007) found a decrease in total phenolics in orange juices after storage of the juices at different temperatures ranging from 18 to 38°C.

João *et al*. (2013) reported vitamin C content in coconut of four varieties as ranging 11.30 to 25.80 µg/mL. From the results, unpasteurized Malayan Green dwarf (MG) had the highest ascorbic acid content of 30.18 µg/mL decreasing to 1.65 µg/mL after it was pasteurized for 90°C for 5 minutes. Similarly MY (control) reduced from 19.10 to 3.59 µg/mL. The reduction in vitamin C content could be attributed to its degradation during heat treatment (Bartholomew *et al*., 2003).

3.3 Microbial Load of Coconut Water

Results of the microbial analyses proved that pasteurization produces safe products by reducing the yeast and mould count (YnMC). Unpasteurized Malayan Yellow recorded a yeast and mould count of 840 CFU/mL which reduced to 60 CFU/mL in the pasteurized Malayan Yellow (MY (80ºC). Unpasteurized Malayan Green also recorded 960 CFU/mL which reduced to 70 CFU/mL after it was pasteurized at 90^{O}C for 5 minutes. Moist heat kill microorganisms by causing denaturation of proteins (Boekhout and Robert, 2003). Death rate is directly proportional to the concentration of microorganisms at any given time. Microbiological analyses showed that pasteurization provided safe products of yeast and moulds counting of less than 1.0 x 10 CFU/g.

4. CONCLUSION

For both varieties, Malayan Green and Malayan Yellow coconut water, the control or the unpasteurized samples had the highest overall mean scores. Malayan Green coconut water pasteurized at 90ºC for 5 minutes recorded the highest overall mean score amongst the pasteurized samples of the Malayan Green Coconut water whilst Malayan

Yellow coconut water pasteurized at 80^{o}C for 15 minutes recorded the highest overall mean score amongst the pasteurized samples of the Malayan Yellow Coconut water. Hence, Malayan Green coconut water pasteurized at 90^{o}C for 5 minutes and Malayan Yellow coconut water pasteurized at 80^{o}C for 15 minutes were selected for analysis. Pasteurization reduced the microbial load and also had a reducing effect on the sensory properties and nutritional content of the coconut water. A reduction in the total soluble sugars, Vitamin C, total phenols and titratable acidity (TA) was observed after pasteurization. Though there were increases in the pH of the pasteurized samples of both varieties of coconut water as compared to the unpasteurized samples, there was no significant difference ($p>0.05$) between the values. It could be concluded that, the green variety was more stable to pasteurization conditions compared to the yellow dwarf.

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Table 1.0: Sensory Properties of Pasteurized Malayan Green Coconut Water

Sample	Clarity	Aroma	Mouthfeel	Aftertaste	Overall Acceptability
698(90^{o}C,5mins)	6.26 ± 1.26^{a}	6.20 ± 1.56^{a}	6.38 ± 1.75^{a}	6.38± 2.03^{a}	6.26 ± 1.77^{a}
807(80^{o}C,15mins)	6.14± 1.51^{a}	5.56 ± 1.67^{b}	6.28 ± 1.90^{a}	6.26 ±1.41^{a}	6.24 ± 1.22^{a}
575(70^{o}C,25mins)	5.46± 2.03^{b}	5.42 ± 1.80^{b}	5.18 ± 1.79^{b}	4.52 ± 2.12^{b}	5.22 ± 1.81^{b}
213 (Control)	7.28± 1.18^{a}	6.20 ± 1.16^{a}	6.40 ± 1.59^{a}	5.78 ± 1.58^{a}	6.32 ± 1.43^{a}

Mean values with different superscripts within the same column indicates significant differences ($p<0.05$).

Table 2.0: Sensory Properties of Pasteurized Malayan Yellow Coconut Water

Sample	Clarity	Aroma	Mouthfeel	Aftertaste	Overall Acceptability
621(80^{o}C,15mins)	6.70 ± 1.62^{a}	6.30 ± 1.80^{a}	5.92 ± 2.04^{b}	5.36 ± 2.26^{a}	6.18 ± 1.79^{a}
976(70^{o}C,25mins)	6.62 ± 1.63^{a}	6.12 ± 1.47^{a}	5.84 ± 1.56^{b}	5.86 ± 1.86^{a}	5.96 ± 1.73^{a}
209(90^{o}C,90mins)	6.64 ± 1.44^{a}	5.72 ± 1.82^{a}	4.82 ± 2.06^{a}	4.82 ± 2.02^{a}	5.20 ± 1.74^{a}
876(control)	7.44 ±1.68^{b}	6.98 ±1.29^{b}	6.64 ± 1.64^{b}	6.92 ±1.59^{b}	7.20 ±1.26^{b}

Mean values with different superscripts within the same column indicates significant differences ($p<0.05$).

Table 3.0: Physicochemical Properties of Preferred Coconut Water

Sample	TSS(^{O}Brix)	pH	TA (%)	Total phenols (mg/L)	Vitamin C (µg/mL)
MG(control)	5.63 ±0.06^{b}	4.67 ±0.00^{a}	0.14± 0.01^{c}	95.15±6.01^{d}	30.18±0.75^{c}
MG (90 ^{O}C)	5.43±0.06^{a}	4.81± 0.01^{c}	0.12±0.00^{bc}	68.80±0.85^{c}	1.65±0.33^{a}
MY(control)	5.80±0.10^{b}	4.78± 0.00^{b}	0.11±0.00^{ab}	46.85±2.76^{b}	19.10±0.56^{b}
MY (80 ^{O}C)	5.27±0.06^{a}	4.84± 0.01^{d}	0.10 ± 0.01^{a}	21.60±0.99^{a}	3.59±0.91a

Mean values with different superscripts within the same column indicates significant differences ($p<0.05$)

Table 4.0: Yeast and Moulds Enumeration

Sample	MG	MG(90^{O}C)	MY	MY(80^{O}C)
YnMC (CFU/mL)	960	70	840	60

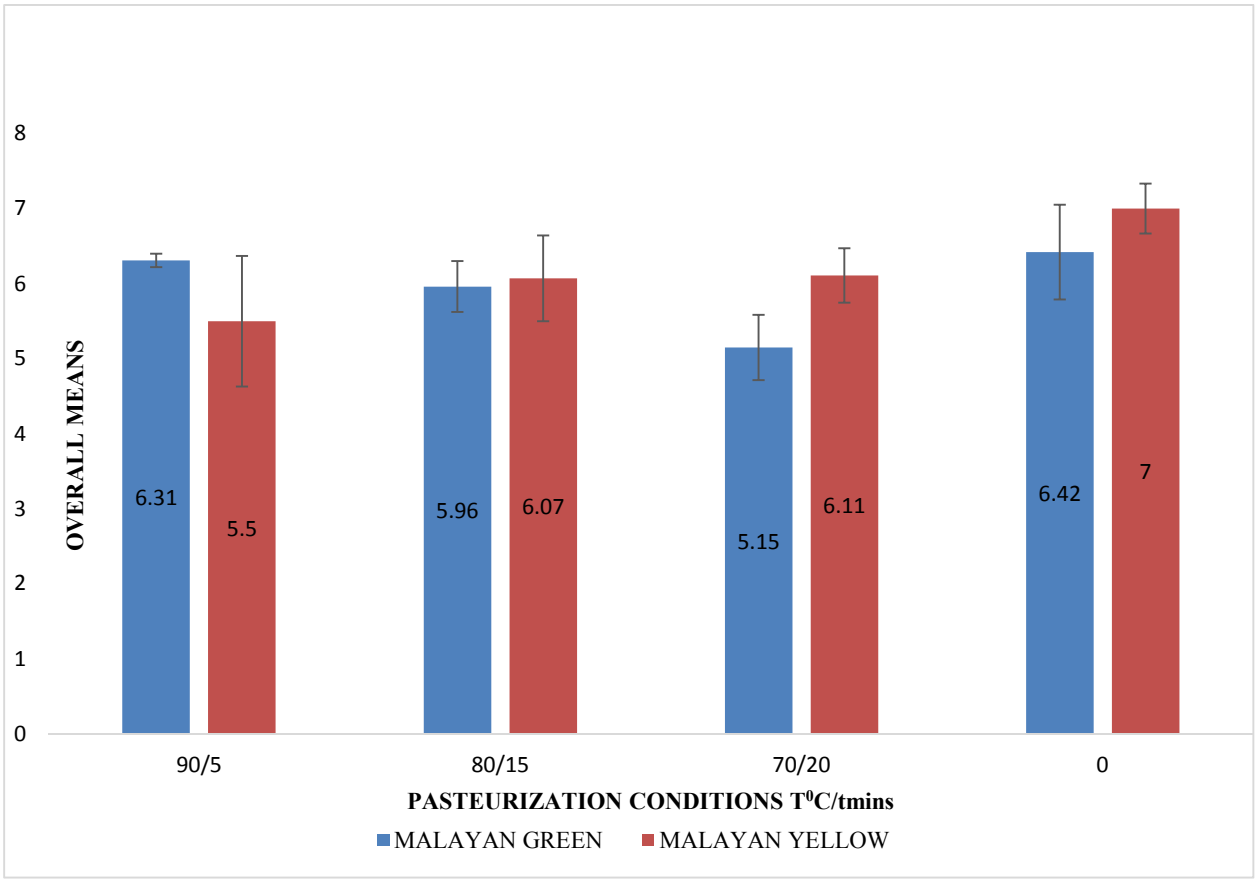

Figure 1.0: Overall Mean Score for Malayan Yellow and Green Varieties