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FDRE TECHNICAL & VOCATIONAL TRAINING INSTITUTE

TECHNICAL AND VOCATIONAL EDUCATION AND TRAINING INSTITUTE SCHOOL OF GRADUATE STUDIES

EFFECT OF BLENDING RATIO OF AVOCADO, ORANGE AND CINNAMON EXTRACT ON QUALITY OF FRUIT JUICE

BY

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MAY/06/ 2026 G.C

ADDISABABA, ETHIOPIA

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A THESIS SUBMITTED TO FDRE TECHNICAL AND VOCATIONAL TRAINING INSTITUTE FACULTY OF AGRO- PROCESSING TECHNOLOGY DEPARTMENT OF FOOD PROCESSING TECHNOLOGY

IN PARTIAL FULFILLMENS OF THE REQUIREMENTS FOR THE AWARD OF MASTER'S DEGREE IN FRUIT AND VEGETABLE PROCESSING TECHNOLOGY

BY

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DECLARATION

I, the undersigned, declared that this thesis is my original work and has not been presented for the award of a degree in any other university, and that all sources of materials used for this thesis have been duly acknowledged.

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This is to certify that the thesis “Effect of Blending Ratio of Avocado, Orange and Cinnamon Extract on Quality of Fruit Juice” is the original work of Mengistu Jorgi, done under my close guidance and submitted for examination with my approval as a FDRE Technical, Vocational and Training Institute advisor.

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LIST OF ABBREVIATIONS

FAOCSD	Food and Agricultural Organization Corporate Statistical Database
USD	United States Dollar
CAGR	Compound Annual Growth Rate
FAO	Food and Agricultural Organization
TSS	Total Soluble Solid
OJ	Orange Juice
GDP	Gross Domestic Product
RSM	Response Surface Method
NaOH	Sodium Hydroxide
TTA	Total Titratable Acidity
DHP	Dynamic High Pressure Homogenization
DCP	2, 6- Dichlorophenol-Indophenol
ACSP	American Chemical Society Publications
PDA	Potato Dextrose Agar
MPN	Most Probable Number
PCA	Plate count agar
DPPH	2, 2-Diphenyl-1-picrylhydrazyl
FRAP	Ferric Reducing Antioxidant Power
PME	Pectin Methyl esterase

ABSTRACT

the present study concentrated on the design of a well-designed blended juice with optimization from avocado (Persea Americana), orange (Citrus sinensis), and extracts of cinnamon (Cinnamomum verum), plus the appraisal of physicochemical, microbial, antioxidant, and sensory properties of the beverage. Using Response Surface Methodology, formulations different in the amount of avocado, orange, and cinnamon were prepared. The physicochemical analysis studied pH and titratable acidity and total soluble solids and vitamin C and color. The research was assessed microbiological quality through total plate count and coliforms and yeast and molds and Staphylococcus aureus count. The research was evaluated antioxidant activity through DPPH testing and FRAPS testing and ABTS testing while sensory evaluation involved by semi- trained panelists. The results of the study showed the control avocado juice pH (6.40) and the optimized juice pH it is in range(3.80-4.50), titratable acidity (0.18-0.58 citric acid mg/100mL), total soluble solids(6.20-12.90°Brix), vitamin C (1.36-2.16 mg/100mL), DPPH (38.5-73.97 %), FRAP(410 - 890 µmol Fe^{2+}*/100 ml), ABTS (42.1- 81.6%), Microbial TPC(1.70-2.10*log_{10} *CFU/ml),CFU(0.75-1.65*log_{10}*CFU/ml),YMC(1.70-2.70*log_{10}*CFU/ml),&Staphylococcus(1.50-2.45*log_{10} *CFU/ml), Sensory evaluation was conducted using fifteen semi-trained panelists who assessed color, flavor, aroma, taste, texture, and overall acceptability using a nine-point hedonic scale, Significant differences ($p < 0.05$) were observed among treatments. Treatment B11T11 composed of avocado, orange and cinnamon extract, garnered the highest overall acceptability due to its balanced flavor, pleasant aroma, taste, higher antioxidant activity, except microbial counts and color parameters in sensory quality. Overall, the avocado-orange-cinnamon juice blends emerged as a functional beverage offering nutritional benefits alongside appealing sensory qualities.*

***Keywords**: Avocado; Orange; Cinnamon; functional beverage; antioxidant property; physicochemical properties; microbiological quality; sensory evaluation, storage stability.*

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1. INTRODUCTION

1.1.Background of the Study

Fruits and vegetables are considered essential components of a healthy diet because of their numerous health advantages (*Slavin & Lloyd, 2012*). (Avocado is classified) as a climacteric fruit and ranks among the most widely consumed fruits worldwide. It offers various health benefits, including aiding in the management of diabetes, preventing heart disease, lowering cholesterol levels, promoting skin and eye health, and assisting in the treatment of osteoarthritis (*Adimas et al., 2024*). Avocado fruits are an excellent source of dietary fiber, potassium, and vitamins B, E, and K, containing 75% monounsaturated fats and 60% of the recommended daily intake of potassium. They are advantageous for managing hypertension, reducing bloating, and regulating blood pressure (*Muzakar & Fudholi, 2019*). Avocado has gained popularity among health-conscious individuals because it is rich in essential nutrients, including beneficial fats, vitamins, and minerals (*Chaudhary et al., 2015)*. Avocado juice is (rich in monounsaturated fats), vitamins, and antioxidants, which can enhance cardiovascular health, aid in digestion, and contribute to overall well-being *(Dreher et al., 2021*). According to research conducted by,(*Jobil et al., 202*1), the energy content of avocado juice varies between 49.06 ± 0.75 and 313 kcal/g, while the protein content is reported to range from 1.36 to 6.13 mg/ml, the dietary fiber content is measured at 1.44 ± 0.74 g/ml, calcium levels fluctuate between 64.11 and 265.15 mg/ml, potassium content spans from 280.11 to 1400.13 mg/ml, magnesium levels range from 19.36 to 97.34 mg/ml, and phosphorus content is found to be between 35.14 and 191.64 mg/ml. Additionally, previous studies have indicated that the juice contains vitamin attributed to the increased incorporation of avocado pulp, along with vitamin K at 70.43 ± 0.01 μg/ml, and ascorbic acid ranging from 6.25 ± 0.23 to 29.69 ± 0.17 mg/ml Worldwide, the annual production of avocados reaches approximately 8.06 million tons. As reported by *t*he Food and Agricultural Organization Corporate Statistical Database

(FAOCSD, 2020), Kenya holds the position of the sixth largest avocado producer in the world *(Nyakang'i et al., 2023*). The avocado (*Persea Americana*) is a widely recognized fruit that is rich in bioactive compounds. Due to its numerous health advantages, the global consumption of this fruit has significantly risen in recent years *(Araújo et al., 2018*). The avocado is utilized in multiple ways and serves diverse commercial purposes across a range of products, such as frozen items, ice cream, avocado oil, guacamole, and cosmetics (*Colombo & Papetti, 2019*).

Citrus (*Citrus sinesis L.*) has been recognized as one of the most significant fruit crops throughout history, serving as an excellent source of vitamin C and possessing substantial antioxidant properties (*Gorinstein et al., 2001*). The sweet orange (*Citrus sinensis (L.) Osbeck)* holds significant importance as the leading species within the Citrus genus, accounting for nearly 50% of the total citrus production globally. This species is cultivated across various tropical and subtropical regions, primarily situated between the latitudes of 35 degrees north and 35 degrees south. According to reported by the *FAO*, sweet oranges are grown on over 3.8 million hectares worldwide, yielding an impressive production of 75.5 million tons *(Ludemann et al., 2024*).

Orange juice holds the title of the most extensively produced fruit juice globally, and its production entails significant costs, in addition to expenses related to its importation and exportation (*Neves et al., 2012*). Given the significant financial investment in the orange juice industry, it is crucial to explore methods that can effectively extend its shelf life. Orange juice is not only widely consumed but also offers numerous health advantages, such as essential vitamins and antioxidants. (Sensory evaluations often indicate a preference) for freshly squeezed orange juice over its processed counterparts, particularly regarding taste and appearance. Consequently, due to the potential loss of nutritional value during processing, there is a strong inclination towards minimal processing techniques for orange juice. To identify optimal minimal processing methods, it is essential to understand the various components of orange juice and their impact on the stability of the product.

Cinnamon is a prized spice obtained from the inner bark of trees in the Cinnamomum genus. The two primary species of commercial importance are Cinnamomum verum, commonly known as Ceylon cinnamon or 'true cinnamon,' and Cinnamomum cassia, referred to as

Cassia cinnamon. This spice is extensively utilized in culinary applications, pharmaceuticals, and cosmetic products, owing to its distinctive flavor, pleasant aroma, and various health benefits (*De Silva et al., 2024*). Cinnamon is primarily employed in the fragrance and essence industries due to its aromatic characteristics, which can be incorporated into a diverse array of food products, perfumes, and medicinal formulations. *(T.-C. Huang et al., 2007*). Cinnamon is mainly grown in tropical and subtropical areas, with significant production occurring in countries such as Sri Lanka, Indonesia, China, Vietnam, and India. Among these, Sri Lanka stands out as the leading exporter of C. verum, whereas China and Indonesia are the primary producers of C. cassia (*Mini Raj et al., 2023*). In 2023, the global cinnamon market was estimated to be worth around USD 1.2 billion, with expectations of a compound annual growth rate (CAGR) of 5.8% from 2024 to 2030, primarily fueled by rising demand in both the food and healthcare industries (Perri & Rocha, 2024).

1.2. Statement of the problems

Ethiopia faces two problems with malnutrition because rural areas have micro nutrients deficiencies while urban areas experience increased obesity rates *(Tsegaye, 2015*). Avocado juice serves as a primary ingredient in food and drink recipes which provides multiple nutritional and functional benefits to recipes that use it. The product contains avocado juice which supplies healthy monounsaturated fats and essential vitamins and minerals and antioxidants that enhance its nutritional value. The product's creamy texture improves drink flavor because it creates a rich smooth texture that eliminates the need for dairy products and artificial thickeners (*Mouritsen & Styrbæk, 2017*). The natural emulsifier properties of avocado juice allow it to stabilize mixtures by preventing them from separating especially when mixed with orange juice and other watery beverages. The creamy flavor of the product works with the acidic taste of citrus fruits to create a flavor combination that maintains balance and delivers a pleasurable experience. The culinary and beverage industry uses orange juice because it provides a lively refreshing taste and natural sweetness which improves the overall flavor of food products. Orange juice contains vitamin C and antioxidants which provide essential health benefits that boost immunity and function as a natural source of energy (*Miles & Calder, 2021*). Orange juice establishes itself as a

fundamental ingredient in culinary and product development through its bright color and refreshing qualities which attract people who want to experience new flavor combinations.

The use of cinnamon extract in juice blends brings value because it provides a distinctive warm spicy taste that enhances the overall flavor profile which creates a more enjoyable drinking experience (*Tamer et al., 2025*). The flavor of cinnamon extract extends beyond its taste because it possesses health advantages which include anti-inflammatory effects and antimicrobial abilities that boost the nutritional content of juice. Urban residents become more cautious about consuming sugary drinks because hepatitis outbreaks occur frequently in Ethiopia (*Yazie & Tebeje, 2019*). The mixture with complete nutritional balance serves as an effective drink option for people living in both rural and urban communities (*Tura et al., 2023*). More than 60% of beverages in Ethiopia are distributed via informal kiosks that lack temperature regulation *(Binge et al., 2023*). The strong spicy slightly sweet taste of cinnamon can overpower the delicate flavors of avocado and orange juice. Ethiopian consumers choose particular flavors because their cultural traditions dictate that they consume traditional spices and citrus drinks which contain kemem and haslamita and their common practice of using cinnamon (qerfa). A drink becomes less appealing to customers when its taste becomes either too spicy from excessive cinnamon or too sour from excessive orange juice. The development of a balanced flavor profile in new products proves essential for success in Ethiopia's expanding juice market among urban youth (*Sarantakou et al., 2023*).

1.3. Objectives of the Study

1.3.1. General Objectives

- The aim of the study is to determine the optimal blending ratio of avocado, orange and cinnamon extract produce juice with improved physicochemical properties, phytochemical composition, microbial quality, antioxidant activity and sensory acceptability.

1.3.2. Specific Objectives

- To evaluate the impact of different blending ratios on essential physicochemical analysis of the juice, phytochemical properties, microbiological analysis, antioxidant properties and sensory quality attributes.
- To determine the blending ratio of avocado pulp, orange juice and cinnamon extracts that maximizes consumer preferences for flavor and aroma while enhancing key health promoting compounds (Vitamin C, antioxidants).
- To conduct a sensory analysis of consumer preferences regarding to color, flavor, aroma, taste, and overall acceptability across different blending ratios.

1.4. Scope of the Study

This study aims to optimize the blending proportions of locally sourced orange juice, avocado pulp, and a commercially available cinnamon extract (extracted with water at a concentration of 1- 2%) to enhance overall consumer preference, increase Vitamin C content, and reduce the cost of raw materials. The blends was formulated using a mixture design, with avocado pulp comprising 20%, 25%&30%, orange juice 53%, 58% &63%, and cinnamon extract at1%, 1.5% and 2%. The physicochemical analyses was involved measuring Brix, pH, Vitamin C content (via titration), and color, while also specifying the exact varieties of oranges and avocados utilized, as different varieties exhibit distinct flavor profiles, Brix levels, acidity, and textures. For instance, fresh oranges and avocados that are readily available in the local market were considered.

1.5. Research Questions on the blended fruit juices results

- What impact does altering the blending ratio of, avocado, orange and cinnamon extract juice having on physicochemical properties, phytochemical composition, microbial quality, antioxidant activity and sensory acceptability?

1.6. Significance of the Study

The careful adjustment of blending ratios for cinnamon extract, avocado pulp, and orange juice is great significance in the fields of food science, nutrition, and product innovation. Cinnamon is well-known for its antioxidant, anti-inflammatory, and blood sugar-regulating effects, whereas avocado offers beneficial fats, dietary fiber, and a smooth texture. Additionally, orange juice, which is abundant in vitamin C and natural sugars, adds acidity, sweetness, and a refreshing taste. Through a methodical examination of their blending ratios, this study aims to create a new functional beverage that optimizes health advantages while maintaining appealing sensory and physicochemical characteristics. The interplay of these ingredients influences essential physicochemical characteristics such as pH, viscosity, browning, and sedimentation (*Bobade et al., 2021*). For example, the antimicrobial properties of cinnamon may contribute to preservation, while the fat content in avocado could affect emulsion stability.

In conclusion, this research enhances scientific understanding by delivering empirical insights into the interactions between plant-based extracts and fruit juices. This investigation connects the fields of nutrition, food technology, and consumer preferences, providing actionable solutions for the creation of healthier, more stable, and commercially successful beverage products.

2. LITERATURE REVIEW

2.1. History and Origin of Avocado

Avocado fruit Originating from Mexico, avocados (*Persea Americana M*.) are cultivated globally in tropical and subtropical climates, where they are highly valued for their rich nutritional profile, which encompasses a considerable amount of oil along with numerous essential vitamins and minerals (*Schaffer et al., 2013*). The avocado ranks as one of the most economically important fruits in the world (*Bost et al., 2013*). Avocado is a type of fruit that continues to mature even after it has been picked from the tree (*Hofman et al., 2003*). Fruits are classified into two groups, non-climacteric and climacteric, according to their ethylene production and respiratory behavior throughout the ripening process (Singh et al., 2013).A climacteric fruit reaches its full maturity while still attached to the tree; however, the ripening process begins only once the fruit has been picked (*Brecht & Yahia, 2009*). To decelerate the ripening process, it is essential to lower the temperature, avoid physical damage, and reduce ethylene production. Non-climacteric fruits, including cashew, pineapple, citrus, strawberry, cherry, and grape, produce little to no ethylene, which does not contribute to their ripening (*Losses & Waste—Extent, 2011)*. The longevity of avocados following their harvest is affected by fungal pathogens, which pose a considerable obstacle to efficient storage and transportation due to postharvest diseases *(Barkai-Golan, 2001*). The primary post-harvest diseases that impact avocados include anthracnose, the Dothiorella/Colletotrichum fruit rot complex, and stem-end rots (*Palou, 2009*). Anthracnose, a disease caused by a fungal pathogen, is generally controlled through the application of fungicides *(Pegg & Brady, 2002*). Ensuring proper hygiene in orchards and maintaining field sanitation by disposing of fallen fruit, along with the removal of dead wood and leaves from trees, are crucial practices for effectively managing anthracnose *(Hartill et al., 1991)*. Various cultivars and rootstocks demonstrate differing degrees of susceptibility to anthracnose, highlighting the importance of taking this aspect into account during the selection process (*Willingham et al., 2001*). Stem-end rot is acknowledged in all areas where avocados are grown; nevertheless, it is not

regarded as being as impactful as anthracnose *(Margetic et al., 2002*). The disease spreads through direct contact, which facilitates the infection of entire batches of fruit.

The study of juice rheology investigates how fruit juice systems flow and change shape which serves as a critical quality indicator for creating improved blended drink formulas (Salehi, 2020). The optimized blended fruit juice developed from avocado (Persea americana), orange (Citrus sinensis), and cinnamon (Cinnamomum verum) extract demonstrates its rheological characteristics through viscosity and consistency and flow behavior which depend on how these ingredients interact with each other. The classification of fruit juices as non-Newtonian fluids arises from their typical pseudoplastic behavior which leads to reduced viscosity when shear rate increases because suspended particles and macromolecules undergo alignment and breakdown from applied force(*Dundar Kirit & Aky\ild\iz, 2022*). Avocado pulp increases viscosity because its lipid content and dietary fiber create thicker liquid while orange juice decreases viscosity through its role as a thinner liquid and cinnamon extract creates small changes to the structural network and stability of the blend. Rheological properties serve as essential factors to establish juice sensory characteristics (mouthfeel and texture) and processing efficiency (pumping and mixing and filling operations) and juice physical stability (resistance against phase separation). The process of understanding juice rheology optimization becomes crucial for maintaining product quality and gaining consumer acceptance and achieving industrial use of functional blended fruit juices *(Salehi, 2020).*

2.2. Avocado Postharvest Chain Management

2.2.1. Harvesting

Fruits should be collected in a manner that prevents mechanical injuries such as cuts, scratches, and abrasions, as these can compromise the aesthetic quality of the fruit and serve as potential entry points for postharvest pathogens that lead to decay during storage and transit (*Kremer-Köhne & Köhne, 1995)***.** Bruising may lead to localized softening. Typically, harvesting techniques involve placing the fruit into a soft picking bag connected to a harvesting pole or directly into a plastic crate to avoid damaging the fruit. For tall trees, harvesting is accomplished using hand-held poles or ladders to reach fruit that is not easily

accessible from the ground. The picking poles should be equipped with a clippers or knife at the end, along with a cloth collection bag. Immediately after harvesting, the fruit should be relocated to a shaded area to minimize weight loss caused by rapid moisture evaporation when exposed to sunlight. It is generally advised that avocados be delivered to the packing facility within two hours of harvesting. While clippers are appropriate for detaching the fruit from the trees, it is advisable to leave approximately 1 cm of the pedicel attached to the fruit.

2.2.2. Field Handling

Following the harvest, it is essential to meticulously transfer the avocado fruit from the picking bag to the field crates to prevent mechanical damage, particularly bruising *(Anjum & Ali, 2004*). Fruits should be kept off the ground to prevent contact with the soil, thereby reducing the risk of contamination from foodborne pathogens like Listeria monocytogenes that may persist in the soil (*Ultee et al., 1999*). Typically, large wooden crates designed to hold around 11 kg of fruit were the favored choice for field containers. It is essential that these containers are not overfilled and are positioned in a shaded location, shielded from direct sunlight (*Allen & others, 1985*). Sun exposure typically raises the pulp temperature, which hastens the ripening process and reduces the fruit's shelf life**.**

2.2.3. Sorting and Grading

In the packing facility, avocados harvested from the orchard are categorized and assessed based on widely accepted quality standards, which include size, skin coloration, and the lack of cuts, wounds, blemishes, insect damage, and pesticide residues. Additionally, once ripened, the fruit should be devoid of diseases such as anthracnose and stem-end rot, as well as physiological issues like grey pulp and vascular browning, along with any bruising *(Ultee et al., 1999*).

2.2.4. Pre-Cooling

It is strongly advised to cool fruit immediately after harvesting to slow down ripening and associated softening(*Johnston et al., 2002*). Pre-cooling is crucial, particularly when field

temperatures exceed 25 °C. Upon arrival, the fruit should be pre-cooled to approximately 16 °C to eliminate field heat.

2.2.5. Packing and Packaging Materials

The utilization of packaging materials results in an increase in the overall cost of the product; however, it often enhances the visual appeal and quality retention of the fruit. Specifically for avocados intended for international markets, the types of packaging and containers differ based on the specific requirements of various packing houses (*Murray & Lopez, 1999)*. It is essential that the packages are adequately ventilated (*Rietveld et al., 2013*). It is important to avoid compression damages on the fruit during storage and transportation (*Hopkins & Thompson, 2002*). Consequently, the packaging must be robust enough to safeguard the fruit, and it is crucial to avoid stacking excessive amounts of fruit on top of one another. Each package should be designed to support a maximum weight of 20 kg, as excessive weight can lead to damage if one box falls onto another. The primary objective during the transportation of fruit should be to minimize losses as much as possible.(Ahmad et al., 2015). In developed nations, the majority of perishable goods are transported under refrigeration. Additionally, many transport systems are outfitted with controlled or modified atmospheres, along with technology that regulates humidity and minimizes vibration. Certain fruits are particularly vulnerable to vibration and abrasion during transit; for instance, soft fruits like ripe mangoes and avocados can sustain significant damage.

One effective method to prevent this issue is to secure the fruit within the packaging and to utilize smaller packages (*Hopkins & Thompson, 2002).*

2.2.6. Storage of avocado

The use of storage conditions containing high concentrations of carbon dioxide and low concentrations of oxygen coupled with low temperatures has proved successful in delaying ripening and senescence in many fruits *(C. Y. Wang, 1990*). Low levels of oxygen decrease overall respiration rate (*Mattoo et al., 1991)*, and also appear to block the ethylene-forming system (*Beyer Jr, 1977*). High carbon dioxide concentrations also decrease ripening, possibly

by acting as a competitive inhibitor of ethylene (*Rhodes, 1981).* A general discussion of the physiology of controlled atmosphere storage has been covered by (*Prange et al., 2011*).

2.2.7. Medicinal and Health Benefits of Avocado

Avocado has several medicinal and health benefits (*Duarte et al., 2016*) The skin of the avocado is used as an antibiotic, for ridding the intestinal tract of parasites, and as a remedy for dysentery (*Guil-Guerrero, 2022*). The seeds are roasted and pulverized for the treatment of diarrhea and dysentery. In the powdered form, the seeds have been used as a dandruff treatment. Pieces of avocado seed are placed in tooth cavities as a toothache palliative. It is recorded that the Amazonian natives used avocado to treat gout. When the pulp of the avocado fruit is added to the diet it helps to reduce cholesterol levels (*Al-Dosari, 2011*). Various studies have confirmed that apart from being a source of energy and vitamins, avocado also delivers specific non-nutritive physiological benefits that may enhance health. It can thus be considered as a "functional food", based on the definition of Mazza *(de la Rosa et al., 2009*). Among the nutraceutical ingredients found in avocado pulp are antioxidants, such as vitamin E or tocopherols (4.31 UI/100 g) and glutathione (17.7 mg/100 g), more than three times the amount in any other fruit). As a source of antioxidants, the vitamin E and glutathione neutralize free radicals that may damage aging cells, the heart (*Owusu, 2012*) and contribute to the development of some types of cancer, such as cancer of the mouth and pharynx *(Owusu, 2012*). Lutein, a carotenoid, helps to protect the eye from diseases such as cataracts and reducing the risk of age related macular eye disorders. Avocados contain a high amount (248 mg/100 g) of lutein (*Owusu, 2012).*The level of β-sitosterol in avocado is similar to that in soy and olives (*Chanioti et al., 2021*).

2.2.8. Orange Fruits and its Nutrient Compositions

Orange is the genus Citrus, belonging to the Rutgenera and 1,300 species. Citrus sinensis (Lemon), Citrus reticulate (tangerine), orange), Citrus medica (Citron), and genus Citrus. Citrus *(Hazarika, 2023*). Citrus are well known as one of the world major fruit crops that are produced in many countries with tropical or subtropical climate. Brazil, USA, Japan, China, Mexico, Pakistan, and countries of the Mediterranean region, are the major Citrus producers.

Citrus fruits and their by-products are of high economic and medicinal value because of their multiple uses, such as in the food industry, cosmetics and folk medicine. Orange juice (OJ) is the most consumed fruit juice in Europe and around the world (Bouwen et al., n.d.) . It is obtained from the endocarp of the Citrus sinensis fruit. Several varieties of oranges are cultivated to make OJ, among which the main ones are Hamlin, Pineapple, Valencia and Pera. Most of the OJ consumed in Europe is imported, primarily from Brazil (79%), but also from Florida (7%), Spain (7%), Italy and Greece (5%) and Mexico and Israel (2%) (Bouwen et al., n.d.). In France in 2013, OJ and nectars represented 47% of the market share (in volume, moving annual total) for fruit juices (all types of products/fruits), among which the majority (90%) corresponded to OJ made from concentrate or not from concentrate (with a fruit content of 100%), while only 10% corresponded to orange nectar (with a fruit content lower than 100%) *(Chanson-Rolle et al., 2016*). OJ contains substantial amounts of several micronutrients such as vitamin C, folate and polyphenols (e.g., hesperidin which is a flavanone) (*Öhrvik & Witthöft, 2008*), and may therefore contribute significantly to their daily intakes. Data obtained from a representative sample of the French population showed that fruit juices contributed to 31% of the daily vitamin C intake of children and to 16% of the daily vitamin C intake of adults *(Braesco et al., 2013*). When applying the market share figures described above, OJ would contribute to 15% of the daily intake of vitamin C for children and adolescents, and 8% for adults. The same data indicated that fruit juices and OJ contributed to 10% and 5% of the daily intake of simple carbohydrates in children, and 5% and 2% in adults, respectively.

Dynamic high pressure homogenization (DHP) is defined by Lacroix and others (Ellerbee, 2009) as a homogenization process where a liquid under high pressure and velocity is pushed through a narrow opening. This process causes physical changes in the product. The authors tested the effects of DHP, using a pressure of 170 MPa, on the inactivation of PME and the stability of orange juice. DHP alone decreased the activity of PME by 20%, but DHP plus a minimal heat treatment of 50°C for 10 minutes decreased the activity of PME by 50-75%. DHP also decreased the particle size of orange juice, and in combination with the decrease in PME, this resulted in a shelf life comparable to that of pasteurized juice. DHP plus the minimal heat treatment had good sensory qualities, and all of these factors led the authors to

conclude that DHP could be an alternative to pasteurization for orange juice processing. If carbon dioxide is added to the headspace of fresh orange juice, an increase in shelf life is seen (*SHOMER et al., 1994*).

The authors tested 10% and 20% carbon dioxide in the headspace of fresh, unpasteurized orange juice. Shelf life at 4°C increased from 15-16 days for fresh juice without carbon dioxide to 25 days with carbon dioxide, and shelf life at 10°C increased from 4-6 days without carbon dioxide to 10-11 days with carbon dioxide. The samples with 20% carbon dioxide in the headspace had very low sensory scores, but the samples with 10% carbon dioxide in the headspace showed no sensory difference from juice without carbon dioxide. These health benefits are as a result of vitamins, especially vitamin C (*Saini et al., 2022)*, phytochemical compounds like liminoids, synephrine, hesperidin flavonoid, polyphenols, pectin. A single orange is said to have about 170 phytonutrients and over 60 flavonoids (Dos *Santos et al., 2024*) .

2.2.9. Post-harvest Handling of Orange Fruits

A variety of advanced technologies are utilized to optimize the post-harvest handling of oranges (*Strano et al., 2022*). These include Cold Chain Management, which employs sophisticated refrigeration systems to sustain ideal temperatures throughout storage and transportation, thereby minimizing spoilage. Additionally, innovative packaging solutions, such as breathable materials and modified atmosphere packaging, play a crucial role in prolonging shelf life by limiting ethylene exposure. Furthermore, automated sorting and grading technologies utilize optical sensors to evaluate size, color, and defects, ensuring uniform quality. Humidity control systems are also essential, as they maintain appropriate moisture levels to avert dehydration and decay. The integration of these technologies can greatly enhance the efficiency and effectiveness of orange post-harvest handling, ultimately improving quality and reducing losses during storage and transport (*Strano et al., 2022*). The major limitations in the postharvest management of horticultural crops in developing countries include ineffective handling and transportation and poor storage (*Betts et al., 2006*). Citrus fruits chilling injury symptoms are surface pitting, and fruit weight loss. Chilling injury symptoms may surface during storage but are more significant after shifting the

commodity to ambient conditions. Chilling injury of the stored produce results in degradation of the cells structures that release metabolites, which encourage microbial growth. Thus, fruits show increase susceptibility to decay when exposed to very low temperature or for extended duration (*Mulas et al., 2007*) . The present study was conducted to assess the response of sweet orange fruits (cv. Blood Red) in cold storage with additional simulate marketing time.

2.2.9.1. Economic Importance of Oranges

Oranges rank among the leading fruit crops worldwide, playing a crucial role in the agricultural GDP of numerous nations (*Mohamed et al., 201*1). Oranges play an essential role in the horticultural industry, offering employment opportunities to millions, including farmers, packers, and distributors. This sector supports both small-scale and large-scale farming enterprises. For many smallholder farmers, oranges serve as a vital source of income, contributing to their financial stability and helping to alleviate poverty through crop diversification (*Öhrvik & Witthöft, 2008*). The conversion of oranges into various products such as juice and marmalade not only creates additional revenue streams but also increases their market value. Furthermore, the export of oranges to a wide range of international markets, including Europe, the Middle East, and Asia, greatly enhances foreign exchange earnings (*S. Huang, 2004*). Enhancing Trade Relations The exchange of oranges has the potential to strengthen economic ties between countries, fostering bilateral trade agreements and collaborations. Promoting Rural Development An increase in orange cultivation can lead to better infrastructure in rural areas, including improvements in roads, storage facilities, and transportation systems. The profits derived from orange cultivation often lead to investments in local communities, thereby improving vital services like education and healthcare. The economic impact of orange farms is significant, as they stimulate local economies by generating a need for ancillary services such as transportation, packaging, and marketing *(Phaleng et al., 2024*). This creates a multiplier effect, where funds spent in local markets are reinvested, thereby benefiting multiple sectors and promoting comprehensive economic development.

2.3. The History of Cinnamon and its Origin

Name Cinnamon, that derivative from a Latin word related to sweet wood, acquired this name from the inner bark which consider the main part of evergreen cinnamon trees. belongs to (*Lauraceae*) family of plant ingdom1.Cinnamon classified as two main varieties *(Gruenwald et al., 2010*).The cassia , which cultivation in Vietnam, and Indonesia. and Ceylon cinnamon, which cultivation in India and Sri Lanka.

Historically, cinnamon has been traded since ancient times, with records from Egypt (*2000 BCE*), where it was used in embalming and medicine. It was highly valued in Europe during the Middle Ages and was a significant commodity in the spice trade. Cinnamon trees are evergreen, growing up to 10–15 meters tall. Key morphological features include: Leaves**,** Bark**,** Flower and Fruit according to (*Britannica & others, 1993*)**.**

The bark of various cinnamon species is one of the most important and popular spices used worldwide not only for cooking but also in traditional and modern medicines. Overall, approximately 250 species have been identified among the cinnamon genus, with trees being scattered all over the world *(Pathirana & Senaratne, 2020*). Cinnamon is mainly used in the aroma and essence industries due to its fragrance, which can be incorporated into different varieties of foodstuffs, perfumes, and medicinal products (*Khunoana, 2011*).

2.3.1. Harvesting Methods and Yield of Cinnamon

Cinnamon is harvested when they are three years old, one year after pruning. Cinnamon bark is harvested twice a year immediately after each of the rainy seasons when the humidity makes the bark peel more easily. The side stems that are about three years old are removed and the bark is stripped off (*Delvaux, 2009*). Cinnamon bark is only obtained from stems that are between 1.2 and 5cm in diameter. The yield varies with type of variety and age. 3-4 year and onwards 62 to 125 kg quills/ha. 10-11 year and onwards - 225 to 300 kg quills/ha. Post-harvest management Cinnamon quills are normally cut into pieces of 10 cm in length and packed into moisture-proof polypropylene bags for sale. Dried cinnamon quills must be stored in Model Project Profile Advancing North East 2 moisture-proof containers away from direct sunlight (*Cox & Kendale, 2004*). If they have absorbed moisture, they should be red dried to a moisture content of 10%.

2.3.2. Traditional Uses

cinnamon is also added to flavor chewing gums due to it smooth refreshing effects and ability to remove bad breath (*Jakhetia et al., 2010*). Cinnamon can also improve the health of the colon, thereby reducing the risk of colon cancer (*GT et al., 2010*) . Cinnamon is a coagulant and prevents bleeding (*Hossein et al., 2013)*. Cinnamon also increases the blood circulation in the uterus and advances tissue regeneration (*Qureshi et al., 2019*). This plant plays a vital role as a spice, but its essential oils and other constituents also have important activities, including antimicrobial (*Chouhan et al., 2017*) ,antifungal *(S.-Y. Wang et al., 2005*), antioxidant(*Gulcin, 2020*) and antidiabetic (*Malviya et al., 2010*) .Cinnamon has been used as anti-inflammatory *(Chao et al., 2005*),antiemetic (*Tung et al., 2010*), nematicidal (*Lan et al., 2012*) , mosquito larvicidal (*Cheng et al., 2004*), insecticidal (*Cheng et al., 2004*), antimycotic, *(Bandara et al., 2012)* and anticancer agent (*Lu et al., 2010*). Cinnamon has also been traditionally used as tooth powder and to treat toothaches, dental problems, oral microbiota, and bad breath (*Aneja et al., 2012*).

2.3.3. Chemical Constituents

Cinnamon is composed of various resinous substances, such as cinnamaldehyde, Cinna mate, cinnamic acid, and a wide range of essential oils (*Senanayake et al., 1978*). It has been reported that the characteristic spicy flavor and aroma of cinnamon are attributed to the presence of cinnamaldehyde, which results from the absorption of oxygen. (*Sangal et al., 2023)* presented a comprehensive overview of the various physiochemical properties of cinnamon, highlighting the existence of numerous essential oils, including trans-cinnamaldehyde, cinnamylacetate, eugenol, L-borneol, caryophyllene oxide, b-caryophyllene, L-bornyl acetate, E-nerolidol, α-cubebene, α-terpineol, terpinolene, and α-thujene (*Tung et al., 2008*).

2.3.4. Economic Importance and Uses of Cinnamon Bark Spices

Cinnamon spice is derived primarily from the stems of the cinnamon plant and is extensively utilized as a flavoring agent and aromatic condiment in both culinary and beverage contexts. It serves as a fundamental component in a variety of dishes, desserts, drinks, and even certain

pharmaceutical formulations (*Alamgir & Alamgir, 2017*). Additionally, cinnamon has a long history of use in traditional medicine, attributed to its potential health benefits, including anti-inflammatory, antimicrobial, and antioxidant properties (*Ranasinghe et al., 2013*). Furthermore, cinnamon oil and extracts obtained from the bark are utilized in cosmetics and perfumes for their appealing scent and possible antibacterial properties, highlighting cinnamon's aromatic attributes as a valuable component in various personal care products. Furthermore, the agricultural sector benefits from cinnamon production, which provides jobs and income for farmers and laborers engaged in the cultivation, harvesting, and processing of cinnamon bark (*Zulelli et al., 2024*).

2.4. Quality Parameters of Fruit Juice

The quality of fruit juice is usually talked about using physicochemical, microbiological, nutritional, and sensory traits, but all of them actually decide if the juice is safe, stable and just likeable for consumers. Physicochemical things typically include pH, titratable acidity (TA), total soluble solids (TSS), viscosity and also color. The pH of fruit juices tends to stay acidic, often between 3.0 and 4.5, and this kind of acidity helps slow down microbial growth and it also supports flavor steadiness, though it is not the only factor. Titratable acidity, which is usually written as (%) citric acid, is linked with perceived sourness and it also hints at how well the juice can resist spoilage. Then there's TSS, measured in (°Brix), it basically shows how much sugar is there and how sweetness is balanced, and in many blended juices it comes out roughly in the 8–15 °Brix zone depending on the recipe.

Nutritional quality is commonly judged through vitamin C levels and total phenolic content , and both of these relate to antioxidant behavior, even so they can decline during processing or storage because oxidation happens. On the microbiological side, it's really about do the important checks like total viable count, yeast and mold, plus coliform bacteria. For safe ready-to-drink juices, the expectation is usually to keep the counts under 10^6 CFU/mL, which is about 6 log CFU/mL, and also make sure pathogens are absent. This is the usual framing as outlined by (on Microbiological Specifications for Foods (ICMSF & others, 2011).

Then there's the sensory quality, the part people notice right away, it covers color, aroma, taste, mouthfeel and overall acceptability. This is usually evaluated by trained, semi- trained

and untrained panelists, or sometimes by consumer tests, and honestly these aspects have a big impact on whether a product sells. In the end, you want a balanced physicochemical composition, a low microbial load, high nutritional value, and sensory features that feel pleasant, so the final fruit juice ends up meeting both what people expect and what international food safety rules require.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The experiment was conducted at Agro-Food Processing Technology Laboratory of FDRE Technical and Vocational Training Institute in Addis Ababa, Ethiopia. The physicochemical and microbial analysis was conducted in the Food Laboratory of Addis Ababa Science and Technology University and antioxidant analysis was conducted at Addis Ababa University 4 kilo campus.

3.2. Raw Materials

The raw materials of fresh avocado fruit and healthy, mature and uniform size fresh ripe sweet orange fruits and cinnamon bark was collected from a supermarket in Addis Ababa or Yeka sub city 02 Keble fruit and vegetable markets, Addis Ababa Ethiopia. The Hass avocado fruit variety was collected just before full ripeness for firmness, flavor, and creamy texture, making them popular for juice production stands from previous study. The total raw materials needed were 10kg of avocado fruit, 15kg orange fruit and 2kg of cinnamon bark spice. Moldy and wound fruits were removed to avoid contamination, changes in color, taste or flavor of the juice. Sugar, distilled water and other ingredients were purchased from shops in Addis Ababa Ethiopia. The samples were transported in cartons to the Federal TVET institute Laboratory for juice formulation, Physico-chemical, microbial, antioxidant and sensory analysis.

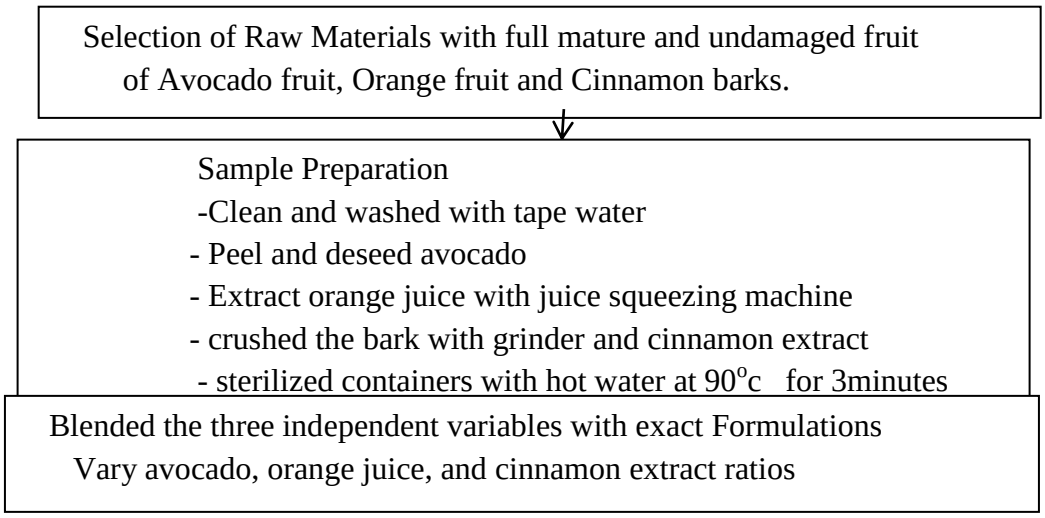
3.2.1. Treatments and Experimental Design

Well-structured Response Surface Methodology (RSM) using Minitab software (version 19.1) was employed. The experiment was having three main factors and three levels. This is the ratio of avocado, orange juice and cinnamon extract, also the experiment was having four treatments with control T0, these are T1, T2, T3, and three replications with a total of 14 experimental units.

Table 1.Experimental Design and Treatment Combinations (14 runs needed with T0)

	Factor 1	Factor 2	Factor 3	Constant ingredients				
Treatment	A:Avocado (%)	B:Orange (%)	C:Cinnamon(%)	Distilled H_20(ml)	Sugar (mg)	Citric acid (%)	NaoH (%)	Rup
T0	100%	0	0	0	0	0	0	3
T1	20.00	62.45	2.00	10	5	0.5	0.05	3
T2	30.00	52.95	1.50	10	5	0.5	0.05	3
T3	25.00	57.95	1.50	10	5	0.5	0.05	3
T4	20.00	63.45	1.00	10	5	0.5	0.05	3
T5	30.00	53.45	1.00	10	5	0.5	0.05	3
T6	25.00	56.95	2.00	10	5	0.5	0.05	3
T7	20.00	62.95	1.50	10	5	0.5	0.05	3
T8	30.00	52.45	2.00	10	5	0.5	0.05	3
T9	25.00	58.45	1.00	10	5	0.5	0.05	3
T10	25.00	57.95	1.50	10	5	0.5	0.05	3
T11	25.00	57.95	1.50	10	5	0.5	0.05	3
T12	25.00	57.95	1.50	10	5	0.5	0.05	3
T13	25.00	57.95	1.50	10	5	0.5	0.05	3

3.2.2. Processing Flow Chart of Blending Ratio of Avocado, Orange and Cinnamon extract Juice.



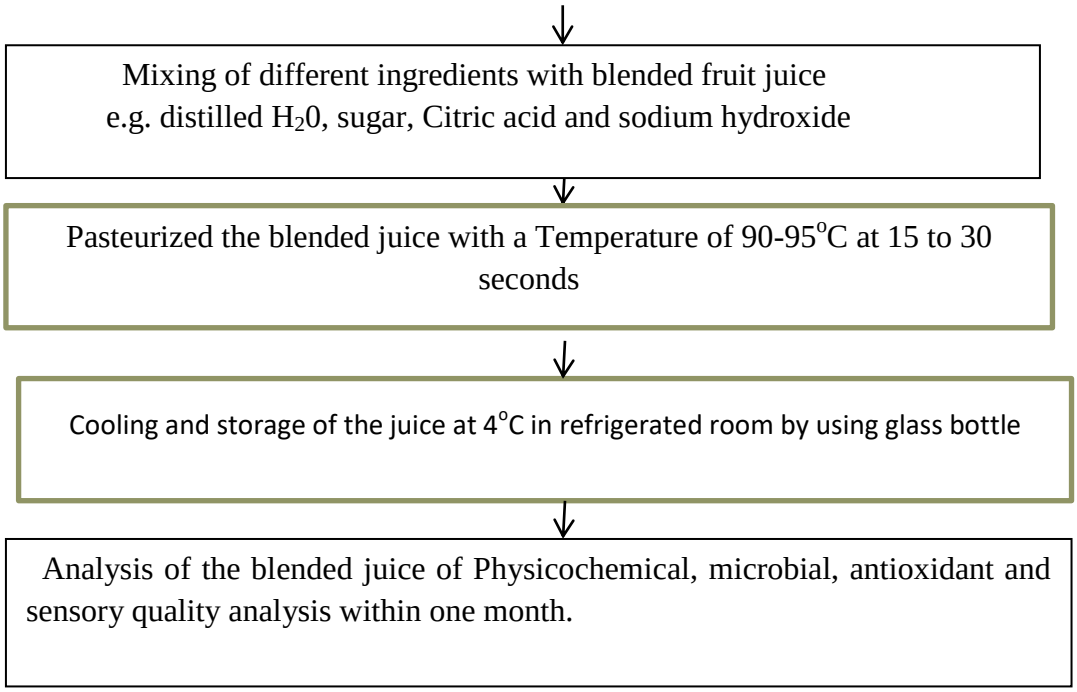


Fig1. Processing Flow Chart of Blending Ratio of Avocado, Orange and Cinnamon extract fruit Juice.

3.2.3. Sample Preparation

The fresh orange and avocado fruit were washed with clean tap water and rinse twice in chlorinated water, then rinse with distilled water. Then they were weighed on an analogue weighing balance (OHAUS, CS200), peel and reweigh *(Mandha et al., 2023*). The orange juices were squeezed/ extracted using an electronic juice extractor (Citrus juicer, CJ625). The clean fresh Hass avocado was peeled and separated from the seed using a stainless-steel knife (G-2 8″ Chef's Knife), and crushed using a lab juicer (AG-8500) to get avocado juice. Another ingredients are Dried cinnamon barks was milled using a lab grinder (Coffee Grinder-120 g, China), the obtaining powder was sieved to pass a 0.5 mm sieve, packing in sealable polyethylene bags, and store at refrigerating temperature (4 ◦C) until the extraction is carried out. Because cinnamon contains numerous volatile aromatic compounds,

particularly cinnamaldehyde, are susceptible to oxidations which are responsible for its distinctive flavor and medicinal properties.

3.3.4. Physico-Chemical Analysis of blended fruit juice

3.3.4.1. Determination of ph of blended fruit juice

The pH was assessed in a ten-milliliter(10ml) sample of juice placed in a beaker, following calibration with phosphate buffers at pH levels of 4.0 and 7.0 (*Adubofuor et al., 2010*).

3.3.4.2. Determination of total titratable acidity (TTA) of blended fruit juice

The titratable acidity of blended juice treated with different concentrations of cinnamon extract was determined by direct titration with 0.1 N NaOH according to *(Ndlela et al., 2022*). Six grams of blended avocado and orange juice treated with different concentrations of cinnamon extract were weighed and transferred into a 100-mL beaker, and 50 mL of distilled water was added, mixed vigorously, and then titrated with 0.1 N NaOH until the endpoint (the first pink color observed) using phenolphthalein as an indicator. Titratable acidity was expressed as a percentage of citric acid. Titratable acidity was calculated using Eq. ([1]):

$$\text{TitratableAcidity (\%)} = \frac{(\text{V NaOH} \times \text{C NaOH} \times \text{milliequivalent})}{\text{Weight of the sample}} \times 100$$

3.3.4.3. Determination of Total Soluble Solids (TSS) of blended fruit juice

The total solids content was determined according to (*Mandha et al., 2023*). Total soluble solids (TSS) were measured at 20 ^{o}C by direct reading on a refractometer *(Abera et al., 2025*).

3.3.4.4. Determination of vitamin C of blended fruit juice

The assessment of Vitamin C levels was performed utilizing the 2,6 dichlorophenol-indophenol (DCP) method as specified by Covenin, with a minor adjustment (*Tiencheu et al., 2021*).

3.3.4.5. Determination of color of blended fruit juice

Colorimeter was used to quantify color attributes using values like L* (lightness), a* (red-green), and b* (yellow-blue) (*Pathare et al., 2013*).

3.3.5. Phytochemical Analysis

The existence of significant classes of antioxidant secondary metabolites, specifically total phenolic contents and total flavonoids, was assessed utilizing standard phytochemical techniques (*Bizuayehu et al., 2016*).

2.3.5.1. Total Phenolic Content (TPC)

The total phenolic contents were assessed using the Folin-Ciocalteu reagent method.
The total phenolic content was represented as GAE (Gallic Acid Equivalents), *(Kaur et al., 2014).*

2.3.5.2. Total Flavonoids

This process was carried out following the technique specified in *(Pérez-Palacios et al., 2008).* A volume of five hundred microliters (0.5 mL) of juice was mixed with 2 mL of methanol, and subsequently, 1 mL of concentrated sulfuric acid was added. A spatula was serving to incorporate a powder of magnesium chloride (MgCl2), and the resulting mixture was observed for 1 minute for effervescence and for the appearance of a brick red hue.

3.3.6. Antioxidant Activity

Antioxidants are substances that assist in inhibiting oxidation, a chemical process that may generate free radicals and result in cellular damage (N. Sharma, 2014).They are essential in safeguarding the body against oxidative stress, a condition associated with numerous health problems, such as heart disease and cancer (*Pizzino et al., 2017*). Antioxidants are naturally present in various foods, especially in fruits and vegetables that are high in vitamins A, C, and E.

The antioxidant capacity of the blended mixture that includes avocado, orange, and cinnamon extracts juice was assessed through three well-established assays: DPPH (2,2-diphenyl-1-picrylhydrazyl), ABTS (2,2'-azinobis-(3-ethylbenzothiazoline-6-sulfonate), and FRAP (Ferric Reducing Antioxidant Power).

3.3.6.1. DPPH (2, 2-Diphenyl-1-picrylhydrazyl) assay

The DPPH assay was evaluated the capacity of antioxidants to neutralize free radicals.
In this investigation, the mixture demonstrated a notable decrease in DPPH radical levels, signifying a robust radical scavenging capability (*Tsimogiannis et al., 2017)*.
This implies that the synergistic effect of the bioactive compounds derived from avocado, orange, and cinnamon enhances the antioxidant potential of the mixture.

3.3.6.2. ABTS (2, 2'-Azinobis-(3-Ethylbenzothiazoline-6-Sulfonate)) assay

The ABTS assay assesses the antioxidant capacity by quantifying the ability to neutralize the ABTS radical cation.
The optimized extract blend exhibited a significant scavenging effect on ABTS radicals, similar to that of standard antioxidants.
This underscores the efficacy of the blend in neutralizing both hydrophilic and lipophilic radicals (*Su et al., 2024*).

3.3.6.3. FRAP (Ferric Reducing Antioxidant Power) assay

The FRAP assay assesses the reducing power of antioxidants by their ability to reduce Fe (III) to Fe(II), (*Berker et al., 2007*). The extract blend demonstrated a significant enhancement in its reducing power, indicating its ability to donate electrons and counteract free radicals. This characteristic is essential for safeguarding biological systems against oxidative stress.

3.3.7. Microbial Analysis of blended fruit juice

Optimization blending juice was treated with different ratio of cinnamon extract, avocado pulp and orange juice was examined for microbial analysis such as total plate, total coliforms, yeast, and mold count.

3.3.7.1. Total plate Count bacteria on blended fruit juice

The total viable count was established using the pour plate method as according to (*Terrones-Fernandez et al., 2023*). A serial dilution (10-1, 10-2, 10-3, and 10-4) of the treated juices was prepared, with 1 mL aliquots added to each of the triplicate petri dishes. Plate count agar (PCA) was introduced into each petri dish and incubated at 35 ◦C for 48 ± 2 hours, after which colonies was enumerated using a colony counter, and the results were reported as CFU/ml.

3.3.7.2. Total Coliform Count bacteria on blended fruit juice

The Most Probable Number (MPN) of total coliform bacteria was assessed using the multiple tube fermentation technique as according to (*Shah et al., 2023*). A volume of 1 mL from the previously prepared 10-^{1}, 10^{-2}, and 10-^{3} dilutions was introduced into three replicate tubes, each containing 10 ml of lactose broth along with inverted Durham tubes, and then incubated at a temperature of 35 ±0.5 ◦C for duration of 24 ±2 hours. Following the inoculation process, the tubes were inspected for signs of gas production or turbidity at the conclusion of the 24-hour incubation period.

3.3.7.3. Yeast and Mold Count of blended fruit juice

A yeast and mold count was conducted in accordance to (*Xu et al., 2021*). A volume of twenty-five mL of treated juice was prepared, followed by a series of dilutions (10–1 to 10-^{4}). A one mL sample from each dilution was inoculated onto Potato Dextrose Agar (PDA).
The Petri dishes containing the inoculated samples was incubated at a temperature of 25 ◦C for a duration of 5 days, after which colonies was enumerated using a colony counter (Microprocessor Colony Counter 6 Digit 043-G, India), and the results were reported as yeast and mold per ml.

3.3.7.4. Staphylococcus Count

The Staphylococcus count denotes the quantification of Staphylococcus bacteria found in a sample, which is frequently utilized in food safety, medical diagnostics, and microbiological research (*Kadariya et al., 2014*). Staphylococcus aureus, a prevalent species, is typically present on the skin and within the nasal passages of healthy people; however, it has the potential to lead to infections if it grows excessively.

In laboratory examinations, blood cultures along with various microbiological techniques are employed to ascertain the presence and quantity of Staphylococcus bacteria. Elevated levels could suggest the presence of an infection or contamination, necessitating additional analysis and potential treatment (*Grabe et al., 2012*).

3.3.8. Storage Stability of the Juice at 4^{o}C in Refrigeration Temperature

The standard pasteurization conditions for all treatments (including mixtures such as avocado–orange–cinnamon juice) generally follow well-established thermal processing regimes used for acidic beverages. High-Temperature Short-Time (HTST) pasteurization represents the main method used for juice processing because it requires juice heating to specific temperature ranges of 95 °C during a 15 to 30 second time period which depends on juice type and composition. Industrial applications use Ultra-High Temperature (UHT) processing at 135 to 150 °C for time duration of 2 to 5 seconds to achieve extended product shelf life, although this process causes minor sensory changes according to *(Chavan et al., 2011)*. HTST conditions which operate at 95 °C for 15 to 30 seconds serve as the standard method for blended fruit juices because they establish balance between microbial safety and shelf stability and physicochemical and sensory quality preservation.

To increase the storage stability of juice at 4^{o}C in refrigerated storage shelf life of about 2 to 4 weeks (*Alim et al., 2023*).

3.3.9. Determination Sensory Evaluation Analysis

A group of fifteen (15) semi-trained panelists, consisting of both BSC degree &MSC degree students from the Agro-Food Processing Technology faculty at the FDRE TVET Institute in Ethiopia, engaged in a sensory analysis of the optimized blended juice samples. The assessment involves analyzing the color, aroma, flavor, texture, taste, and overall acceptance of optimized blended juice produced with varying ratios of avocado, orange, and cinnamon extract. The sensory evaluation was conducted in accordance with established protocols (Arilla et al., 2023). The assessment of these attributes were carried out using nine (9)point hedonic scale, by 15 semi- trained panelists from the MSC and BSC Students at technical and vocational education and training institute. The panel, consisting of 15 male nonsmokers aged 25 to 35, evaluated blended juice samples coded with three-digit numbers. Each panelist received water for rinsing between samples before testing next samples and score sheet for recording ratings on color, aroma, taste, flavor, and overall acceptability. Which facilitates the evaluation of different characteristics from ‘extremely like' (9) to ‘extremely dislike' (1). The scale includes intermediate levels such as' very much like' (8) 'much like' (7), 'like' (6), 'slightly like' (5), 'slightly dislike' (4), and 'dislike' (3),'much dislike' (2).

3.3.9.1. Forms of Sensory Evaluation Product Analysis Acceptability Test

Table2. Sensory Evaluation Questioner formats

<table>
<tr><td colspan="7">Name of panelist: product name : Quality of fruit juice</td></tr>
<tr><td colspan="3">Panelist NO: 15</td><td colspan="4">Date:07/05/2018E.C</td></tr>
<tr><td colspan="7">Instruction: Please taste the sample and check out how much you like or dislike. Use the appropriate scale to show your attitude by giving the point that best describe you’re feeling about the sample</td></tr>
<tr><td>Hedonic Score</td><td colspan="6">Quality attributes</td></tr>
<tr><td>9- Extremely Like</td><td>Color</td><td>Flavor</td><td>Aroma</td><td>Taste</td><td>Overall Acceptability</td><td>Sample code</td></tr>
</table>

8-Verymuch-Like						
7-much Like						
6-like						
5-likeSlightly						
4-Dislikeslightly						
3 Dislike Moderately						
2-DislikeVery much						
1- Extremely Dislike						

Comments/suggestion……

…….

Panelist signature_____

3.3.9.2. Data Analysis

A well-structured Response Surface Methodology (RSM) used Minitab Software version 19.1 was employed and used General linear models (GLM).

4. RESULT AND DISCUSSION

4.1. **Physicochemical analysis result of blended fruit juice**

Physicochemical characteristics of avocado-orange-cinnamon extract optimized blended fruit juice are showed on the table 3. All measured parameters (pH, titratable acidity, total soluble solids, and vitamin C) revealed marked variations between the treatments ($p < 0.01$) indicating that different formulations had great effects on juice quality.

Table 3. Physicochemical analysis of optimized blended fruit juice.

Trt	Ph	TA (%)	TSS (°Brix)	Vit. C (mg/100 ml)
B0T0	6.40 ± 0.05^{a}	0.18 ± 0.01^{g}	6.20 ± 0.15^{j}	0.31 ± 0.02^{j}
B1T1	4.40 ± 0.04^{bc}	0.42 ± 0.02^{cdef}	9.80 ± 0.21^{i}	1.43 ± 0.06^{hi}
B2T2	4.30 ± 0.04^{cd}	0.38 ± 0.02^{ef}	9.40 ± 0.18^{i}	1.36 ± 0.06^{i}
B3T3	4.10 ± 0.03^{ef}	0.58 ± 0.03^{a}	12.60 ± 0.30^{ab}	2.08 ± 0.08^{ab}
B4T4	3.90 ± 0.03^{gh}	0.46 ± 0.03^{bcd}	11.20 ± 0.25^{efg}	1.74 ± 0.07^{def}
B5T5	4.20 ± 0.04^{de}	0.41 ± 0.02^{cdef}	10.80 ± 0.20^{gh}	1.61 ± 0.07^{efgh}
B6T6	4.00 ± 0.03^{fg}	0.44 ± 0.02^{bcdef}	11.60 ± 0.27^{def}	1.82 ± 0.08^{cde}
B7T7	4.50 ± 0.05^{b}	0.39 ± 0.02^{def}	9.60 ± 0.19^{i}	1.47 ± 0.06^{ghi}
B8T8	4.10 ± 0.03^{ef}	0.47 ± 0.03^{bc}	11.00 ± 0.22^{gf}	1.68 ± 0.07^{defg}
B9T9	4.30 ± 0.04^{cd}	0.37 ± 0.02^{f}	10.10 ± 0.24^{hi}	1.51 ± 0.07^{fghi}
B10T10	3.90 ± 0.03^{gh}	0.45 ± 0.03^{bcde}	12.10 ± 0.28^{bcd}	1.99 ± 0.08^{abc}
B11T11	3.80 ± 0.02^{h}	0.51 ± 0.03^{ab}	12.90 ± 0.32^{a}	2.16 ± 0.09^{a}
B12T12	$4.00 \pm 0.03f^{g}$	0.50 ± 0.03^{b}	11.60 ± 0.26^{cde}	1.90 ± 0.08^{bcd}
B13T13	3.90 ± 0.03^{gh}	0.47 ± 0.02^{bc}	12.40 ± 0.29^{abc}	2.03 ± 0.08^{abc}

Notes: Values are expressed as mean ± standard deviation. Means within the same column followed by different superscript letters are significantly different ($p < 0.05$), according to Tukey's HSD test.

4.1.2. PH

According to the results of the Physico-chemical analysis on (Table 3), the pH value ranges from 3.80 to 4.50 for a blended juice and 6.40 of control samples. (*Priecina & Karklina 2015*), increasing cinnamon extract concentration and orange juice concentration decreased pH value and increased titratable acidity due to the naturally occurring organic acids to reduce microbial load and increased storage life when compared to control samples. Within the range accepted for vegetables and fruit juices of 2 to 5 as reported by (*Li et al., 2012*), conversely again; all blended formulations are significantly lower in pH due to the introduction of orange juice, which contains quite large proportions of organic acids and particularly citric acid that, in turn, makes the final product more acidic. Among the blended juices, formulations that contain the highest amounts of orange juice exhibited a significantly low pH value ($p < 0.05$) while treatments B4T4, B10T10, B11T11, and B13T13 showed pH values that fall within (3.80-3.90). These overall results showed pH values in the range of fruit beverages where pH ranges from 3.5 to 4.5, which is essential for microbial safety and stability of the product. Treatments with intermediate pH values (approximately 4.0-4.3) did not differ significantly ($p > 0.05$) from each other and are considered optimal to achieve balance between acidity and palatability. The high pH obtained in treatment B7T7 (4.50 ± 0.05) indicates a lower contribution of acid, which can enhance smoothness in the taste; however, it may slightly compromise microbiological stability of the product. Above, it states that the control sample pH would be the highest of all the samples. All the other samples, including those from B4T4, B10T10, B11T11, and B13T13 which were mixtures of avocado and orange juice, also recorded a decrease in ph. This decrease is due to high, naturally occurring organic acid content in orange juice, increases acidity, and improves microbial stability (Igual et al., 2010). Such trends have also been reported for blended citrus-based beverages.

4.1.3. Titratable Acidity (TA)

The study demonstrated that titratable acidity (TA) of the optimized blended fruit juice formulations containing avocado, orange, and cinnamon extract showed significant differences across treatments ($p < 0.05$). The mean values varied from 0.18 ± 0.01% in the control sample (B0T0, 100% avocado) to 0.58 ± 0.03% in treatment B4T4 as shown in (Table2). The notably lower TA in the control sample is indicative of the naturally low acid content found in avocado pulp. In contrast, the higher TA values in the blended treatments can be largely attributed to the addition of orange juice, which is high in citric acid (*Igual et al., 2010).* Furthermore, the observed gradual increase in TA with a higher proportion of orange juice suggests a direct and significant influence of the formulation on the acidity of the juice. In previous research conducted by (*Tiepolo et al., 2000*) my studies are similar to this work. All blended juice treatments (B1T1–B13T13) showed TA values that fails within the acceptable range for blended fruit juices (0.30–0.60%), suggesting that the formulations were organoleptically acceptable and met juice quality standards. Treatments with moderate acidity levels (around 0.38–0.46%) did not show significant differences from one another ($p > 0.05$) and are anticipated to deliver an optimal sensory balance between sweetness and acidity.

4.1.4. Total soluble solids (TSS)

The TSS content of the optimized blended juices from avocado-orange-cinnamon varies amongst the different treatments and was significantly different ($p < 0.05$). Among the different treatments, indicating that the formulation is quite critical with respect to the amount of soluble sugar. The control sample (B0T0, 100% avocado) had the lowest TSS value (6.20 ± 0.15 °Brix), which mirrors the fact that avocado pulp has very low sugar content. Conversely, the blended formulations had significantly higher TSS values ($p <0.05$): ranging from 9.40 - 12.90 ± 0.32 °Brix, due to the addition of orange juice which provides natural sugars like sucrose, glucose, and fructose *(Govind & Po, 2019).* Treatments that incorporated more orange juice exhibited greater TSS values ($p < 0.05$), with the highest TSS level recorded at 12.90 °Brix for B4T4, B10T10, B11T11, and B13T13, Such values are still well within the limits as applicable for fruit-based beverages and are related to sweetness

enhancement and preference by consumers. Moderately TSS values formulations (around 10.8-11.6 °Brix), showed no significant differences from one another ($p > 0.05$) which means similar contributions of sugar and blending effectiveness among these treatments. The addition of cinnamon extract did not have a significant effect on TSS as it adds very minimal soluble solids compared to those contributed by the fruit components(*Adimas et al., 2024*). This increase in TSS in the blended formulations shows that mixing avocado with orange juice has the potential for improving sweetness and flavor quality. The synergistic action of elevated TSS and balanced acidity may also have contributed to the overall sensory appeal of the juices so that blended formulations were judged nutritionally and organoleptically superior to the control, which was avocado only(*Tiepolo et al., 2000*).

4.1.5. Vitamin C Content

In this finding the Control sample shows very low vitamin C measurements (0.31 ± 0.02), supporting the idea that avocado is not a good source of vitamin C. On the other end, blended samples displayed a very high concentration of vitamin C between 1.36 ± 0.06 and 2.16 ± 0.09. Highest vitamin C values (2.16 ± 0.09) were recorded in formulations with higher levels of orange juice, while intermediate blends showed moderate values (approximately 1.5-1.9). To be brief, vitamin C content was consistently affected by different treatments showing very significant pronouncement on formulation effect ($p < 0.05$). Treatments with higher orange juice proportions (notably B4T4, B10T10, B11T11, and B13T13) consistently demonstrated lower pH, higher titratable acidity, increased TSS, and enhanced vitamin C content, placing them in superior post-hoc groups across most parameters. These formulations offer improved nutritional quality, sensory balance, and potential shelf stability, making them promising candidates for functional beverage development

Increase of vitamin C in blended juices could primarily be due to the high ascorbic acid nature of orange juice (*Kujawińska et al., 2022*). With increasing orange juice, the level of vitamin C increased predominantly, thus favoring the correlation between formulation and nutrient content. Cinnamon was added in small amounts; however, it may have indirectly supplied other antioxidant compounds aiding vitamin C against oxidative degradation (*Shahid et al., 2018*). The lesser value observed in the control group reflects the vitamin C

nutritional deficiency of juice obtained from avocado alone (*Jobil et al., 2021*). The results suggest that blending avocado juice with orange juice and cinnamon enhances the nutritional status, particularly with respect to vitamin C, and consequently improves the functional and health benefits offered by the product.

Table 4. Color Characteristics of Blended Fruit Juices

Treatment	L* (Lightness)	a* (Red–Green)	b* (Yellow–Blue)
B0T0	42.6 ± 0.8^{f}	-4.8 ± 0.3^{f}	12.5 ± 0.6^{f}
B1T1	54.2 ± 1.0^{e}	1.6 ± 0.2^{e}	24.8 ± 0.9^{e}
B2T2	52.8 ± 0.9^{e}	1.2 ± 0.3^{e}	23.6 ± 0.8^{e}
B3T3	58.9 ± 1.1^{c}	2.1 ± 0.2^{c}	30.2 ± 1.0^{c}
B4T4	61.4 ± 1.2^{b}	2.6 ± 0.3^{b}	34.5 ± 1.1^{b}
B5T5	57.2 ± 1.0^{d}	1.8 ± 0.2^{d}	28.9 ± 0.9^{d}
B6T6	60.6 ± 1.1^{b}	2.3 ± 0.3^{c}	31.8 ± 1.0^{c}
B7T7	55.0 ± 0.9^{e}	1.5 ± 0.2^{e}	25.6 ± 0.8^{e}
B8T8	56.5 ± 1.0^{d}	2.0 ± 0.3^{cd}	29.5 ± 0.9^{cd}
B9T9	57.8 ± 1.0^{d}	1.9 ± 0.2^{d}	27.2 ± 0.8^{d}
B10T10	60.1 ± 1.2^{b}	2.4 ± 0.3^{bc}	33.1 ± 1.1^{b}
B11T11	63.2 ± 1.3^{a}	2.8 ± 0.3^{a}	35.8 ± 0.02^{a}
B12T12	59.8 ± 1.1^{c}	2.5 ± 0.3^{b}	32.6 ± 1.0^{b}
B13T13	62.0 ± 1.2^{ab}	2.7 ± 0.3^{ab}	34.2 ± 1.1^{b}

Notes: Values are expressed as mean ± standard deviation (n = 3). Mean values in the same column followed by different superscript letters differ significantly ($p < 0.05$), according to Tukey's HSD test.

4.1.6. Determination of Color blended fruit juice

4.1.6.1. L* (Lightness)

The lightness (L*) values of the blended juice formulations made from avocado, orange, and cinnamon showed that non-significant differences across all treatments because of ($p>0.05$), highlighting the considerable impact of formulation on the color of the product. The control sample (B0T0, 100% avocado) had the lowest L* value at 42.6 ± 0.8, which reflects the naturally darker green hue of avocado pulp (*Arilla et al., 2023*).

4.1.6.2. a* (Red–Green Coordinate)

The a* values for the blended juice formulations of avocado, orange, and cinnamon displayed non-significant difference across all treatments ($p>0.05$).

4.1.6.3. b*(Yellow–Blue)

Significant differences in b* values of the avocado–orange–cinnamon blended juice formulations was noted across treatments; such differences were found to be highly significant ($p < 0.05$), thereby indicating a major effect of the formulation on yellowness. Control sample BT0 (100% avocado) had an extremely low b* value (12.5±0.6), indicating a very light yellow color associated with avocado pigment of green nature. In contrast, the blended formulations showed significantly higher b values ($p < 0.05$) **, which ranged from 23.6±0.8 to 35.8±0.02, denoting the increasing yellowness contributed by orange juice. Treatments showing high percentages of orange juice had significantly higher b* values ($p <0.05$) with B1T1, B3T3, B4T4, B7T7, B10T10, B11T11, and B13T13 exhibiting strong yellowness (≥33.0). This further enhancement is actually due to the carotenoid pigments of orange juice, especially β-carotene that intensifies yellow-orange hues and masks the green color of the avocado. Contrasting formulations with average b* values (approximately 28.9-31.8) did not differ significantly from each other ($p > 0.05$), thus inferring similar yellow color intensity among these treatments. The cinnamon extract might have had some but minor contribution to color enhancement via brownish-yellow tones; however, this influence

is nowhere near the orange juice. In general, with increased b* values, the combination of avocado with orange juice showed promising improvements in yellowness and cosmetic attractiveness of the juice. High b* values are generally associated with freshness and juice richness of fruits, implying that blended mixtures, particularly those higher in orange juice content, would be more attractive and acceptable to consumers than the avocado-alone control (*Kessler, 2010*).

4.2. Microbiological Analysis

Table 5. Microbiological Quality analaysis of optimized blended fruit Juice

Treatment	TPC (log_{10} CFU/ml)	CFC (log_{10} CFU/ml)	Yeast & Mold (log_{10} CFU/ml)	Staphylococcus (log_{10} CFU/ml)
B0T0	2.10 ± 0.08^{n}	2.10 ± 0.08^{l}	2.70 ± 0.09^{l}	2.45 ± 0.08^{l}
B1T1	1.90 ± 0.07^{h}	1.50 ± 0.05^{h}	2.00 ± 0.06^{h}	1.80 ± 0.05^{h}
B2T2	1.95 ± 0.06^{j}	1.60 ± 0.06^{j}	2.10 ± 0.07^{j}	1.90 ± 0.06^{j}
B3T3	1.85 ± 0.05^{f}	1.45 ± 0.04^{f}	1.95 ± 0.06^{f}	1.75 ± 0.05^{f}
B4T4	1.70 ± 0.06^{a}	1.25 ± 0.03^{b}	1.75 ± 0.05^{b}	1.55 ± 0.04^{b}
B5T5	2.00 ± 0.07^{l}	1.70 ± 0.07^{k}	2.20 ± 0.08^{k}	2.00 ± 0.06^{k}
B6T6	2.05 ± 0.08^{m}	1.75 ± 0.06^{m}	2.25 ± 0.09^{m}	2.05 ± 0.07^{m}
B7T7	1.98 ± 0.07^{k}	1.65 ± 0.07^{j}	2.15 ± 0.07^{j}	1.95 ± 0.06^{j}
B8T8	1.75 ± 0.06^{c}	1.35 ± 0.04^{d}	1.85 ± 0.05^{d}	1.65 ± 0.05^{d}
B9T9	1.92 ± 0.06^{i}	1.30 ± 0.06^{c}	2.10 ± 0.07^{i}	1.90 ± 0.06^{i}
B10T10	1.80 ± 0.05^{e}	1.40 ± 0.03^{e}	1.90 ± 0.06^{e}	1.70 ± 0.05^{e}
B11T11	1.78 ± 0.05^{d}	1.30 ± 0.04^{c}	1.80 ± 0.05^{c}	1.60 ± 0.04^{c}
B12T12	1.72 ± 0.06^{b}	1.20 ± 0.03^{a}	1.70 ± 0.05^{a}	1.50 ± 0.04^{a}
B13T13	1.88 ± 0.07^{g}	1.45 ± 0.05^{f}	1.95 ± 0.06^{f}	1.75 ± 0.05^{f}

Notes: Values are means ± standard deviation (n = 3). Means in the same column followed by different superscript letters are significantly different at ($p < 0.05$) according to Tukey's HSD test.

4.2.1. Total Plate Count (TPC)

The total microbial count of fruit juice should not exceed 10^4–10^5 CFU/mL (4–5 log CFU/mL) according to internationally accepted food safety standards such as those of Codex Alimentarius and WHO*(Iqbal et al., 2016*). Microbial loads reaching or exceeding 6 log CFU/mL are considered unacceptable and indicate poor hygienic quality and potential health risk*(Park et al., 2022*).

The initial total plate count (TPC) for the blended avocado–orange–cinnamon extract fruit juice formulations is detailed on Table 5. The microbial load at week 0 (freshly prepared juice) varied from 1.70 ± 0.06 to 2.10 ± 0.08 $\log_{10}$ CFU/mL across all treatments. The control treatment (B0T0), which is made up of 100% avocado juice, displayed the highest microbial count at 2.10 ± 0.08 $\log_{10}$ CFU/mL. This is likely due to the avocado pulp's rich nutrient and moisture content, which supports microbial survival and proliferation. Conversely, the blended formulations that include orange juice and cinnamon extract exhibited lower microbial loads. Among the combined treatments, B4T4 (1.70 ± 0.06 $\log_{10}$ CFU/mL) and B12T12 (1.72 ± 0.06 $\log_{10}$ CFU/mL) exhibited the lowest total plate count (TPC) values. The decrease in microbial load in these treatments is likely attributed to the acidic properties of orange juice and the antimicrobial characteristics of cinnamon extract, especially cinnamaldehyde and phenolic compounds, which suppress microbial activity. Similar patterns were noted in treatments B8T8 and B11T11, which also demonstrated relatively low microbial counts (<1.80 $\log_{10}$ CFU/mL). Overall, the low initial TPC values observed in all treatments suggest a high level of hygienic quality and appropriate handling during the juice preparation process.

The findings also indicate that combining avocado juice with orange juice and cinnamon extract notably improves microbial quality by decreasing the initial microbial load *(Adimas et al., 2024*). This enhanced microbial condition at the outset is vital for prolonging the refrigerated shelf life and guaranteeing the safety of the blended fruit juice products.

4.2.2. Coliform Count ($\log_{10}$ CFU/ml)

Coliform counts exhibited a trend kind to that of TPC the avocado control (B0T0) displayed the highest coliform count (2.10 log CFU/mL), suggesting a greater vulnerability to contamination when antimicrobial barriers are absent.

All formulated blends demonstrated significant decreases in coliform levels, with reductions ranging from 0.75 to 1.65 log CFU/mL. Treatments that included ≥50% orange juice and ≥1.5% cinnamon (B12T12, B4T4, B9T9, B10T10&B11T11) recorded the lowest coliform counts, frequently falling below 1 log CFU/mL.

The noted reduction underscores the synergistic impact of the low pH from orange juice combined with the bioactive compounds in cinnamon extract, which are recognized for their ability to inhibit microbial growth. Notably, all treated samples remained within acceptable microbiological standards for fruit beverages, reflecting good hygienic quality*(Lima Tribst et al., 2009*).

4.2.3. Yeast and Mold Count (log_{10} CFU/ml)

The yeast and mold counts (YMC) for the blended avocado–orange–cinnamon extract juice are expressed as log CFU/mL. The findings revealed significant differences among the treatments, highlighting the impact of formulation composition on fungal proliferation.

The YMC values varied from 1.70 ± 0.05 to 2.70 ± 0.09 log CFU/mL. The control treatment exhibited the highest yeast and mold count at 2.70 ± 0.09 log CFU/mL, suggesting that pure avocado juice is more prone to fungal growth due to its relatively high nutrient levels and low acidity. Conversely, treatments with greater amounts of orange juice and cinnamon extract showed reduced yeast and mold counts, with the minimum value noted at 1.70 ± 0.05 log CFU/mL. The decrease in fungal counts observed in the blended formulations can be linked to the synergistic antimicrobial properties of organic acids present in orange juice and the bioactive elements found in cinnamon extract, including cinnamaldehyde and phenolic compounds, which are recognized for their ability to inhibit the growth of yeast and mold. Moreover, the acidic pH level of orange juice establishes an environment that is not conducive to fungal growth. Briefly, the yeast and mold counts for all treatments were maintained below 3 logs CFU/mL, a level that is typically deemed acceptable for refrigerated fruit-based beverages. These findings suggest that the combination of avocado juice with orange juice and cinnamon extract significantly enhances microbial safety and promotes improved shelf stability by curbing yeast and mold proliferation during storage *(Adimas et al., 2024*).

4.2.4. Staphylococcus aureus Count (log_{10} CFU/ml)

Staphylococcus aureus was found solely in the control (B0T0) and in formulations with a low concentration of cinnamon and reduced orange juice content (B2T2, B5T5–B7T7, B9T9).

Nevertheless, the counts were still relatively low (≤1.20 log CFU/mL). Importantly, Staphylococcus aureus was not present in formulations that contained ≥1.5% cinnamon and ≥50% orange juice (*Franklyne et al., 2019*), demonstrating a significant inhibitory effect. The lack of this pathogen in the majority of treatments indicates that the formulations are microbiologically safe and appropriate for consumption when processed correctly.

Table 6. Storage Stability of the Juice Ph at 4^{o}c in refrigeration temperature

Treatment	0 Week	2 Weeks	4 Weeks
B0T0	6.55 ± 0.03^{a}	6.32 ± 0.04^{a}	6.05 ± 0.05^{a}
B1T1	4.25 ± 0.02^{d}	4.10 ± 0.03^{c}	3.95 ± 0.04^{c}
B2T2	4.30 ± 0.03^{cd}	4.15 ± 0.03^{c}	3.98 ± 0.03^{c}
B3T3	4.18 ± 0.02^{e}	4.02 ± 0.02^{d}	3.88 ± 0.03^{d}
B4T4	4.22 ± 0.03^{de}	4.05 ± 0.03^{d}	3.90 ± 0.04^{d}
B5T5	4.35 ± 0.03^{c}	4.18 ± 0.04^{c}	4.02 ± 0.04^{c}
B6T6	4.40 ± 0.02^{b}	4.22 ± 0.03^{b}	4.05 ± 0.03^{b}
B7T7	4.28 ± 0.03^{cd}	4.10 ± 0.03^{c}	3.92 ± 0.04^{cd}
B8T8	4.32 ± 0.02^{c}	4.15 ± 0.03^{c}	3.98 ± 0.03^{c}
B9T9	4.20 ± 0.03^{de}	4.05 ± 0.04^{d}	3.85 ± 0.04^{d}
B10T10	4.15 ± 0.02^{e}	3.98 ± 0.03^{e}	3.80 ± 0.03^{e}
B11T11	4.18 ± 0.03^{e}	4.00 ± 0.03^{e}	3.82 ± 0.04^{e}
B12T12	4.12 ± 0.02^{e}	3.95 ± 0.03^{e}	3.78 ± 0.03^{e}
B13T13	4.10 ± 0.03^{e}	3.92 ± 0.03^{e}	3.75 ± 0.04^{e}

Notes: Values are expressed as mean ± standard deviation (n = 3). Mean values within the same column followed by different superscript letters are significantly different ($p < 0.05$) according to Tukey's HSD test.

4.3.1. Storage Stability of the Juice Ph at 4^{o}c in refrigeration temperature

The avocado, orange and cinnamon blended juice formulations had a drop in acidity over time. The statement holds for all types of blends that were analyzed. Indeed, the longer the juice has been held, the higher acidic it has become. When the juices were first made the one that was just avocado had a lower acidity level, than the other blends. This acidity level was 6.55. The avocado juice had an acidity level because avocado pulp is not very acidic to begin with. The avocado, orange and cinnamon blended juice formulations had acidity levels because they were blended with other things. The control started to get more acidic over time. During the 4-week period, pH dropped from 4.25 to 3.95 for treatment B1T1. The treatment B13T13 showed similar results with a pH drop from 4.10 to 3.75 over the same length of time. Both B1T1 and B13T13 were acidic due to the high acid content of orange juice.

The blended juice treatments, like B1T1 to B13T13 had low initial pH values. After four weeks, pH dropped to about 6.05 ± 0.05. Whereas treatment B1T1 underwent a drop in pH from 4.25 to 3.95 after four weeks. When we stored these juice treatments in the fridge their pH values went down a lot after 2 and 4 weeks. For example treatment B1T1 is observed to have pH lower from 4.25 at the start to 3.95 after 4 weeks. This also applies to treatment B13T13 with pH going down from 4.10 to 3.75 with time. The blended juice treatments, including B1T1 and B13T13 had changes, in their pH values during this time. The pH level goes down slowly. This can be because of the acid that keeps forming or organic acids get released or there is a little fermentation happening while the things are being stored. This slow reduction, in pH is something that can happen when there is continued acid development or when organic acids are released or when mild fermentation processes occur during storage of the things.

The ph values of all the formulations went down a lot but they were still okay for fruit drinks. This is because they were between 3.5 and 4.5 which is what you want for fruit-based beverages. This was true for the 4 weeks that we stored them.

Some of the treatments like B10T10 to B13T13 had pH values after 4 weeks. This was the case because orange juice has a lot of acid in it. On the handsome treatments, like B5T5 and B6T6 had a bit higher pH values. These fruit drinks might taste milder which some people

like. According to (*Kharat et al., 2017*), the statistically significant changes observed confirm that both formulation and storage duration significantly influenced pH, and that blending avocado with orange juice effectively maintained product safety and quality during storage compared with the avocado only control(*Stephen & Radhakrishnan, 2022*).

Table 7. Titratable acidity at 4^{o}c in refrigeration temperature

Treatment	0 Week	2 Weeks	4 Weeks
B0T0	0.18 ± 0.01^{f}	0.22 ± 0.01^{f}	0.28 ± 0.02^{f}
B1T1	0.42 ± 0.02^{d}	0.48 ± 0.02^{d}	0.55 ± 0.03^{d}
B2T2	0.38 ± 0.02^{e}	0.44 ± 0.02^{e}	0.50 ± 0.03^{e}
B3T3	0.45 ± 0.02^{c}	0.52 ± 0.03^{c}	0.60 ± 0.03^{e}
B4T4	0.46 ± 0.02^{c}	0.53 ± 0.03^{c}	0.62 ± 0.03^{e}
B5T5	0.40 ± 0.02^{de}	0.46 ± 0.02^{de}	0.53 ± 0.03^{de}
B6T6	0.39 ± 0.02^{e}	0.45 ± 0.02^{e}	0.52 ± 0.03^{e}
B7T7	0.44 ± 0.02^{cd}	0.50 ± 0.03^{cd}	0.58 ± 0.03^{cd}
B8T8	0.41 ± 0.02^{de}	0.47 ± 0.02^{de}	0.54 ± 0.03^{de}
B9T9	0.48 ± 0.02^{b}	0.55 ± 0.03^{b}	0.64 ± 0.03^{b}
B10T10	0.50 ± 0.02^{ab}	0.58 ± 0.03^{ab}	0.67 ± 0.04^{a}
B11T11	0.47 ± 0.02^{b}	0.54 ± 0.03^{b}	0.63 ± 0.03^{b}
B12T12	0.49 ± 0.02^{ab}	0.56 ± 0.03^{ab}	0.66 ± 0.04^{a}
B13T13	0.51 ± 0.02^{a}	0.59 ± 0.03^{a}	0.68 ± 0.04^{a}

Notes: Values are expressed as mean ± standard deviation. Mean values within the same column followed by different superscript letters are significantly different ($p < 0.05$) according to Tukey's HSD test.

4.3.2. Storage Stability of the Juice TA at 4^{o}C in Refrigeration Temperature

The acidity of avocado-orange-cinnamon blended juice increased more during the period of storage in each of the juice treatments. This means that the composition of the juice and its

time of storage affect the acid condition of the juice. When the juice was just made, the sample with the avocado had a lower acidity. This is because avocado initially doesn't carry much acidity itself. The acidity that was recorded at this point for such a sample was 0.18 percent. The control increased heavily over time. Total acid during storage after four weeks, the increase in total acid was up to about 0.28 percent per 0.02 percent. This may have been due more because of biochemical changes rather than the lack of organic acid formation during storage. Total Acid formation should be an important consideration in the storage period with explanations of what happened. Total acids tell us a lot about the happenings. The blended juice treatments from B1T1 to B13T13 had lots of acid at the beginning because they had orange juice, and orange juice is high in acid. The acid contents were varying from 0.38 percent to 0.51 percent. The control treatment remained more acidic than the blended juice treatments. There was increasing acid in all the juice treatments until 2 weeks and 4 weeks. The blended juice treatments were having acid during this period. For instance, treatment B1T1 went up from 0.42 percent at the beginning to 0.55 percent after 4 weeks. Treatment B13T13 also increased from 0.51 percent to 0.68 percent within this period. This permitted the rise in treatment TA because the organic compounds were continued to break down the bound acids. Some mild fermentation occurred while the storage was on. Blended fruit juices did possess the correct level of acidity when harvested after four weeks. The acid concentration would not usually be less than 0.30% or more than 0.70%, which is again a desirable level for blended juices. Thus, four weeks is still fairly good as far as the quality of the blended fruit juices was concerned. The blended fruit juices B9T9 to B13T13 had a high acidic end after the four weeks, which means that they had a better capacity for eliminating unwanted microbes due to their acidity. This is again quite a desirable level for blended juices, typically between 0.30 and 0.70 percent. So even after four weeks, the quality of blended fruit juices was still quite good. B9T9 to 13 of blended fruit juices, with high acidity after the end of 4 weeks, are less effective in eliminating unwanted microbes as they have a better capacity to eliminate unwanted microbes due to their acidity.

The acidity is maintained at a level that ranges from 0.30 to 0.70 percent, which is again quite a desirable level for blended juices, a fruit juice a blended mixed fruit juices would its quality be still good even after four weeks. Blend fruit juices, B9T9 to B13T13, had a high

acidity at the end of four weeks, making them more effective in eliminating these unwanted microbes, since they are more acidic. High acidity levels in the blended juices, however, might have suppressed consumer acceptance (*Bhardwaj & Pandey, 2011)*. The general variations observed confirm that storage time significantly affected titratable acidity and that blending of avocado with orange juice was very efficient in increasing acidity and imparting better stability than the control of avocado only.

Table 8. Total Soluble solid content at 4^{o}C in refrigeration temperature

Treatment	0 Week	2 Weeks	4 Weeks
B0T0	6.20 ± 0.15^{f}	6.35 ± 0.14^{f}	6.50 ± 0.16^{f}
B1T1	9.80 ± 0.20^{e}	10.00 ± 0.18^{e}	10.20 ± 0.22^{e}
B2T2	9.50 ± 0.18^{e}	9.70 ± 0.20^{e}	9.90 ± 0.19^{e}
B3T3	11.20 ± 0.25^{c}	11.40 ± 0.24^{c}	11.60 ± 0.26^{c}
B4T4	12.80 ± 0.30^{a}	13.10 ± 0.28^{a}	13.40 ± 0.32^{a}
B5T5	11.00 ± 0.22^{cd}	11.20 ± 0.23^{cd}	11.40 ± 0.25^{cd}
B6T6	11.50 ± 0.24^{c}	11.70 ± 0.26^{c}	11.90 ± 0.27^{c}
B7T7	9.40 ± 0.19^{e}	9.60 ± 0.21^{e}	9.80 ± 0.20^{e}
B8T8	11.10 ± 0.23^{cd}	11.30 ± 0.25^{cd}	11.50 ± 0.26^{cd}
B9T9	9.90 ± 0.20^{e}	10.10 ± 0.22^{e}	10.30 ± 0.23^{e}
B10T10	12.60 ± 0.28^{ab}	12.90 ± 0.30^{ab}	13.20 ± 0.31^{ab}
B11T11	13.00 ± 0.32^{a}	13.30 ± 0.34^{a}	13.60 ± 0.35^{a}
B12T12	11.70 ± 0.26^{bc}	11.90 ± 0.28^{bc}	12.10 ± 0.29^{bc}
B13T13	12.40 ± 0.29^{ab}	12.70 ± 0.30^{ab}	13.00 ± 0.32^{ab}

Notes: Values are expressed as mean ± standard deviation. Mean values within the same column followed by different superscript letters differ significantly ($p < 0.05$) according to Tukey's HSD test.

4.3.3. Storage Stability of the Juice TSS at 4^{o}C in Refrigeration Temperature

The effect of storage duration on the Total Soluble Solids (TSS) content in formulations of avocado–orange–cinnamon juice is presented on Table 6. TSS measurements (°Brix) were conducted at 0, 2, and 4 weeks of storage to evaluate product stability. Initially (0 week), TSS values ranged from 6.20 °Brix in the control sample (B0T0) to 13.00 °Brix in treatment BT11 (Avocado 20% + Orange 60% + Cinnamon 1.5%). The significantly lower TSS observed in the control formulation can be explained by the absence of orange juice, which is naturally rich in soluble sugars. Treatments with higher concentrations of orange juice (50–60%) demonstrated significantly elevated TSS values, indicating that the concentration of orange juice was the main factor contributing to soluble solids in the formulations. Throughout the storage period, a gradual rise in TSS was noted across all treatments. After two weeks, total soluble solids (TSS) showed an insignificant increase of approximately 0.15–0.30 °Brix whereas the total increase varied by 0.30–0.40 °Brix four weeks later as compared to the other initial values. In B4T4, for instance, TSS increased from 12.80 °Brix at week 0 to 13.40 °Brix at week 4, whereas B0T0, the control, went from 6.20 to 6.50 °Brix in the same period. The increase in TSS could be due to the hydrolysis of complex carbohydrates into simple sugars, moisture shifts across the juice matrix, and partial degradation of pelting substances *(GOVIND, 2019*). Similar observations were witnessed in blended fruit beverages held under refrigerated storage in which slow biochemical changes remain. All treatments had highest TSS values in formulations containing 60% orange juice (BT4, BT10, BT11, and BT13), thus showing better sweetening retention and compositional stability. Increasing concentration of cinnamon had little effect on TSS indicating that cinnamon principally functions in the formulation as a flavor and antimicrobial agent rather than TSS enhancer. Any slight increase in TSS, as mentioned earlier, could be considered as malodorous fermentation or spoilage; thus it is indicative that the juice formulations have maintained their physicochemical properties for about 4 weeks under storage. This stability indicates that the avocado-orange-cinnamon blends may be stored over a short period without compromising too much in quality.

4.4.4. Storage Stability of optimized blended fruit juice on Microbial analysis

Table 9. Storage Stability at 4^0c in refrigerated room of Total Plate Count (log_{10} CFU/ml)

Treatment	0 Week	2 Weeks	4 Weeks
B0T0	2.10 ± 0.08^{m}	3.85 ± 0.12^{m}	5.40 ± 0.15^{m}
B1T1	1.90 ± 0.07^{h}	3.20 ± 0.10^{g}	4.60 ± 0.13^{g}
B2T2	1.95 ± 0.06^{j}	3.35 ± 0.11^{i}	4.75 ± 0.14^{i}
B3T3	1.85 ± 0.05^{f}	3.10 ± 0.09^{e}	4.40 ± 0.12^{e}
B4T4	1.70 ± 0.06^{a}	2.90 ± 0.08^{a}	4.10 ± 0.11^{a}
B5T5	2.00 ± 0.07^{l}	3.50 ± 0.11^{k}	4.95 ± 0.14^{k}
B6T6	2.05 ± 0.08^{l}	3.65 ± 0.12^{l}	5.10 ± 0.16^{l}
B7T7	1.98 ± 0.07^{k}	3.45 ± 0.10^{j}	4.85 ± 0.13^{j}
B8T8	1.75 ± 0.06^{c}	3.00 ± 0.09^{c}	4.25 ± 0.12^{c}
B9T9	1.92 ± 0.06^{i}	3.30 ± 0.10^{h}	4.65 ± 0.13^{h}
B10T10	1.80 ± 0.05^{e}	3.05 ± 0.09^{d}	4.30 ± 0.12^{d}
B11T11	1.78 ± 0.05^{d}	3.00 ± 0.08^{b}	4.20 ± 0.11^{b}
B12T12	1.72 ± 0.06^{b}	2.95 ± 0.08^{b}	4.15 ± 0.11^{b}
B13T13	1.88 ± 0.07^{g}	3.25 ± 0.10^{f}	4.55 ± 0.13^{f}

Notes: Means with the same superscript within a column are not significantly different ($p < 0.05$) according to Tukey's HSD test.

4.4.4.1. Storage Stability at 4^0c in refrigerated room of Total Plate Count

The variations in Total Plate Count (TPC) for avocado–orange–cinnamon extract juice formulations during refrigeration at 4 °C over the course of 0, 2, and 4 weeks are detailed in Table 7. At the beginning of week 0, all treatments showed low initial microbial loads, which ranged from 1.70 to 2.10 log_{10} CFU/ml, suggesting that the raw materials and processing conditions were of good hygienic quality. During the storage period, TPC values exhibited a significant increase ($p < 0.05$) across all treatment groups. After duration of 2 weeks, TPC values varied from 2.90 to 3.85 log_{10} CFU/ml, whereas after 4 weeks, the counts further

escalated to a range of 4.10–5.40 $\log_{10}$ CFU/ml. The control sample (B0T0, 100% avocado) consistently demonstrated the highest level of microbial growth throughout the storage period, achieving a measurement of 5.40 ± 0.15 $\log_{10}$ CFU/ml by week 4 due to high nutrient and moisture content of avocado juice. On the other end of the spectrum, those formulations with higher contents of orange juice and cinnamon extract (particularly B4T4, B8T8, B10T10, B11T11, and B12T12) were the most affected in terms of reduced values of TPC as compared to the rest. Its TPC values were documented in the treatment after week 4 and were found to range between 4.10 and 4.30 $\log_{10}$ CFU/ml which are all under the global widely acceptable standard of 6 $\log_{10}$ CFU/ml for chilled fruit beverages. Microorganisms of psychotropic origin are observed to survive and multiply very slowly under down temperatures (*Jay, 2005*). This gradual rise of TPC in refrigerated storage can be anticipated. While microbial growth is significant at 4 °C, the ultimate prevention of this growth does not happen and quite significantly, there is continued increase of total viable counts in time. Because there are higher pH values along with the absence of natural antimicrobials into the control sample (B0T0), conditions for microbial growth are more favorable. Avocado pulp alone supplies nutrients (e.g., lipids and carbohydrates) for microbial growth if not sufficiently acidified, whereas the blended formulations contributed to lower pH (inhibitory to many spoilage microorganisms). According to *(Marchese et al., 2017*) Cinnamaldehyde and eugenol are antimicrobials that damage the cell membranes as well as inhibit enzymatic activity, thereby acting as the active principles that have lowered the TPC in cinnamon-enriched treatments, especially at combination with 2% cinnamon extract. Although the increase of the count during storage showed all treatments still accepted microbiological limits for refrigerated fruit beverages, it reflected that the combination of acidification, natural antimicrobial sources, and cold storage contributed to product stability for at least 4 weeks.

Table 10. Storage Stability at 4^0c in refrigerated room of Coli form (log_{10} CFU/ml)

Treatment	0 Week	2 Weeks	4 Weeks
B0T0	2.10 ± 0.07^{l}	2.40 ± 0.09^{l}	2.75 ± 0.10^{l}
B1T1	1.50 ± 0.05^{h}	1.85 ± 0.07^{h}	2.20 ± 0.08^{h}
B2T2	1.60 ± 0.06^{j}	1.95 ± 0.08^{j}	2.30 ± 0.09^{j}
B3T3	1.45 ± 0.05^{f}	1.80 ± 0.06^{f}	2.15 ± 0.07^{f}
B4T4	1.25 ± 0.04^{b}	1.60 ± 0.05^{b}	1.95 ± 0.06^{b}
B5T5	1.70 ± 0.06^{m}	2.05 ± 0.09^{k}	2.40 ± 0.10^{k}
B6T6	1.75 ± 0.07^{m}	2.10 ± 0.09^{m}	2.45 ± 0.11^{m}
B7T7	1.65 ± 0.06^{k}	2.00 ± 0.08^{j}	2.35 ± 0.09^{j}
B8T8	1.35 ± 0.05^{d}	1.70 ± 0.06^{d}	2.05 ± 0.07^{d}
B9T9	1.60 ± 0.06^{j}	1.95 ± 0.08^{j}	2.30 ± 0.09^{j}
B10T10	1.40 ± 0.05^{e}	1.75 ± 0.06^{e}	2.10 ± 0.07^{e}
B11T11	1.30 ± 0.04^{c}	1.65 ± 0.05^{c}	2.00 ± 0.06^{c}
B12T12	1.20 ± 0.04^{a}	1.55 ± 0.05^{a}	1.90 ± 0.06^{a}
B13T13	1.45 ± 0.05^{f}	1.80 ± 0.06^{f}	2.15 ± 0.07^{f}

***Notes**: Means with the same superscript letter within a column are not significantly different ($p < 0.05$) according to Tukey's HSD test.*

4.4.4.2. Storage Stability at 4^0c in Refrigeration of Coliforms (log_{10} CFU/ml)

Table 8 depicted variations in coliform counts (CFC) of avocado-orange-cinnamon blended juice during refrigeration at 4 degrees centigrade after 0, 2, and 4 weeks. They all registered a low coliform count at the initial weeks (1.20-2.10 log_{10} CFU/mL), with the highest CFC in the control sample (B0T0, 100% avocado, with 2.10 ± 0.07 log_{10} CFU/mL) and the two formulations having higher levels of orange juice and cinnamon (B12T12: 1.20 ± 0.04 log_{10} CFU/mL, and B4T4: 1.25 ± 0.04 log_{10} CFU/mL) scoring the lowest initial counts of coliforms. All treatments significantly raised ($p < 0.01$) in coliform counts after 2 weeks of storage under refrigeration (1.55 to 2.40 log_{10} CFU/mL), the control sample remaining with a higher level CFC (2.40 ± 0.09 log_{10} CFU/mL) than the rest and formulations containing cinnamon extract (>1.5%) displaying lesser microbial counts compared with the others. In this study, after 4 weeks of storage, the increased CFC values of coliforms were significantly different ($p < 0.05$) from the values recorded at 0, 2, and 4 weeks of storage with values between 1.90 log_{10} CFU/mL and 2.75

$\log_{10}$ CFU/mL, where B0T0 (2.75 ± 0.10 $\log^{10}$ CFU/mL) had the maximum population and T12 (1.90 ± 0.06 $\log^{10}$CFU/mL), B4T4 (1.95 ± 0.06 $\log^{10}$ CFU/mL), and B11T11 (2.00 ± 0.06 $\log_{10}$ CFU/mL) had the least amounts of coliforms at the end of the storage time. Stored cold, the coliform counts in the freezing condition increased constantly and, by itself, hinted that one more time factor played a role which was the most potent, while 4 degrees refrigeration was efficient in preventing rapid growth even so couldn't do the trick with such high counts of coliforms shown in B0T0 because of the high pH value and lack of antimicrobial constituents which favor coliform survival and growth, whereas treatments with orange juice were comparatively stable in the respect of microbial growth due to much higher acidity which was unwelcoming to coliforms, as well as with cinnamon extract which has bioactive constituents, such as cinnamaldehyde and eugenol, able to rupture bacterial cell membranes and arrest metabolic activity. The continuously lower CFC values seen in treatments with higher concentrations of cinnamon (1.5-2%) and higher percentage of orange juice (50-60%) prove synergetic antimicrobial activity due to the combination of acidity and naturally plant-derived antimicrobials *(Satapathy & Tartte, 2024*). Significantly, all treatments complied with the microbiological standards acceptable throughout the entire 4-week storage of refrigerated fruit-based beverages.

Table11. Storage Stability at 4^0c in refrigerated room Yeast and mold (CFU/ml)

Treatment	0 Week	2 Weeks	4 Weeks
B0T0	2.70 ± 0.09^{l}	3.10 ± 0.11^{l}	3.45 ± 0.13^{l}
B1T1	2.00 ± 0.06^{h}	2.35 ± 0.09^{h}	2.70 ± 0.10^{h}
B2T2	2.10 ± 0.07^{j}	2.45 ± 0.10^{j}	2.80 ± 0.11^{j}
B3T3	1.95 ± 0.06^{f}	2.30 ± 0.08^{f}	2.65 ± 0.09^{f}
B4T4	1.75 ± 0.05^{b}	2.10 ± 0.07^{b}	2.45 ± 0.08^{b}
B5T5	2.20 ± 0.08^{k}	2.60 ± 0.10^{k}	2.95 ± 0.12^{k}
B6T6	2.25 ± 0.09^{m}	2.65 ± 0.11^{m}	3.00 ± 0.13^{m}
B7T7	2.15 ± 0.07^{j}	2.55 ± 0.09^{j}	2.90 ± 0.11^{j}
B8T8	1.85 ± 0.05^{d}	2.20 ± 0.07^{d}	2.55 ± 0.08^{d}
B9T9	2.10 ± 0.07^{i}	2.50 ± 0.09^{i}	2.85 ± 0.10^{i}

B10T10	1.90 ± 0.06^{e}	2.25 ± 0.08^{e}	2.60 ± 0.09^{e}
B11T11	1.80 ± 0.05^{c}	2.15 ± 0.07^{c}	2.50 ± 0.08^{c}
B12T12	1.70 ± 0.05^{a}	2.05 ± 0.06^{a}	2.40 ± 0.07^{a}
B13T13	1.95 ± 0.06^{f}	2.30 ± 0.08^{f}	2.65 ± 0.09^{f}

Notes: Means sharing the same superscript letter within a column are not significantly different ($p < 0.05$) according to Tukey's HSD test.

4.4.4.3. Storage Stability at 4^0c in refrigerated room Yeast and mold (log_{10} CFU/ml)

The changes in counts of the strains studied (yeast and mold) for avocado-orange-cinnamon blended juice during cold storage at a temperature of 4 °C at 0, 2, and 4 weeks, are summarized in Table 9. At the zero weeks in most cases, yeast and mold counts were generally low for all treatments, within the range of 1.70 to 2.70 log_{10} CFU/ml. Control sample (B0T0, 100% avocado) had the highest yeast and mold count with 2.70 ± 0.09 log_{10} CFU/mL, while the formulations containing higher amounts of orange juice and cinnamon extract had relatively lower counts of yeast and mold at the initial measurement, especially B12T12 (1.70 ± 0.05 log_{10} CFU/mL) and B4T4 (1.75 ± 0.05 log_{10} CFU/mL). After two weeks of cold storage, it was found out that all forms of yeast and mold counts increased significantly ($p < 0.05$) ranging from 2.05 to 3.10 log_{10} CFU/mL. As before, the highest microbial load was the same for the control sample at 3.10 ± 0.11 log_{10} CFU/mL, whereas treatments of high levels of cinnamon concentrations resulted comparatively lesser amounts of increases. Like two weeks storage, the progressive increase was observed up to 2.40-3.45 log_{10} CFU/mL ($p < 0.05$) at four weeks holding. Again, the highest count was shown by B0T0, at 3.45 ± 0.13 log_{10} CFU/mL, while B12T12 (2.40 ± 0.07 log_{10} CFU/mL), T4 (2.45 ± 0.08 log_{10} CFU/mL), and B11T11 (2.50 ± 0.08 log_{11}CFU/mL) treatments showed the least yeast and mold growth by the end of storage period. The continuous increase in the yeasts and molds during cold storage suggests that lower temperatures slow down fungal growth, but do not inhibit it altogether(Ribes et al., 2018). Yeasts and molds are able to tolerate extremely acidic and low temperatures quite well unlike many bacteria and thus can allow growth inside(Hamad, 2012). A higher count of yeasts and molds in the control sample (B0T0) could be correlated to its higher pH and absence of antimicrobial agents, which made

the environment highly conducive for fungal growth. On the other hand, treatments with orange juice increased stability on account of acidity, which could inhibit the metabolism of fungus. The inclusion of cinnamon extract was also vital to inhibit the growth of yeast and mold. High concentrations of antifungals such as cinnamaldehyde in cinnamon can compromise the cell membrane integrity and the enzyme activity of fungi. Higher levels of cinnamon (1.5-2%) particularly in B4T4, B11T11, and B12T12 also led to reductively low yeast and mold counts through the storage period. Even though increases were recorded, all treatments were within acceptable microbiological standards for refrigerated fruit-based beverages during the four-week storage under refrigeration, which demonstrated sufficient shelf stability.

Table 12. Storage Stability at 4^0c in refrigerated room Staphylococcus (log_{10} CFU/ml)

Treatment	0 Week	2 Weeks	4 Weeks
B0T0	2.45 ± 0.08^{l}	2.80 ± 0.08^{l}	3.10 ± 0.09^{l}
B1T1	1.80 ± 0.05^{e}	2.10 ± 0.06^{e}	2.45 ± 0.07^{e}
B2T2	1.90 ± 0.06^{f}	2.20 ± 0.07^{f}	2.55 ± 0.08^{f}
B3T3	1.75 ± 0.05^{d}	2.05 ± 0.06^{d}	2.40 ± 0.07^{d}
B4T4	1.55 ± 0.04^{b}	1.85 ± 0.05^{b}	2.20 ± 0.06^{b}
B5T5	2.00 ± 0.06^{g}	2.30 ± 0.08^{g}	2.65 ± 0.09^{g}
B6T6	2.05 ± 0.07^{h}	2.35 ± 0.08^{h}	2.70 ± 0.10^{h}
B7T7	1.95 ± 0.06^{g}	2.25 ± 0.07^{g}	2.60 ± 0.08^{g}
B8T8	1.65 ± 0.05^{c}	1.95 ± 0.06^{c}	2.30 ± 0.07^{c}
B9T9	1.90 ± 0.06^{f}	2.20 ± 0.07^{f}	2.55 ± 0.08^{f}
B10T10	1.70 ± 0.05^{d}	2.00 ± 0.06^{d}	2.35 ± 0.07^{d}
B11T11	1.60 ± 0.04^{b}	1.90 ± 0.05^{b}	2.25 ± 0.06^{b}
B12T12	1.50 ± 0.04^{a}	1.80 ± 0.05^{a}	2.15 ± 0.06^{a}
B13T13	1.75 ± 0.05^{d}	2.05 ± 0.06^{d}	2.40 ± 0.07^{d}

Notes: Means with the same superscript letter within a column are not significantly different ($p < 0.05$) according to Tukey's HSD test.

4.4.4.4. Storage Stability at 4^0c in refrigerated room Staphylococcus (log_{10} CFU/ml)

The counts of Staphylococcus spp. in avocado–orange–cinnamon blended juice during refrigerated storage at 4 °C for 0, 2, and 4 weeks are detailed in(Table 10). Staphylococcus counts were generally low at the onset of week 0 with mean counts ranging from 1.5 to 2.45 log_{10} CFU/mL in all treatments. The highest starting counts, casting B0T0 (100% avocado) as a control sample, were recorded (2.45±0.08 log_{10} CFU/mL). In contrast, treatments with relatively greater amounts of orange pulp juice and even cinnamon extract were all observed with the least initial levels, as in B12T12 (1.50±0.04 log_{10} CFU/mL) and B4T4 (1.55±0.04 log_{10} CFU/mL). Holding storage at low temperature (4°C) manifested that inhibiting activity with respect to Staphylococcus species could not be prevented. Counts of Staphylococcus spp increased markedly ($p < 0.05$) after four weeks of storage to levels between 2.15 and 3.10 log_{10} CFU/mL. The highest populations were again recorded at B0T0 (3.10 ± 0.09 log_{10} CFU/mL). The treatment followed by least growth in Staphylococcus was B12T12 at 2.15 ± 0.06 log_{10} CFU/mL, while B4T4 was at 2.20 ± 0.06 log_{10} CFU/mL and B11T11 was at 2.25 ± 0.06 log_{10} CFU/mL. The fact that counts of Staphylococcus spp continued to rise during cold storage indicated that the low temperature (4 °C) may have slowed growth rate but not stopped it (*Suo et al., 2014).* Control sample (B0T0, T6T6&T5T5) consistently gave counts that were much higher than any other sample. This is because of its high pH and lack of antimicrobial components which create a more conducive environment toward the growth of Staphylococcus. The formulations that contained orange juice, on the other hand, exhibited better microbial stability due to their high acidity, which usually negatively affects the metabolic activity of Staphylococcus. Interestingly, the incorporation of cinnamon extract showed an appreciable inhibitory action. Cinnamons are bioactive compounds such as cinnamaldehyde and eugenol which show membrane-disrupting action on bacterial cells and inhibit enzyme systems responsible for maintaining the activeness of bacterial cells. Among the concentrations of cinnamon used, 1.5-2% treatment levels (particularly B4T4, B11T11, and B12T12) resulted in the least Staphylococcus counts at storage. Increased Staphylococcus spp counts were recorded, but counts remained within the limits of acceptable microbiological quality for refrigerated fruit-based beverages during the 4-week storage period, indicating good microbiological stability*(ALIU, 2021*).

Table 13. Overall Sensory Acceptability during Storage Stability at 4 °C

Treatment	0 week	2 weeks	4 weeks
B0T0	7.00 ± 1.00^{b}	6.73 ± 1.05^{bc}	6.27 ± 1.10^{c}
B1T1	6.73 ± 1.03^{b}	6.47 ± 1.07^{c}	6.07 ± 1.12^{c}
B2T2	7.40 ± 0.74^{b}	7.07 ± 0.80^{b}	6.60 ± 0.86^{bc}
B3T3	7.33 ± 0.82^{b}	7.00 ± 0.88^{b}	6.53 ± 0.92^{bc}
B4T4	7.00 ± 1.07^{b}	6.73 ± 1.10^{bc}	6.33 ± 1.15^{c}
B5T5	7.07 ± 1.10^{b}	6.80 ± 1.12^{bc}	6.40 ± 1.18^{c}
B6T6	7.07 ± 1.16^{b}	6.80 ± 1.20^{bc}	6.47 ± 1.25^{bc}
B7T7	7.00 ± 1.07^{b}	6.73 ± 1.10^{bc}	6.33 ± 1.14^{c}
B8T8	7.13 ± 0.83^{b}	6.87 ± 0.90^{bc}	6.47 ± 0.96^{bc}
B9T9	7.00 ± 1.00^{b}	6.73 ± 1.05^{bc}	6.33 ± 1.10^{c}
B10T10	7.33 ± 0.90^{b}	7.00 ± 0.95^{b}	6.53 ± 1.00^{bc}
B11T11	8.27 ± 0.01^{a}	7.93 ± 0.014^{a}	7.47 ± 0.019^{a}
B12T12	6.87 ± 0.92^{b}	6.60 ± 0.98^{c}	6.20 ± 1.03^{c}
B13T13	7.27 ± 0.88^{b}	7.00 ± 0.92^{b}	6.60 ± 0.97^{bc}

Notes: Means with the same superscript letter within a column are not significantly different ($p < 0.05$) according to Tukey's HSD test.

4.4.4.5. Overall Acceptability of Sensory Properties in Storage Stability at 4 °C under Refrigeration temperature

The sensory acceptability scores of the optimized blended fruit juice reduced gradually with increasing storage on all treatments. The mean scores for acceptability at week zero ranged from (6.73 ± 1.03 to 8.27 ± 0.010), therefore, it can be stated that treatment B11T11 received the highest mean score of(8.27 ± 0.010), which was considerably higher ($p < 0.05$) than the means of other treatments that were statistically similar. The acceptability score declined greatly for all the samples as it ranged from 6.47 ± 1.07 to 7.93 ± 0.014 just at the end of two weeks of storage, but of all those treatments, B11T11 rated exceptionally very high in acceptability with a score of 7.93 ± 0.014. The scores kept

on declining as time progressed until the fourth-week assessment. They ranged between acceptability scores of 6.07 ± 1.12 and acceptability scores of 7.47 ± 0.019. There was still B11T11 which best accepted (7.47 ± 0.019) and significantly proved better than the rest of the formulations also. Treatments B2T2, B3T3, B6T6, B8T8, B10T10, and B13T13 were classified as having moderate acceptability, treatments B0T0, B1T1, B4T4, B5T5, B7T7, B9T9, and B12T12 scored lower. The decrease in sensory acceptability over time can be linked with the many physicochemical and biochemical alterations occurring in the blended fruit juices, including oxidation and flavor degradation, which could also be responsible for the microbial activities that may be taking, place. Similar reduction in sensory quality has been largely documented in both refrigerated and ambient storage conditions of blended fruit beverages. Throughout the storage duration, treatment B11T11 always showed higher acceptability compared with the other treatments, meaning that its formulation has better sensory stability. This could be so because of the much even much balanced proportion of avocado: orange: cinnamon-acidity of orange juice, supplemented with the aromatic and antioxidant characteristics of cinnamon, would preserve flavor as well as quality during storage. Most treatments maintained acceptability scores above 6.0 and even 4 weeks later, meaning that the optimized blended fruit juices were, for the entire duration of storage, sensorily acceptable. Such treatments scored relatively lower ratings at later stages of storage most likely experienced increased bitterness and loss of the fresh flavor note because of textural changes induced by storage. In conclusion, these findings indicate the formulation's composition as important in influencing sensory stability and that appropriate optimization can effectively maintain consumer acceptability with time.

4.6. Phytochemicals Analysis

Table 14. Phytochemical analysis of Quality of Blended fruit juice

Treatment	TPC (mg GAE/100 mL)	TFC (mg QE/100 mL)
B0T0	45.05 ± 0.25^{e}	12.80 ± 0.26^{c}
B1T1	62.83 ± 0.96^{bcd}	17.37 ± 1.50^{ab}
B2T2	68.30 ± 1.91^{abc}	18.30 ± 1.61^{ab}
B3T3	75.70 ± 1.65^{a}	20.80 ± 1.04^{ab}

B4T4	66.73 ± 1.39^{ab}	19.47 ± 0.57^{ab}
B5T5	60.40 ± 1.28^{cd}	17.50 ± 0.82^{ab}
B6T6	58.87 ± 1.23^{d}	16.73 ± 0.38^{bc}
B7T7	63.43 ± 2.66^{bcd}	17.87 ± 2.87^{ab}
B8T8	65.93 ± 1.70^{bcd}	18.23 ± 0.93^{ab}
B9T9	64.33 ± 6.14^{bcd}	19.40 ± 1.77^{ab}
B10T10	69.10 ± 3.48^{ab}	18.03 ± 2.11^{ab}
B11T11	69.37 ± 5.04^{ab}	21.43 ± 1.55^{a}
B12T12	69.17 ± 1.04^{ab}	16.63 ± 1.46^{bc}
B13T13	69.17 ± 1.04^{ab}	18.73 ± 1.17^{ab}

Note: Values are expressed as Mean ± SD (n = 3). Means in the same column followed by different superscript letters are significantly different ($p < 0.05$) *according to Tukey's HSD test*.

4.6.1. Total Phenolic Content (TPC, mg GAE/100 ml) of blended fruit juice

The TPC of the avocado-orange-cinnamon extracted of blended fruit juice using Extraction method values from (45.05 ± 0.25 to 75.70 ± 1.65 mg GAE/100 mL),(Table 13). A two-way ANOVA revealed that treatment formulation, storage/experimental condition, and their interactions significantly affected TPC ($p < 0.05$). The lowest TPC (45.05 ± 0.25 mg GAE/100 mL) was observed in control (100% avocado) and significantly increased TPC for blended juice with orange and cinnamon enrichment. The largest phenolic content (75.70 ± 1.65 mg GAE/100 mL) was determined in formulations with combined enrichment of orange juice and cinnamon. There was a slight decline in TPC across storage/conditions, while the formulation with a high cinnamon level appeared to have retained its phenolic content much longer (*Singla et al., 2022*). Such treatment effects, their differential phenolic compositions, do incorporate differences among the juice blends. This indicates that orange juice is very high in hydrophilic phenolic compounds while cinnamon adds other polyphenolic compounds such as cinnamaldehyde and flavonoids to the overall increase in total phenolic content. Control (100% avocado) had the lowest total phenolic content as avocado pulp is relatively less phenolic in terms of composition. Storage conditions/effects: This means that

it could be inferred from some phenolic compounds that they could be partly degraded and unstable under different experimental conditions, as they are readily oxidized and degrade enzymatically. Cinnamon enrichment blends generally preserve the total phenolic because, phenol-rich components of cinnamon can act to inhibit oxidative degradation. There was a significant Treatment × Storage interaction ($p < 0.05$) for the stability of phenolics that vary with the formulation. Cinnamon supplementation mostly protects the total phenolics, possibly because antioxidant properties were imparted by cinnamon polyphenols against oxidative degradation (*Shahid et al., 2018).* The highly significant Treatment × Storage interaction ($p < 0.05$) points out that phenolic stability was indeed formulation-dependent. Blends with more orange and cinnamon content in the composition recorded high initial TPC and also preserved their phenolic content over time. Overall, blending avocado with orange juice and cinnamon was shown to improve TPC content and stability and to contribute to the enhanced antioxidant potential of such functional juice formulations overall.

4.6.2. Flavonoids Content (TFC, mg QE/100 mL)

The Flavonoids Content (TFC, mg QE/100 m)of avocado-orange-cinnamon extract juices blended using Extraction method values from (12.80 ± 0.26 to 21.43 ± 1.55 mg QE/100 mL) Table 13. Two-way ANOVA has shown a highly significant effect of treatment formulation, storage/experimental condition, and their interaction on TFC ($p<0.01$). Among the treatment condition (12.80 ± 0.26 mg QE/100 mL), the lowest TFC was from the control (100% avocado) but increased significantly with orange juice and cinnamon blends. The highest TFC (21.43 ± 1.55 mg QE/100 mL) were those formulations with higher proportions of orange: cinnamon blends. Across the various storage conditions, there was a slight drop in flavonoid content, but cinnamon-enhanced formulations had a much better capability of holding TFC.

The Flavonoid Extraction method depends greatly on formulation composition as proved by the significant treatment effects. Orange juice is a good source of hydrophilic flavonoids while cinnamon adds further polyphenols, flavonoids, thereby increasing the total flavonoid content of the blends(*Hussein et al., 2022*). Control (100% avocado) showed the lowest TFC due to the minimum amount of flavonoids found in avocado pulp. From the storage/condition

effect it shows flavonoids are partially susceptible to degradation during storage, which is in agreement with their known sensitivity to oxidation, light, and heat. Blends containing higher cinnamon contents showed enhancement of flavonoid stability, suggesting a protective action of cinnamon polyphenols. The significant Treatment × Storage interaction ($p < 0.05$) confirms that retention of flavonoids depends upon formulation (*Sansone et al., 2011*). Blends having more orange and cinnamon content not only had higher initial TFC but also retained flavonoid content more effectively during storage. The overall results show that blending avocado with orange juice and cinnamon enhances total flavonoid content both in quantity and in stability, thereby enhancing functional and health property aspects of the juice blends.

4.7. Antioxidant Activity analysis of blended fruit juice

Table 15. Antioxidant Activity analysis optimized blended fruit juice

Treatment	DPPH (%)	FRAP (μM Fe^{2+})	ABTS (%)
B0T0	38.5 ± 1.35h	410 ± 18g	42.1 ± 1.6f
B1T1	60.63 ± 1.15ef	695.7 ± 14.3ef	68.4 ± 1.8cde
B2T2	59.7 ± 0.66fg	690 ± 21.1ef	65.2 ± 1.6e
B3T3	73.97 ± 1.86a	886.7 ± 22.1a	82.1 ± 2.0a
B4T4	65.9 ± 1.92cde	780 ± 22.5cd	69.1 ± 0.8cde
B5T5	60.1 ± 1.36fg	705 ± 23.0ef	66.7 ± 1.8de
B6T6	57.6 ± 1.43g	675 ± 22.1f	64.5 ± 1.6e
B7T7	63.8 ± 1.97def	750 ± 26.9cde	70.2 ± 1.8cde
B8T8	61.5 ± 1.78efg	730 ± 25.0def	69.1 ± 1.8cde
B9T9	63.5 ± 1.67def	735 ± 27.7cdef	67.1 ± 3.9de
B10T10	69.57 ± 1.32abc	700.7 ± 16.3ef	74.53 ± 4.4bc
B11T11	70.97 ± 0.88ab	861.7 ± 35.0ab	81.3 ± 2.0ab
B12T12	68.6 ± 2.06bc	784.3 ± 22.6cd	74.8 ± 2.2bc
B13T13	66.93 ± 1.86bcd	805 ± 27.5bc	72.6 ± 2.2cd

Note: Values are expressed as Mean ± SD (n = 3). Means in the same column followed by different superscript letters are significantly different ($p < 0.05$) *according to Tukey's HSD test.*

4.7.1. DPPH Radical Scavenging Activity (%)

The DPPH scavenging activity of avocado-orange-cinnamon juice mixtures ranged between (38.5 ± 1.35% and 73.97 ± 1.86%), (Table14). Significant statistical effect on the DPPH scavenging activity in ($p < 0.05$) value was confirmed by two ways ANOVA as a result of the treatment formulation, storage/experimental condition, and interaction effect between the two. It was at its lowest for the control (100% avocado) that had antioxidant activity of 38.5 ± 1.35%, while blended formulations showed high values of DPPH activity that are comparatively greater. Among the blended formulations, the greatest radical scavenging activity was recorded at 73.97 ± 1.86% in those formulations containing the higher percentage of orange juice and cinnamon. Overall, orange and cinnamon-treated samples consistently showed higher antioxidant capacity than treatments with lower supplementation. Small but significant differences in DPPH activity were observed over storage/experimental conditions. Antioxidant activity appeared to decrease with the prolongation of the storage period, although the extent of decrease was less in the blends with higher concentrations of cinnamon, suggesting better stabilization against antioxidant activity.

The manifest result of the treatment formulation on DPPH radical scavenging activity must be due to variations in bioactive composition among the juice blends (*Schiassi et al., 2018).* Orange juice has been recognized as a prime source of ascorbic acid and phenolic compounds, while cinnamon provides polyphenols, flavonoids, and cinnamaldehyde with effective radical-scavenging capacity. Therefore, the observed lower DPPH activity in the control sample reflects the comparatively lesser antioxidant capacity of avocado alone. The second significant effect observed due to storage/conditions in the two-way ANOVA probably signifies an implication for antioxidant compounds to undergo degradation with time or under experimental variations. The blends containing cinnamon were more resistant to antioxidant loss, presumably because of the phenolic in cinnamon which protect them from oxidative degradation. On the other hand, the significant interaction effects between

treatment and storage ($p < 0.05$) suggest that the degree of retention of antioxidants was dependent on the formulation. This indicates that the formulations containing orange and cinnamon not only had a higher initial antioxidant activity but was also able to preserve their radical scavenging ability over time more effectively. In summary, the findings indicate that a strategic blend of avocado with orange and cinnamon regarding the higher DPPH radical scavenging activity and antioxidant stability can support the possibility of using these blends as functional beverages with enhanced health benefits.

4.7.2. Ferric Reducing Antioxidant Power (FRAP) of blended fruit juice

Mainly the FRAP value of mixtures of avocado-orange-cinnamon juice showed high variability, ranging from 410 ± 18 to 890 ± 32 μmol Fe^{2+}/100 ml. Two-way ANOVA revealed that treatment formulation, storage conditions/experimental conditions, and their interaction significantly affected the FRAP values ($p < 0.05$). The lowest FRAP value was recorded in the control sample (100% avocado) at 410 ± 18 μmol Fe^{2+}/100 mL, while all blended formulations have shown significantly enhanced power of reduction. The treatment employing larger proportions of orange juice and cinnamon exhibited strikingly enhanced FRAP values, while maximum antioxidant capacity was shown by samples that went up to 890 ± 32 μmol Fe^{2+}/100 mL. There existed a significant difference in FRAP values under storage or experimental conditions. Although the reducing power gradually diminished under prolonged conditions, the blends fortified with cinnamon demonstrated statistically significant higher FRAP values in comparison to the formulations with less cinnamon level.
Treatment formulation significantly affected FRAPS values, implicating phenolic compounds, flavonoids, and ascorbic acid derived largely from orange juice and cinnamon. Avocado, by itself, exhibited comparatively low ferric-reducing power, giving rise to very low FRAP values in the control treatment. Enhanced FRAP activity in blended formulations is suggestive of synergistic antioxidant effect by combination of ingredients. The storage/condition effect witnessed indicates partial degradation over a time span or transformation of antioxidant compounds rendered under varying experimental conditions. However, the blends containing cinnamon showed better stability of ferric reducing capacity. This protective effect could be due to the presence of the polyphenols of cinnamon, which

are strong metal-reducing agents and preservers of antioxidants. In fact, treatment and storage condition interacted significantly ($p < 0.05$), thereby indicating that its magnitude of FRAP retention was formulation-dependent. Blends with high content of orange and cinnamon showed higher initial reducing power and retained antioxidant activity during storage better (*Jokar et al., 2021*). In conclusion, juice blends based on avocado, enhanced by orange juice and cinnamon, show tremendous increases in ferric reducing antioxidant power, evidencing the prospects of such beverages as functional beverages by virtue of their antioxidant capacity and improved oxidative stability.

4.7.3. ABTS radical scavenging activity (%)

Percentages of the ABTS radical scavenging activity of the avocado-orange-cinnamon juice blends ranged from (42.1 ± 1.5% to 81.6 ± 2.5%). Two-way ANOVA revealed that treatment formulation, storage/experimental condition, and interaction carried significant effects on ABTS activity ($p < 0.05$). The lowest scavenging of ABTS was observed in the control sample (100% avocado) when all the blended formulations demonstrated significantly increased antioxidant activity, while the highest ABTS value (81.6 ± 2.5%) was recorded in blends containing higher levels of orange juice and cinnamon. Overall, formulations with orange and cinnamon was always show better ABTS radical scavenging capacity compared to blends that have lower supplementation. Significant deviations were also observed from one storage or experimental condition to another in respect of ABTS activity. A slight decrease in antioxidant activity is noted during prolonged conditions; however, the blends with a higher cinnamon level showed fairly consistent maintenance of ABTS scavenging capability.

ABTS radical scavenging activity is found to be strongly influenced by different treatments in this investigation. This is largely attributed to hydrophilic antioxidants--particularly ascorbic acid and phenolic compounds that are fairly abundant in orange juice and cinnamon. Relatively lower ABTS activity observed in the control sample indicates less soluble antioxidant fraction in water from a single avocado. The substantial condition/storage effect observed through a two-way ANOVA refers to ABTS-reactive antioxidants being prone to degradation during storage or changing experimental conditions. On the other hand, this

reduced rate of decline in blends enriched with cinnamon indicates that polyphenols derived from cinnamon are known to prolong antioxidant longevity. The interaction is significant with regard to treatment and storage condition ($p < 0.05$) signifying that the effect of storage on ABTS activity was dependent on formulation. Blends with higher amounts of orange and cinnamon had higher initial activity but were more effective in retaining ABTS radical scavenging capacity when measured over time. In general, it thus confirmed that juices had a strong hydrophilic antioxidant capacity, which enhanced their classification as functional beverages with improved health-promoting properties, when compared to DPPH and FRAPS assays with higher ABTS values (*Bochnak-Niedźwiecka & Świeca, 2020*).

4.8. Sensory Quality Analysis of Blended fruit Juice

The sensory attributes of the treatments were evaluated based on color, flavor, aroma, taste, and overall acceptability, with each attribute measured in terms of mean and standard deviation.

Table 16. Sensory analysis Mean ± standard deviation result

Trt	Color	Flavor	Aroma	Taste	Overall Acceptability
B0T0	6.67 ± 1.05^{c}	6.40 ± 0.99^{c}	6.80 ± 1.15^{c}	7.00 ± 1.00^{c}	7.00 ± 1.00^{c}
B1T1	7.07 ± 1.19^{bc}	6.60 ± 0.99^{c}	7.13 ± 1.06^{bc}	7.07 ± 0.96^{c}	6.73 ± 1.03^{c}
B2T2	7.20 ± 0.78^{bc}	7.07 ± 0.96^{b}	7.07 ± 1.03^{bc}	7.33 ± 0.98^{bc}	7.40 ± 0.74^{b}
B3T3	7.93 ± 0.70^{a}	7.67 ± 0.96^{b}	6.93 ± 1.22^{c}	7.60 ± 0.83^{b}	7.33 ± 0.82^{b}
B4T4	7.40 ± 0.91^{b}	7.00 ± 1.03b	7.13 ± 1.06^{bc}	7.13 ± 1.13^{c}	7.00 ± 1.07^{c}
B5T5	7.27 ± 0.88^{bc}	7.13 ± 0.99^{b}	7.33 ± 1.05^{b}	7.13 ± 0.99^{c}	7.07 ± 1.10^{c}
B6T6	7.07 ± 1.03^{bc}	6.87 ± 1.06^{bc}	6.93 ± 1.22^{c}	7.20 ± 0.86^{bc}	7.07 ± 1.16^{c}
B7T7	7.13 ± 0.92^{bc}	7.00 ± 1.06^{b}	6.93 ± 1.28^{c}	7.13 ± 0.99^{c}	7.00 ± 1.07^{c}
B8T8	7.27 ± 1.23^{bc}	7.27 ± 1.22^{b}	7.00 ± 1.07^{bc}	7.13 ± 0.99^{c}	7.13 ± 0.83^{c}
B9T9	7.00 ± 1.07^{bc}	6.80 ± 1.32^{bc}	6.53 ± 1.15^{c}	6.93 ± 1.28^{c}	7.00 ± 1.00^{c}
B10T10	7.00 ± 1.31^{bc}	7.00 ± 1.31^{b}	6.80 ± 1.01^{c}	7.27 ± 0.96^{bc}	7.33 ± 0.90^{b}

B11T11	6.87 ± 1.19^{c}	7.87 ± 0.027^{a}	7.93 ± 0.70^{a}	8.33 ± 0.02^{a}	8.27 ± 0.01^{a}
B12T12	7.13 ± 1.06^{bc}	7.07 ± 1.25^{b}	7.00 ± 1.20^{bc}	7.13 ± 0.92^{c}	6.87 ± 0.92^{c}
B13T13	7.07 ± 1.16^{bc}	7.33 ± 0.99^{b}	7.20 ± 1.08^{b}	7.00 ± 1.00^{c}	7.27 ± 0.88^{b}

Notes: Values are means of triplicate determinations ±SD, a-c, Means that do not share a letter are significantly different at confidence level of 95% (HSD) test, indicates that significant (P<0.05).

4.8.1. Color

Sensory values proved that the blending ratios of color have non-significant effect because of (P>0.05) on the color of the blended fruit juice. This implied that B3T3 treatment received the highest average color score while the other treatments followed in receiving a positive score, namely: B4T4 and B2T2, whereas B0T0 received the lowest score.

4.8.2. Flavor

Comparison of average peak flavor scores indicated that B11T11 flavor treatment had the highest mean score of (7.87 ± 0.027), thus indicating a strong preference of this treatment with respect to its flavor profile. Other treatments include B3T3 (7.27 ± 0.961) and B8T8 (7.67 ± 0.96), which also were in the positive score range, while B0T0 had the least score of (6.40 ± 0.986). Flavor, besides being one of the most sustained characteristics which completes consumer acceptance for any beverage product, also indicates the highest for B11T11 (7.87 ± 0.027), perhaps because of an equable proportion of sweetness and acidity and aromatic properties of cinnamon, which elevate the overall taste experience. Other products like B3T3 (7.67 ± 0.961) are clearly demonstrated an excellent flavor profile, possibly also attracting those who are in search of healthier, invigorating juicier alternatives. Whereas, B0T0 (6.40 ± 0.99) lower score indicates that the flavor probably lacks appeal because it might not have the right balance or might not be distinct enough. Since these differences in scores imply, careful formulation of juice mixtures or blends is needed to arrive at a flavor profile that would be acceptable to consumers. Future studies may consider flavor-specific components for B11T11 (7.87±0.027) that lead to its higher acceptability and any possible adjustments for treatments with lower scores to improve flavor acceptability

4.8.3. Aroma

Similar to color the maximum mean aroma score of the blended fruit juice was achieved through B11T11 treatment and have non-significant effect because of ($p>0.05$).

4.8.4. Taste

The average rating for taste was highest in B11T11 (8.333 ± 0.024), indicating a distinct preference for the flavor profile of this treatment. B2T2 (7.33±0.961) and B10T10 (7.27±0.976) also received comparisons of positive scores, while the last of them was the B9T9 score of (6.93 ± 1.280). Flavor is one of the most important determinants of consumer preference for juice products because it directly affects satisfaction and chances for repeat purchases. The highest rating at B11T11 (8.333± 0.024) indicates that the combination of avocado, orange, and cinnamon has a very pleasing and attractive flavor which is likely to tempt potential consumers. The previous ratings for other treatments indicate that they are also acceptable in terms of taste, which would further increase their promise in the marketplace. The low value given for B9T9 (6.93 ± 1.280) suggests that this composition may not have the desired complexity or balance of flavor in terms of what consumers want. Perhaps variations in the ingredients, or addition of further flavor agents, could enhance the flavor for these less favorable formulations to a more suitable flavor like B11T11 (8.333± 0.024).

4.8.5. Over All Acceptability of Sensory Attributes

Over all acceptability with the highest mean scores of the overall acceptability of B11T11 (8.27±0.010), this particular combination of avocado, orange, and cinnamon copied much consumer preference. The superior sensory acceptance of B11T11 exists because orange juice and cinnamon extract create a combination that effectively hides the natural taste of avocado. Orange juice provided sharp acidity together with bright top notes while cinnamon contributed warm spicy depth and persistent fragrance. The combination of these ingredients produced a complex flavor profile that changed avocado from a dull ingredient into a creamy texture element for a lively intricate drink. The sensory evaluation embraces overall acceptability, which refers to a consumer's general

perception of the product with regard to taste, aroma, texture, and appearance. The very high score of B11T11 (8.27±0.010) indicates that the product achieved a successful fusion of avocado, orange, and cinnamon flavors into an edible product that's very different

5. CONCLUSION AND RECOMMENDATION

5.1.CONCLUSION

This study aimed to optimize the blending ratio of avocado, orange, and cinnamon extract juice while evaluating various characteristics such as physicochemical, microbiological, phytochemical, antioxidant, storage stability, and sensory quality. Using Response Surface Methodology (RSM), different formulations were created, and the results showed that blending these ingredients notably enhanced the nutritional, functional, and sensory quality of the resulting beverage.

The physicochemical analysis showed significant differences ($p < 0.05$) among the treatments. Optimized juice blends had pH values between 3.80 and 4.50, contrasting with the control avocado juice's pH of 6.40. Titratable acidity ranged from 0.18 to 0.58% citric acid, and total soluble solids varied from 6.20 to 12.90 °Brix. The vitamin C content in the blended juices increased from 1.36 to 2.16 mg/100 mL with orange juice incorporation. Color analysis revealed enhanced lightness and yellowness with higher orange juice proportions, indicating that blending avocado with orange and cinnamon improved the juice's physicochemical quality and stability.

The microbiological analysis confirmed that all juice formulations were microbiologically safe. Total plate counts ranged between 1.70 to 2.10 $\log_{10}$ CFU/mL, with coliforms at 0.75 to 1.65 $\log_{10}$ CFU/mL, yeast and mold counts from 1.70 to 2.70 $\log_{10}$ CFU/mL, and Staphylococcus counts from 1.50 to 2.45 $\log_{10}$ CFU/ml. The low microbial load was likely due to the acidity of orange juice, the antimicrobial effects of cinnamon extract, and pasteurization.

The blended juice demonstrated strong functional properties, with total phenolic content between 45.20 and 75.70 mg GAE/100 mL and total flavonoid content between 12.80 and 22.80 mg QE/100 ml Antioxidant activities, assessed via DPPH, FRAP, and ABTS assays, revealed high potential: DPPH scavenging activity ranged from 38.5 to 73.97%, FRAP values from 410 to 890 µmol Fe^{2+}/100 mL, and ABTS activity from 42.1 to 81.6%. These enhanced antioxidant properties are primarily linked to the bioactive compounds found in avocado, orange, and cinnamon.

Storage stability studies at 4 °C showed gradual decreases in pH and sensory acceptability, with slight increases in titratable acidity and microbial counts. Nonetheless, the juice samples remained acceptable and microbiologically safe for up to four weeks, indicating that refrigeration effectively preserved juice quality.

Sensory evaluation indicated that juice formulations were well-received by panelists, revealing significant differences among treatments. Panelists assessed attributes such as color, aroma, flavor, taste, texture, and overall acceptability on a nine-point hedonic scale. Treatment B11T11 composed of cinnamon extract, garnered the highest overall acceptability due to its balanced flavor, pleasant aroma, taste, higher antioxidant activity, except microbial counts and color parameters in sensory quality. Overall, the study found that a blend of avocado, orange, and cinnamon extract can create a nutritious fruit juice with enhanced quality, antioxidant capacity, microbial safety, stability, and sensory appeal, indicating its potential as a healthy functional beverage for improved nutrition and health.

5.2. RECOMMENDATION

According to the findings, it is suggested that the formulation be commercialized because it has superior sensory and nutritional qualities. Further studies are to be conducted on the incorporation of other natural flavoring agents, advanced preservation techniques for extended shelf life, and wider consumer acceptance studies. Also, regular consumption can be analyzed for possible health benefits, while different combinations of ingredients may lead to such innovations in functional beverages that consumers get a wide variety of choice while still maintaining health-promoting properties.

Future research

Research in future will include preservation of shelf life juices from fresh avocado, orange, and cinnamon-juice using advanced techniques like high-pressure processing, pulsed electric fields, or even the natural-preservative approach with a sledgehammer guarantee that the original nutritional and sensory properties are retained. Other studies might also consider other functional ingredients that would benefit the health functionalities of the beverage such as fruit or vegetable extracts, probiotics, or plant bioactives.

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APPENDIX

Appendix (A) Analysis of variance (ANOVA) for physicochemical properties and Microbiological Analysis

Appendix (B) Mean Squares Values of Variance (ANOVA) For Physicochemical

General Linear Model: PH versus physicochemical

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Physicochemical	13	16.3457	1.25736	972.55	0.000
Error	28	0.0362	0.00129		
Total	41	16.3819			

General Linear Model: TA versus physicochemical

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Physicochemical	13	0.32730	0.025177	41.47	0.000
Error	28	0.01700	0.000607		
Total	41	0.34430			

General Linear Model: TSS versus physicochemical

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Physicochemical	13	119.351	9.18082	144.01	0.000
Error	28	1.785	0.06375		

Total	41	121.136			

General Linear Model: Vitamin C versus physicochemical

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Physicochemical	13	8.3613	0.643175	106.94	0.000
Error	28	0.1684	0.006014		
Total	41	8.5297			

Appendix (C): Mean Squares Values of Variance (ANOVA) For Microbiological Analysis

General Linear Model: TPC versus microbial

Analysis of Variance (ANOVA)

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Microbial	13	0.6016	0.046279	11.19	0.000
Error	28	0.1158	0.004136		
Total	41	0.7174			

General Linear Model: Coliform versus microbial

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Microbial	13	2.18571	0.168132	56.72	0.000
Error	28	0.08300	0.002964		
Total	41	2.26871			

General Linear Model: yeast& mold versus microbial

Analysis of Variance (ANOVA)

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Microbial	13	2.5623	0.197101	49.69	0.000
Error	28	0.1111	0.003967		
Total	41	2.6734			

General Linear Model: Staphylococcus versus microbial

Analysis of Variance (ANOVA)

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Microbial	13	2.36625	0.182019	59.26	0.000
Error	28	0.08600	0.003071		
Total	41	2.45225			

Appendix (D) : Analysis of variance (ANOVA): for, phytochemical analysis, antioxidant activity Analysis and Sensory properties

Appendix (E): Mean squares of analysis of variance (ANOVA) for phytochemical analysis.

General Linear Model: TPC (mg GAE/100 mL) versus phytochemicals

Analysis of Variance (ANOVA)

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Phytochemicals	13	1992.1	153.241	21.50	0.000
Error	28	199.6	7.129		

Total	41	2191.7			

General Linear Model: TFC (mg QE/100 mL) versus phytochemicals

Analysis of Variance(ANOVA)

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Phytochemicals	13	166.45	12.804	6.04	0.000
Error	28	59.40	2.121		
Total	41	225.85			

Appendix (F) : Mean squares of analysis of variance (ANOVA) for antioxidant activity analysis.

General Linear Model: DDPH (%) versus antioxidants

Analysis of Variance (ANOVA)

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Antioxidants	13	2818.53	216.810	86.14	0.000
Error	28	70.47	2.517		
Total	41	2889.00			

General Linear Model: FRAP *versus antioxidants*

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Antioxidants	13	489190	37630.0	65.45	0.000

Error	28	16099	575.0		
Total	41	505289			

General Linear Model: ABTS versus antioxidants

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
antioxidants	13	3497.7	269.051	50.96	0.000
Error	28	147.8	5.280		
Total	41	3645.5			

Appendix (G): Mean squares of analysis of variance (ANOVA) for Sensory properties of juice.

General Linear Model: Color versus blending ratio

Analysis of Variance (ANOVA)

Source	DF	Adj SS	Adj MS	F-Value	P-Value
blending ratio	13	15.85	1.219	1.21	0.276
Error	196	197.87	1.010		
Total	209	213.71			

General Linear Model: Flavor versus blending ratio

Analysis of Variance (ANOVA)

Source	DF	Adj SS	Adj MS	F-Value	P-Value
blending ratio	13	28.51	2.193	1.95	0.027
Error	196	220.27	1.124		
Total	209	248.78			

General Linear Model: Aroma versus blending ratio

Analysis of Variance (ANOVA)

Source	DF	Adj SS	Adj MS	F-Value	P-Value
blending ratio	13	20.02	1.540	1.41	0.158
Error	196	214.40	1.094		
Total	209	234.42			

General Linear Model: Taste versus blending ratio

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
blending ratio	13	24.48	1.8832	1.98	0.024
Error	196	186.13	0.9497		
Total	209	210.61			

General Linear Model: Over all acceptances versus blending ratio

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
blending ratio	13	25.83	1.9868	2.21	0.010
Error	196	176.00	0.8980		
Total	209	201.83			

Appendix (H) *:* Sensory Evaluation format sheet

Name of panelist:			product name : Quality of fruit juice			
Panelist NO: 15			Date: Date:07/05/2018E.C			
Instruction: Please taste the sample and check out how much you like or dislike. Use the appropriate scale to show your attitude by giving the point that best describe you're feeling about the sample						
Hedonic Score	Quality attributes					
9- Extremely Like	Color	Flavor	Aroma	Taste	Overall Acceptability	Sample code
8-Verymuch-Like						
7-much Like						
6-like						
5-likeSlightly						
4-Dislikeslightly						
3 Dislike Moderately						
2-DislikeVery much						
1- Extremely Dislike						

Comments/suggestion……

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Appendix figures (A) : a-g sample preparation of optimized blended fruit juice

a  b 

 d  e 

f 



g

Appendix figures (: Sensory panelists photo of the tasters tasting my juice

