Processing effect on nutritional qualities of value added products from select underutilized fruits of Sikkim

A Thesis Submitted

to

Sikkim University

In Partial Fulfilment of the Requirement for the

Degree of Doctor of Philosophy

By

Ningma Doma Sherpa

Department of Horticulture

School of Life Sciences

Sikkim University

Gangtok Sikkim - 737102

INDIA

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DECLARATION

I Ningma Doma Sherpa, hereby declare that the thesis entitled "**Processing effect on nutritional qualities of value added products from select underutilized fruits of Sikkim**" was done by me and the content of this thesis did not form basis of the award of any previous degree to me or, to the best of my knowledge, to anybody else and that the thesis has not been submitted by me for any other research degree in any other University/Institute.

The content of this thesis has also been subjected to plagiarism check.

This is being submitted in partial fulfilment of the requirements of the Degree of Doctor of philosophy in Horticulture, School of Life sciences, Sikkim University.

Date: 28/12/2021
Place: Gangtok

Ningma Doma Sherpa
Ningma Doma Sherpa
Registration No.: 14SU15587

6 माइल, सामदुर, तादोंग - 737102
गंगटोक, सिक्किम, भारत
फोन-03592-251212, 251415, 251656
टेलीफैक्स - 251067
वेबसाइट - www.cus.ac.in

6th Mile, Samdur, Tadong-737102
Gangtok, Sikkim, India
Ph. 03592-251212, 251415, 251656
Telefax : 251067
Website : www.cus.ac.in

सिक्किम विश्वविद्यालय
SIKKIM UNIVERSITY

(भारत के संसद के अधिनियम द्वारा वर्ष 2007 में स्थापित और नैक (एनएएसी) द्वारा वर्ष 2015 में प्रत्यायित केंद्रीय विश्वविद्यालय)
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"Processing effect on nutritional qualities of value added products from select underutilized fruits of Sikkim"

Submitted by **NINGMA DOMA SHERPA** under the supervision of Dr. Karma Diki Bhutia, Department of Horticulture, Sikkim University, Gangtok, 737102, India.

Ningma Doma Sherpa

Ningma Doma Sherpa

Signature of the Scholar

Karma

Dr. Karma Diki Bhutia

Countersigned by the Supervisor

6 माइल, सामदुर, तादोंग - 737102
गंगटोक, सिक्किम, भारत
फोन-03592-251212, 251415, 251656
टेलीफैक्स - 251067
वेबसाइट - www.cus.ac.in

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(A central university established by an Act of Parliament of India in 2007 and accredited by NAAC in 2015)

6th Mile, Samdur, Tadong-737102
Gangtok, Sikkim, India
Ph. 03592-251212, 251415, 251656
Telefax : 251067
Website : www.cus.ac.in

CERTIFICATE

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All the assistance and help received during the course of the investigation have been duly acknowledged by her.

I recommend this thesis to be placed before the examiners for evaluation.

Date: 28|12|2021

Place: Gangtok

(Karma Diki Bhutia)

SUPERVISOR
Department of Horticulture

6 माइल, सामदुर, तादोंग - 737102
गंगटोक, सिक्किम, भारत
फोन-03592-251212, 251415, 251656
टेलीफैक्स - 251067
वेबसाइट - www.cus.ac.in

6th Mile, Samdur, Tadong-737102
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Date: 28/12/2021
Place: Gangtok

Niladri Bag 28.12.2021
(Dr. Niladri Bag)
Head and Associate Professor
Department of Horticulture

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Date: **Ningma Doma Sherpa**
Place:

CONTENT

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS USED

°B	Degree Brix
%	Percent
°C	Degree Centigrade
µg	Micro gram
A.O.A.C	Association of Official Analytical Chemists
AAE	Ascorbic acid equivalent
FW	Fresh weight
GM	gram
Kg	Kilogram
Mg	milligram
MI	millilitre
No.	Number
nm	Nanometre
ND	Not Detected/Determined
SD	Standard Deviation
CD	Critical difference
DPPH	2,2-diphenyl-1-picrylhydrazyl
DW	Dry weight
e.g.	For example
et al.	Co – workers
GAE	gallic acid equivalent
QE	quercitin equivalent

CHAPTER-1 INTRODUCTION

Sikkim is a hilly state in the Eastern Himalayas between 88^{o} to 89^{o} East longitudes with 27^{o} to 28^{o} North latitude, with a diverse range of biodiversity, particularly underutilized plants edible for decades. (Sundriyal, 1999) discovered that locals in the Sikkim Himalaya consume 190 wild edible species. There is a lot of interest and attention being paid to this area these days, especially because of their nutrition and various mineral compositions (Arora and Pandey, 1996). It is clear that nearly 64 percent of the people in the state rely on agriculture for a living. Fruits are a natural source of micronutrients such as minerals and vitamins, as well as secondary metabolites such as polyphenols (Sundriyal, 1999). Fruits, particularly those identified as underutilized, play an important role in improving health and nutrition, as well as household food security, which contributes an important part to the diet of local inhabitants. The Sikkim Himalayas have a high diversity of underutilized or lesser-known plant species (>250 species). It is patently obvious that these underutilized plant species are considered to be poor people's food (Sharma *et al.,* 2016). Underutilized fruits play a significant role in supplying foods for local communities all over the world (Sundriyal*et al.,* 2003; Mbuvi and Boon, 2009) by meeting economic status as well as prospective functions, particularly by improving the local community and their livelihoods. The native people of Sikkim use inflorescences, tubers, leaves, roots, rhizome and fruits of wild plants are consumed by local people as well as various other purposes such as medicine (Rai *et al.,* 2005) and usually, the sensory attribute of plants tends to attract them. Underutilized fruits are neither domesticated nor cultivated, but they are known to contribute to food security, health and nutrition, medicinal treatment, economic status, cultural heritage, and environmental protection (Jaenicke&Hoschle-Zeledon, 2006). Several works of literature have been published on the nutritional aspect of these wild food plants, which have been found to be nutritionally richer than some cultivated and domesticated ones (Burlingame, 2000). Underutilized crops are currently receiving much-needed attention and have the potential towards becoming useful parents in breeding programmes, as a source of income, and as a source of future food and supply (Burlingame, 2000; Olorodo, 2004).

(Salt *et al.*, 2010) defined ionome as the study of minerals, nutrients, and trace elements. ICP's goal is to ionise and analyse atoms in preparation for detection via optical emission spectroscopy (ICP-AES) or mass spectrophotometry (ICP-MS). Ionome content is essential for the regulation and maintenance of many functions in the human body, and it is also widely distributed in nature in various forms. It is also required for molecular, biological, and chemical functions in cells (Prashanth *et al.,* 2016). Fruits, also known as protective foods, are known to provide the requisite vitamins and essential elements for human health, such as calcium, iron, zinc, potassium, and so on (Aberoumand & Deokule, 2009). Polyphenols, vitamins, minerals, and antioxidants found in underutilized fruits have been shown to have anti-aging, anti-inflammatory, and anti-cancer properties due to radical scavengers, singlet oxygen quenchers, and metal chelators (Prakash and Kumar, 2011).

There is a need for, and a great opportunity for the value addition of these underutilized edible fruits that lead to domestication. Food processing is the transformation of a commodity into consumable food products. Food processing ensures growers of fair returns, ultimately improving their socioeconomic situation. It creates employment opportunities in the agricultural sector through the development of entrepreneurship. Processing the fruits increases their utilization by reducing wastage of these underutilized fruits, delivering year-round availability in abundance, boosting and increasing awareness about the importance of nutritional value, and continuing to improve their marketing prospects through value addition. As a result, better value recognition has resulted in a new path for the use of these underutilized fruit species while also promoting their conservation and domestication.

Overpopulation, increasing deforestation due to urbanization, and overexploitation have all been observed in recent years as a threat to the extinction of some of these underutilized fruits that have been valued for centuries. Despite the importance of these underutilized fruit crops, they have been overlooked in the past because exotic crops for production purposes were preferred, but now these unexploited and underutilized species are generating interest and attention due to their potential contribution in preventing many health-related diseases, malnutrition, obesity, diet-related disorders, and hidden hunger.

Processing is well known for reducing vitamins, carotenoids, and anthocyanin levels depending on the method used. High temperature is known to accelerate reactions resulting in a decrease in nutrition composition. It alters the stability of various micronutrients found in foods. The term "thermal" refers to the process of heat treatment. Since antiquity, heat treatment has been a successful method of preserving foods. It is also affordable and accessible to locals in areas where sophisticated instruments are not available. It is well established that high temperatures gradually reduce nutrient compositions while inactivating food – poisoning and spoilage and altering sensory attributes such as colour and flavour (Rawson *et al.*, 2011), resulting in high-quality food that meets the demand for nutritious food. Both vitamin A and ascorbic acid are micronutrients that are sensitive to light, oxidising agents, and heat, complicating nutritional compositions. Food products are fortified to compensate for nutrient loss by adding nutrients, minerals, prebiotic culture, and blending with other fruits or food products. Food selection (vehicle) and nutrient addition (fortificant) are critical criteria for food fortification. The food chosen should be easily accessible to the population and sufficient to meet and match their dietary requirements on a daily basis (Das *et al.*, 2013). It confronts the nutritional needs of a region's and countries' populations. According to FAO estimates, approximately 800 million people lack adequate food and nutrition security, particularly among underprivileged populations. Anaemia affects 42 percent of children under the age of five, and 40 percent of pregnant women worldwide (WHO: Geneva 2021). According to this viewpoint, food fortification has the potential to provide micronutrient status to a significantly larger fraction of the population. It will provide consumers and local residents with an easy way to introduce these new products into their daily diet as a health-enhancing aid, especially when fortified, as there is a constant effort to develop nutritious, delicious, nutritious, and appealing food products from a variety of sources.

Further to that, the potential of processed products is considered safe for consumption while they're in good sensory and quality by inactivating microbiological activity and increasing shelf life without affecting health. Although some literature has indeed been evaluated regarding documentation, genetic improvement, health and nutrition aspect, and epidemiology research of these select underexploited fruits, research on diversified value-added products, its processing impact on nutritional and ionome profiling aspect, including fortification of these value-added products are scarce and require thorough evaluation, identification, maintenance, and exploration to outsource its potential. It also contributes significantly to promoting awareness of the dietary benefits of the underutilized fruits as raw, value-added products, and fortified foods with higher margin recognition among residents and others across the country.

Despite the numerous nutritional benefits of these wild edible fruits, processed products of these fruits are underutilized due to time-consuming preparation and a lack of understanding of the health benefits. As a result, innovative processed products made from these fruits can reduce the time required for preparation, making them an excellent choice for today's consumers.

Considering the necessity and significance of underutilized edible fruit crops in maintaining nutritional and food security, as well as improving the livelihood development of Sikkim's local residents five of the most prominently consumed underutilized fruit species namely *Diploknema butyracea, Hippophae salicifolia, Docynia indica, Elaeagnus latifolia*, and *Machilus edulis,* were chosen for the current study. The current study, titled **"Processing effect on nutritional qualities of value added products from select underutilized fruits of Sikkim"**used a systematic approach to achieve the following objectives:-

1. Nutritional assessment and ionome profiling of select underutilized fruits (*Diploknema butyraceae, Hippophae salicifolia, Docynia indica*, *Elaeagnus latifolia* and *Machilus edulis*).
2. Development of diversified value added products from select underutilized fruits of Sikkim.
3. Effect of processing on nutritional and ionome content of the processed products.
4. Fortification after processing and comparing with the commercial products.

CHAPTER-2 REVIEW OF LITERATURE

Wild edible fruits are not cultivated at the commercial level neither domesticated as they are grown in the forest area being the source of nutritional food for the local population since decade (Beluhan and Ranogajec, 2010). Several studies reported the chemical composition and nutritional value of wild food (Shadidi and Naczk, 2004; Alasalvar and Shadidi, 2005; Liyana-Pathirana *et al.*, 2006; Prajapati *et al.*, 2009; Halilova and Ercisli, 2010; Imran *et al.,* 2010; Abou-Arab *et al.,* 2011; Badhani *et al.,* 2011; Kasim *et al.,* 2011; Rathod and Valvi, 2011) and several reports have been reported wild edible plant as nutritionally superior when compared to the cultivated ones (Burlingame, 2000). The wild edible fruit can be a major source or alternate for nutritional food maintaining food security and livelihoods during scarcity and drought situations in future. (Afolayan and Jimoh, 2009). The wild edible fruit plants species and their genetic diversity are being endangered due to deforestation, urban lifestyles and cultural transformations which have led to changes. Many indigenous communities had transformed or changed their traditional beliefs and their knowledge regarding these plants over some time (Benz *et al.,* 2000; Byg and Balslev 2001; Ladio and Lozada, 2003). Since traditional knowledge on wild fruits is being gradually vanishing through acculturation and loss of plant conservation along with indigenous people and their cultural background, promoting research on wild fruit plants is a necessity for future (Asfaw, 2009). The potential role of wild edible fruits *Diploknema butyracea, Hippophae salicifolia, Docynia indica, Elaeagnus latifolia, Machilu edulis,* its processed products and fortification plays a major role in providing food security belonging to the tribal area. A perusal of literature reveals not much work has been identified on this aspect. Fortunately, scattered literature that are available suggested some systematic work but unfortunately, these are not on a detail and full-scale basis.

Therefore, a systematic approach was made in the present study entitled **"Processing effect on nutritional qualities of value added products from select underutilized fruits of Sikkim"** which are presented under the following heads:

- **Nutritional assessment and Ionome profiling**
- **The impact of processing on nutritional and ionome profiling of value added foods**
- **Fortification and Sensory Assessment**
- **Microbial Assessment**

2.1. Nutritional assessment

2.1.1. Total soluble solid (TSS) and Titratable acidity

Total soluble solid is an important characteristic, helps to measure the sugar content of fruits and vegetables whereas Titratable acidity indicates the total or potential acidity of the total number of acid molecules, both protonated and unprotonated. (Kapoor Pallavee and Mathur Ashwani, 2017) reported the total soluble sugar (TSS) content in *Hippophae rhamnoides L*. ranges from (9.3 to 27.9° Brix). TSS determined for the underutilized fruits of *Elaeocarpus sikkimensis* had highest acidity (3.75 %) followed by *Baccaurea sapida* (2.26 %), *Bassia butyracea* (2.24 %), *Eriolobus indica* (2.23 %), *Diploknema butyraceae* (0.026 %), *Elaeagnus latifolia* (0.072 %), *Eriolobus indica* (0.085%), *Machilus edulis* (0.006 %), *Spondias axillaris* (0.036 %), *Passiflora edulis* (3.30 %), *Prunus cerasoides* (1.41 %), *Morus alba* (1.49 %)

and *Terminalia chebula* had 3.24 % respectively (Sundriyal *et al.,* 1998; Sundriyal and Sundriyal, 2001. TSS of *Rubus ellipticus* juice was 16.6 % (Parmar and Kaushal, 1982). Titratable acidity, pH and total dry weight (percent citric acid) of sea buckthorn were perceive as (17.60 ± 1.94) – (21.97 ± 2.34) mg/100 g, (3.20 ± 0.07) – (4.78 ± 0.15) and (0.84 ± 0.40) % – (2.00 ± 0.08 %) (Eccleston *et al.,* 2002). (Rymbai *et al.,* 2016) reported TSS (8.2–14.1 %) and acidity (1.93 %) in the fruit of *Baccaurea sapida, Elaeagnus latifolia* (TSS 11.9 % and titratable acidity with (2.8 %), *M. esculenta* (TSS 5.7–6.5 % and titratable acidity 2.5–4.8 %). (Kumar *et al.,* 2015) discovered the maximum TSS in the fruit of *Diploknema butyraceae* (18º Brix) and the minimum was recorded in *Machilus edulis* (3º Brix). (Sharma *et al*., 2015) estimated the physico-chemical characteristics of five edible wild fruits grown in Manipur, with the TSS and titratable acidity being highest in *Docynia indica* (8º Brix) and *Rhus semialata* (16.51%) respectively.

(Deb and Bhawmik, 2013) researched the physico-chemical compounds of Burmese grape (*Baccaurea sapida Muell)* - an underutilized fruit of West Bengal and reported total soluble solids in a range of (11.52º Brix - 13.12º Brix) and acidity in a range (1.99 % to 2.236 %) among different accessions of Burmese Grape. (Bhutia, 2013) carried out chemical analysis of various fruits of Sikkim which were significantly different among the species as *D. butyraceae* (18.50º Brix), *E. sikkimensis* (17.03º Brix), *E. indica* (11.53º Brix), *F. roxburghii* (7.60º Brix), *E. latifolia* (6.92º Brix), *F. roxburghii* (7.60º Brix), *R. ellipticus* (6.14º Brix), (6.86 º Brix), and *M. edulis* (3.55º Brix). The TSS of *Elaeagnus angustifolia* fruit was estimated to have highest as (13.14 º Brix) (Ersoy *et al.,* 2013).

2.1.2. Total, Reducing and Non –Reducing Sugars

Sugar is the major component in fruits and a source of energy. (Kuna *et al.,* 2018) carried out the research work on *Prunus* pulp and crush and reported reducing sugar (0.45±0.05 mg/g) FW and (0.85±0.00 mg/g) FW. (Kumar *et al.,* 2015) discovered the maximum total sugar in *Eriobolus indica* fruit (13.04 %) while *Machilus edulis, Terminalia chebula*, *Castanopsis hystrix, Spondias axillaris* and *Eleaegnus latifolia* had the minimum sugar content (3 percent). The amount of non-reducing sugar (0.1 to 6.0%) in fresh fruits varied between species. *Diploknema butyraceae* contained the highest percentage of non-reducing sugar whereas *E. indica* and *C.hystrix* fruits recorded the minimum.

Total soluble sugar, reducing sugar and non-reducing sugar of *Eleaegnus latifolia* and *Spondias pinnata* were recorded to be (5.28 ± 0.10 mg $100g^{-1}$), (33.93 ± 1.8 mg $100g^{-1}$), (17.83 ± 0.99 mg $100g^{-1}$) and (16.1 ± 2.16 mg $100g^{-1}$) respectively and in the fruits of *S. pinnata* (4.35 mg 100 g^{-1}), (1.51 mg $100g^{-1}$) and (2.83 mg $100g^{-1}$) of total reducing and non-reducing sugar were reported (Khomdram *et al.,* 2014).

(Bhutia, 2013) analyzed the chemical composition of different underutilized fruits of Sikkim and the value of total, reducing and non-reducing sugar of various fruits were recorded as *D. butyraceae* (12.21 %, 5.98 % and 5.91%), *D. indica* (7.52 %, 3.55 %, and 3.76 %), *E. indica* (13.04 %, 12.90%, and 0.92%), *E. latifolia* (3.03 %, 2.72 %, 4.99 %), *E. sikkimensis* (7.26 %, 5.10 %, 2.05 %), *F. roxburghii* (8.53%, 8.38 %, 0.13 %), *M. edulis* (3.03 %, 2.31 % and 0.68 %), and *S. axillaris* (3.16 %, 2.01 %, 1.11 %). (Deb and Bhawmik, 2013) carried out the research work on physico-chemical properties of Burmese Grape (*Baccaurea sapida*) of West Bengal and reported that among different accessions the content of the total sugar was in the range of (4.01-4.29 %).

2.1.3. Total Antioxidant

Antioxidants, a substance when available at low concentrations in a chain reaction either delay or prevent oxidation of that substrate (Leong and Shui, 2002; Halliwell and Whitemann, 2004). (Kuna *et al.,* 2018) conducted the research work on *Prunus* pulp and crush and reported total antioxidant (88.98±1.11%) and (57.25±3.75 %) through DPPH (2 2 diphenyl - 1 picrylhrdrazyl) assay. (Garg *et al.,* 2018) prepared jam blending Indian Blackberry and other fruits where it was reported that the jamun–kiwifruit jam was found to be a nutritionally enriched product having maximum content of total antioxidants with the value (46.75 ± 0.67%). (Hasim Kelebek and Serkan Selli, 2014) reported the antioxidant activities in mandarin juices and wines where the IC50 value found in DPPH assay recorded from (15.9 to 26.7 mg /100 ml) for the wines as well as (33.9 to 48.8 mg /100 ml) range for the mandarin juices respectively. The antioxidant activities of crude extracts from *Baccaureasapida* (pulp and peel) were determined TEAC (trolox equivalent antioxidant capacity) calculated from DPPH, ABTS and FRAP (full form) assay showed the wide range of antioxidant capacities (Mann *et al.,* 2016). *(Cherospondias axillaris*) fruit sample were evaluated for antioxidant properties by applying DPPH radical (2, 2-diphenyl-1-picrylhydrazyl) method and it was depicted that lapsi fruit contains antioxidant properties strongly along with a maximum percentage of DPPH radical inhibition recorded in an extract with ethanol (98%) (Labh *et al.,* 2015).

(Khomdram *et al.,* 2014) reported the DPPH assay IC50 value of some wild endemic fruits of the Manipur region of India that ranged from (181.21 ± 2.0 μg mL^{-1}) to (2717.46 ± 363.6 μg mL^{-1}). In-vitro antioxidant activities of wine and juice of *Baccaurea ramiflora* fruit sample was determined based on DPPH radical scavenging assay for five months of ageing process and inhibition of the sample was recorded in the range of (5.85 to 37 %) (Goyal *et al.,* 2013). (Prakash *et al.,* 2012) reported antioxidant activities of some promising wild fruits (edible) showed a wide variation ranging from (8.6 %) *Citrullus colocynthus,* seeds to (80.3 %) *Emblica officinalis* fruits.

(Haripyaree and Guneshwor, 2012) investigated the antioxidant activity of twenty fruits, *Baccaurea sapida, Eleocarpus floribundus, Rubus ellipticus* and *Spondias pinnata* were among them. Inhibition of DPPH (%) activity of methanolic extracts of these fruits and their IC50 values were found as *Baccaureasapida* (21.5±0.72μg ml^{-1}& 293.0 IC50 values), *Eleocarpus floribundus* (20.2±0.40μg ml^{-1}& 294.2 IC50 Values), *Rubus ellipticus* (28.1±0.22 μg ml^{-1}& 348.9 IC50 values) and *Spondias pinnata* (45.9±0.40 μg ml^{-1}& 238.2 IC50 values).

(Karuppusamy *et al.,* 2011) determined the antioxidant activities using DPPH scavenging methods in some lesser- known fruits from Western Ghats in India and reported highest antioxidant activity for two fruit species of *M. leschenaultia* (361.2 ± 3.69 μg ml^{-1}) and *G. fragrantissima* (240.2 ± 1.28 μg ml^{-1}) which are 2.5 times higher than the antioxidant activity of the *Z. rugosa* (116.9 ± 1.02 μg ml^{-1}) and *F. leucopyrus* (76.8 ± 1.22 μg ml^{-1}) extracts. The fruit extract of *R. ellipticus* and

G. tiliaefolia were found as a medium in antioxidant activity i.e. (196.4 ± 1.84 μg ml^{-1} and 120.2 ± 1.86 μg ml^{-1}) respectively.

2.1.4. Ascorbic acid

It is a water- soluble vitamin essential for diverse biological functionscollagen synthesis, repair of tissue, hormones and neurotransmitters also have biochemical functions (Leong and Shui, 2002) and is present in abundant concentrations in several plants and animal tissues. It also functions as an antioxidant that reduces free radical damage by scavenging oxyradicals (Fischer-Nielsen *et al.,* 1992). Fruits and vegetables are a rich source of Vit C (Fox and Cameroon, 1976). Wild fruits appeared to be rich in vitamin C and their consumption helps boost the body's immune system (Holford, 1998).

(Garg *et al.,* 2018) found a high amount of ascorbic acid (0.08 ± 0.01 mg/100 g sample) in jam made from blending Indian Blackberry and other fruits being nutritionally rich. (Rajalakshmi *et al.*, 2017) reported maximum Vit C (19.1 mg 100 g^{-1}) in the fruit of *S. jambose* and (12.35 mg 100 g^{-1}) in *T. orientalis* while estimating the physicochemical constituents of some wild fruits.

(Kulkarani *et al.,* 2017) reported that fresh aonla juice contained (120.95 mg/100 ml) of ascorbic acid. Vitamin C estimated in *Grewia sapida* fruit was (8.6 ± 0.30 mg $100g^{-1}$) (Islary *et al.,* 2016). (Hazali *et al.,* 2015) determined the amount of Vitamin C in whole *Baccaurea angulate* fruit, skin and pulp were recorded as (2.55 ± 0.00 mg $100g^{-1}$), (1.29±0.00 mg $100g^{-1}$) and (2.57± 0.00 mg $100g^{-1}$) respectively. (Kalita *et al.,* 2014) evaluated five unexplored edible plants which do have nutritional potential and reported Vitamin C contents of *S. spirale* fruits had higher value (53.4 mg $100g^{1}$), which was followed by *S. spirale* (leave) and *P. pedicellatum, G. hirta, M. roxburghii* and *C. spinulosa*. *Morus spp* fruit were recorded highest ascorbic acid (286 mg/100 g) followed by *Baccaurea sapida* (273.33 mg/100 g) and *Hippophae rhamnoides* with (263 mg/100 g) (Sundriyal and Sundriyal, 2001).

2.1.5. Total Carotenoids

Total Carotenoids is found in many fruits and vegetables (Gropper *et al.*, 2005; Rodriguez-Bernaldo de Quiros and Costa, 2006). Carotenoids are the chemoprotective agents in fruit and vegetables (Nishiyama *et al.*, 2005). (Kuna *et al.*, 2018) conducted the research on Prunus pulp and crush and reported the content of total carotenoid (2.16±0.09 mg/g) FW and (0.07±0.00 mg/g) FW. Carotenoid content of sea buckthorn fruit varies with the growing conditions but typically ranges from (30 to 40 mg/100 g) fruit and its fruit juice contain (45 %) β-carotene (Eccleston *et al.*, 2002). β-carotene has also been recognized as a potential anti-cancer compound (Van and Goldbohm, 1995). (Singh *et al.*, 2012) reported the fruit of *Malpighia glabra* an underutilized fruit of Andaman Island was found to be rich in total carotenoids (precursor of Vitamin A) i.e., (109.16 mg $100g^{-1}$).

(Bhutia, 2013) studied ascorbic acid of *M. alba* (0.1 mg 100 g^{-1}), (62.9 mg 100 g^{-1}) *Machilus edulis*. (Kumar *et al.*, 2015) estimated total carotenoid ranging from (0.2 to 63.0 mg $100g^{-1}$) where the highest content were estimated in *Machilus edulis* fruit while *Rubus ellipticus* were recorded the least.

2.1.6. Total Anthocyanin

Total Anthocyanin is a pigment (polyphenolic) found in most plant species and provides red, violet and blue colours found in most plant species (Nielsen *et al.,* 2003). Anthocyanin is presented as red, orange and blue colours in plants including vegetables, flowers and fruits (Chandra *et al.*, 1992). (Sundriyal and Sundriyal, 2001) observed *Elaeagnus latifolia* (1.58 mg/ 100g), *Diploknemabutyracea* (0.615 mg/100 g), *Eriolobus indica* (0.435 mg/100 g), *Machilus edulis* (0.391 mg/100 g), *Elaeocarpus sikkimensis* (2.98 mg/100g), *Passiflora edulis* (1.31 mg/100g) *Spondiasaxillaris* (0.59 mg/100g of total carotenoids.

(Kumar *et al.*, 2015) observed anthocyanin which ranged from (0.1 to 3.8 mg $100g^{-1}$) fresh weight and was found highest in the fruits of *Rubus ellipticus* while *Castanopsis hystrix* and *Duchesnia indica* possesed the lowest value. The total anthocyanins of *Pyracantha crenulata* (0.62±0.08 mg $100g^{-1}$), *Pyrus pashia* (0.47±0.02 mg $100g^{-1}$) and *Ficus palmata* (0.39±0.05 mg $100g^{-1}$) (Saklani *et al.*, 2012). (Singh *et al.*, 2012) evaluated (2367 mg kg^{-1}) anthocyanin in the fruit of *R. discolor*.

2.1.7. Total Flavonoids

Total Flavonoids are compounds having a major role of antioxidants with anti-inflammatory benefits. It is an important index for quality parameters. (Kuna *et al.*, 2018) conducted the research on Prunus pulp and crush and noted the content of

total flavonoids (0.48±0.04 mg/g) FW and (0.02±0.00 mg/g) FW. *Eugenia operculata Roxb.* and *Antidesmabunius L* with the value (64.323±8.828 mg QE g-1 DE), (108.761±7.015 mg QE $^{-1}$ DE) of total flavonoids were determined by (Islary *et* *al.,* 2017). (Mann *et al.,* 2016) revealed (85.58 µg RE) and (71.67 µg RE) per mg of methanol extract in *Baccaurea sapida*.

(Singh *et al.,* 2014) evaluated *Haematocarpus validus* where the content of flavonoids were (542 RE mg $100g^{-1}$). While evaluating the phytochemical analysis of *Elaeagnus latifolia Linn*. extract with 70% methanol, (5.44 ± 0.16 mg QE 100 g^{-1}) of total flavonoid content were reported (Panja *et al.,* 2014). (Saini *et al.,* 2012) reported the *Ficus palmata* (298 mg GAE 100 g^{-1} FW) with the highest amount of total flavonoids in the acetone extract while *Ficus auriculata* (96.45 mg GAE 100 g^{-1} FW) recorded least. The maximum content total flavonoid content was observed in the 80% methanolic extract of *G. parvifolia* with the value of (5.9 ± 0.1mg RE g^{-1}) followed by the peel (80% methanol), flesh (aqueous extract) and peel (aqueous extract), (3.6 ± 0.3, 2.2 ± 0.1, and 1.2 ± 0.0 RE g^{-1}) respectively (Hassan *et al.,* 2013).

The total flavonoid content was calculated using catechin as standard (R2 = 0.9994) and it varied between (96.45 to 201 mg GAE100 g^{-1}) FW in methanol extracts while total flavonoid contents in acetone extracts were (240 to 298 mg GAE 100 g^{-1}) FW. Saini *et al.,* 2012 reported the highest amount of total flavonoids in the acetone extract of *Ficus palmata* (298 mg GAE 100 g^{-1} FW) while least noted in the methanol extract of *Ficus auriculata* (96.45 mg GAE 100 g^{-1} FW).

2.1.8. Total phenols

Total phenol is phenolic compounds having redox properties contained in the plants which act as antioxidants. (Sharma *et al.,* 2015) reported *R. semialata* (172.84 mg GAE g^{-1}), *Dyconia indica* (49.26 mg GAE g^{-1}) of total phenol respectively. (Korekar *et al.,* 2014) studied on total phenolics content of seventeen Seabuckthorn

(*Hippophaerhamnoides L.)* in natural population which range from (964 to 10,704 mg gallic acid equivalent 100 g^{-1}). *Garcinia cowa* decipher the total phenol content (74.18±0.64 µg GAE mg^{-1}) (Sarma *et al.,* 2014). (Chu Go *et al.,* 2021) reported the total phenol content of (373.24 ± 3.341 µg GAE/mg) in the underutilized fruit of *Eliodoxa conferta.*

(Prakash *et al.,* 2012) reported the total phenolic content was found to be highest in *Elaeocarpus serratus Linn (*chorphon) i.e. (400 mg 100 g^{-1}) while lowest is *Ficus palmata Forsk* (Heibam) i.e. (160 mg 100 g^{-1}) (Swapana *et al.,* 2012). (Saini *et al.,* 2012) studied on three wild edible fruits of Uttarakhand for antioxidant, antiproliferative activities and polyphenolic composition and mentioned that the total phenolic contents of methanol extracts ranged from (58 to 490.5 mg GAE 100 g^{-1} FW) and that of acetone extracts were (74.51 to 494.7 mg GAE 100 g^{-1}) of FW using gallic acid as standard (R2 = 0.9928).

(Karuppusamy *et al.,* 2011) investigated the antioxidant activity of selected six lesser-known edible fruits from Western Ghats of India. Their experiment showed phenolic content in order of higher to lower in the following fruits *Mahonia leschenaultii* (86.8 ± 0.30 GAE $100g^{-1}$), *Gaultheria fragrantissima* (80.4 ± 3.18 GAE $100g^{-1}$), *Rubus ellipticus* (72.0 ± 1.25 GAE $100g^{-1}$), *Grewia tiliaefolia* (44.1 ± 1.81 GAE $100g^{-1}$), and *Flueggealeucopyrus* (31.7 ± 4.92 GAE $100g^{-1}$). (Seal 2011) determined the total phenols which ranged from (6.42 ± 0.34 to 28.56 ± 0.78 mg GAE g^{-1}) dry matter. The acetone extract of *M. esculanta* (2.56) ± 0.78 mg GAE g^{-1}) were observed maximum followed by *M. nagi* (19.31 ± 0.51 GAE g^{-1}) while the minimum was observed in *Elaeagnus pyriformis* extract (6.42 ± 0.34 mg GAE g^{-1}). (Prakash *et al.,* 2011) studied some underutilized fruits with antioxidants and suggested significantly varied ranging from (10.5 mg GAE g^{-1}) to (343.2 mg GAE g^{-1}) in *Carissa carandus* and *Caesalpinia mexicana.* An appreciable amount of TPC was also obtained in the fruit of *Eriolobus indica* (23.7 mg GAE g^{-1}), *Ficus hookeri* (20.7 mg GAE g^{-1}) and *Elaeocarpus sikkiminensis* (18.2 mg GAE g^{-1}).

2.2. Ionome profiling

(Kapoor Pallavee and Mathur Ashwani, 2017) reported 24 mineral elements in the berries of (*Hippophae rhamnoides L.*) juice with the potassium being most abundant. The amount of potassium in the strawberry berries juice of Indian and Chinese origins were (647.2mg/L) and (100- 806mg/L). (Stobdan *et al.,* 2011; Alam Zeb, 2004). Sodium and calcium were also observed relatively higher. Selenium (0.53mg/L) and copper (0.7mg/L) were reported minimum in Indian origin juice extract and were not reported in juice Chinese origin.*Baccaurea sapida* fruit peel and pulp obtained calcium (39.7 ±0.29 and 42.5 ± 0.31 mg g^{-1}), magnesium (103.4 ± 0.32 and 109.3 ± 0.21 mg g^{-1}), calcium (39.7 ±0.29 and 42.5 ± 0.31 mg g^{-1}), sodium (75.8 ± 0.91 mg g^{-1}), potassium (1195 ± 0.71 and 738 ± 0.67 mg g^{-1}), and iron (10.9 ± 0.22 and 13.2 ± 0.25 mg g^{-1}) (Mann *et al.*, 2016).

(Sudhakaran and Nair, 2016) showed the results of the mineral analysis which are depicted as potassium (956 mg 100 g^{-1}dw) was found to be higher followed by calcium (450 mg 100 g^{-1}dw) in the fruit of *G. umbellate*. In addition, the fruit was also having a substantial amount of magnesium (245 mg 100 g^{-1}dw), iron (3.4 mg 100 g^{-1}dw), (14.1 mg 100 g^{-1}dw) and zinc (1 mg 100 g^{-1}dw). The iron content was also recorded highest in *P. americana* fruit (40mg 100 g^{-1}) (Rajalakshmi *et al.*, 2017).

(Pramanick *et al.*, 2014) determined Mg, Na, K, Ca, Cu, Co, Mo and Zn and other macro and micronutrients from *Sonneratia apetala* fruit pulp and jelly, a common mangrove tree in the Indian Sundarbans using Inductively Coupled Plasma –Mass Spectrometry (ICP-MS) for elemental analysis and observed that the jelly prepared from *S.apetala* pulp contains (13.54 ppm Zn, 9.54 ppm Cu) and no trace of Co and Mo was found. The major element of the pulp and jelly obtained the order K>Na>Ca>Mg. Trace elements like Zn, Cu, Co and Mo have also been recorded in the pulp and jelly following the order is Zn>Cu>Co>Mo. (Seal *et al.*, 2014) reported sodium (0.17 ± 0.004 mg g^{-1}) in the fruit of *G. cissiformis,* (0.66 ± 0.005 mg g^{-1}), *G. cochinchinense* (57.22 ± 0.84 mg g^{-1}), potassium content (6.16 ± 0.16 mg/g^{-1}) *Elaeagnus latifolia* fruit, *G. cochinchinense* (57.22 ± 0.84 mg g^{-1}), fruit of *G. cochinchinense* (10.74 ± 0.13 mg g-$^{-1}$), *G. cissiformis* (7.27 ± 0.10 mg g^{-1}) and *Z.armatum* (6.58 ± 0.10 mg g^{-1}) also had an appreciable calcium content.

(Velimirovic *et al.*, 2013) evaluated two commercial fruit juices for the macro and micronutrient elements where it were reported that among macro elements, maximum potassium (K) were depicted with the value (230.17µg/g) in samples of multivitamin cloudy juice. While evaluating iron content, ranging from (2.237 to 5.911µg/g) for clear juices whereas 3.55 to 10.05µg/g in cloudy fruit juices. CU>Zn>Ni were in descending order in terms of their content in those commercial juices.

(Adriana Deheleanand Dana Alina Magdas, 2013) investigated on 21 commercial fruit juices analyzed for minerals and heavy metal content by the Inductively coupled mass spectrometry method. The major elements ranged from (1.12-196.11 mg/L) for Sodium (Na), (13.07-140.42 mg/L) for Magnesium (Mg) concentration and the highest was calculated in pineapple juices.

(Valvi and Rathod, 2011 investigated the mineral element of wild edible fruits which belong to Kolhapur district. Among the fruits studied by them, *Grewia tiliifolia* fruits showed the highest values of phosphorus, nitrogen and magnesium similarly in *Ficus racemosa* fruits sodium, calcium, and potassium likewise iron was observed maximum in *Meynalaxiflora* fruits, in *Elaeagnus conferta* fruits Zinc was present, whereas, *Flacourtia indica* fruit copper and manganese are found abundantly. The mineral content observed in mature and ripened fruits of *Meynalaxiflora* are phosphorus in mature fruit is (1.36 ± 0.025 mg/100g DW) and in ripened fruit (0.15 ± 0.043 mg/100g DW;); Ca is (219.6 ± 0.57 mg/100g DW) (M), (325.1 ± 0.6 mg/100g DW); Mg is (138.7 ± 0.2 mg/100g DW), (99.5 ± 0.90 mg/100g DW); Sodium is (220.3 ± 0.57 mg/100g DW), Iron is (35.5 ± 0.4 mg/100g DW), (27.5 ± 0.11 mg/100g); Zinc is (5.34 ± 0.33 mg/100gDW) and Copper is (0.84 ± 0.032 mg/100g DW), Manganese is (1.15 ± 0.015 mg/100g DW).

(Rai *et al.*, 2005) reported the appreciable amount of element concentration from the wild edible fruits of Sikkim. Sodium was observed in a range of (2.9 to 22.3 mg 100 g-^{1}). It was depicted maximum in *Machilus fructifera* fruit (22.3 mg 100 g^{1}) and lowest in the fruits of *Castanopsis hystrix* (2.9 mg 100 g^{1}) and the content of other fruits species are as *Dyconia indica* (15. 3 mg 100 g^{1}), *Ficus hookeriana* (12.8 mg 100 g^{1}), *Elaeagnus conferta* (6.6 mg 100 g^{1}) and *Cherospondias axillaris* (5.0 mg 100g^{1}). The potassium content was found in a range of (160.5 to 911.6 mg 100 51 g^{1}). It was observed maximum in *Castanopsis hystrix* (911.6 mg 100g^{1}) and minimum in *Fragaria nubicola* (160.5 mg 100g^{1}). It was also observed appreciable amount in the fruits of *Ficus hookeriana* (736.1 mg 100 g^{1}), *Cherospondias axillaris* (639.3 mg 100 g^{1}), *Machilus fructifera* (415.3 mg 100 g^{1}) and *Eleagnus conferta* (233.5 mg 100

g^{1}) and calcium content were found maximum in *Chorospondias axillaris* (202.1 mg 100 g^{1}) followed by *Dyconia indica* (200.5 mg 100 g^{1}) and *Castanopsis hystrix* (199.0 mg 100 g^{1}) respectively.

(Sundriyal *et al.*, 2003) investigated Sikkim Himalayas underutilized edible plants: Need for domestication and reported that most prominently six fruit species are utilized for their nutritive value in which the content of Fe(%) were (0.109) in *Spondias axillaris*, (0.180) in *E. Latifolia*, (0.253) in *Machilus edulis*, (0.178) in *Diploknema butyracea*, (0.075) in *Baccaurea sapida* and (0.110) in *Eriolobus indica*, he also reported the concentration of Ca (%) were (1.583) in *Spondiasaxillaris*, (1.470) in *E. Latifolia*, 0.150 in *Machilus edulis*, (0.817) in *Diploknema butyracea*, (0.158) in *Baccaurea sapida* and (0.124) in *E. Indica*. The concentration of Ca (mg/100gm) in *Docynia indica* (mail) was (62.2), *Machilus fructifera* (famphal) were (12.83), *Ficus hookeriana* (nebara) was (38.1) and in *Elaeagnus conferta* (muslendi) were (5.8) (Arun *et al.*, 2005). (Chetna *et al.*, 2014) determined Fe were (3.32 mg/100gm), Mn was (1.53 mg/100gm), Zn was (15.82 mg/100gm) and Ca were (86.69 mg/100gm) in bael fruit proves a good source for nutrition supplements.

2.3. Impact of processing on Nutritional assessment and Ionome profiling

Processing of fruits includes many reasons besides the business development with good return on investment for the owners such as it prevent postharvest losses, reducing wastage, preserve its quality, it preserves the nutritional value of the fruits, helps to make available as seasonal horticultural produce throughout the year, to produce in a desirable and convenient form for the consumer, and to develop diversified new products which will further increase the value of the fruits along with farmers benefit (Boekel *et al.,* 2010). Thermal and Non-thermal processing are two methods followed in the processing sector which add value and ensure the safety of the commodity providing food safety to the consumer (Noranizan and Benchamaporn, 2007). Nonthermal processing is an alternative and promising method to thermal processing including the inactivation of microbes and enzymes in foods and it does not allow the temperature to exceed 50 °C, which will reduce the degradation of nutrients and sensory attributes due to high temperature (Gallego-Juarez, 2001). Thermal processing involves (refrigerating, pasteurization, baking, freezing) and nonthermal includes (microwaving, pressure processing and clarification) besides this mechanical methods are also followed which includes (trimming, peeling, mixing and cutting). Pasteurization at 90 °C for 3 minutes caused 67% decrease in the total monomeric anthocyanins well as 55% decrease in the antioxidant activity measured using ORAC assay. However, it may also increase the antioxidant activity in some cases. This is because it releases compounds from the cell matrices. It reduces the enzymatic browning by inactivating enzymes like polyphenol oxidases. But on the other hand, it accelerates the non-enzymatic browning reactions in food. It affects the color, pigments like chloropHyll and carotenoids by chemical reactions like degradation and isomerisation. Anthocyanins include polymerization and depolymerisation which leads to brown pigments (Boyles M. J. and Wrolstad, R. E, 1993). Vitamin degradation can also occur during heat treatment and it depends on oxygen, light, pH and water solubility. Heat sensitive vitamins are the Fat-soluble Vitamins A (in the presence of oxygen), D, E whereas B2 (riboflavin), Vitamin C (ascorbic acid) and Vitamins B1 (thiamine) is water- soluble (Awuah *et al.,* 2007).

(Sablani *et al.*, 2010) reported that canning of raspberries (100°C, 28 minutes) and blueberries (100°C, 22 minutes) increases the phenolic content and antioxidant activity by 50% and 53%, respectively. Phenolic compounds in blueberry juice have recovered highly and after steam blanch for three minutes showed higher radical-scavenging activity to DPPH and hydroxyl radicals as compared to non- blanched juice (Rossi *et al.*, 2003). Blanching (95°C for three minutes) in combination with pasteurization during the preparation of blueberry purees reduced 43% total monomeric anthocyanins compared to fresh fruit (Brownmiller *et al.*, 2008).

(Shourove *et al.*, 2018) investigated the locally found underutilized star fruit juice along with the antioxidant compound and physicochemical stability during thermal processing and observed that total soluble solids had not significantly varied whereas flavonoids concentration when treated at 70°C and 80°C it did increase similarly at 90°C the content did not varied. In case of other bioactive compounds, ascorbic acid was evaluated maximum in fresh juice (24.17±0.70mg/100ml) but when increased temperature and time the content were decreased similarly when estimated β-carotene it also tends to decrease, while in the case of total polyphenol content (TPC) it did not alter with temperature and estimated the value as (540.08±16.64 mg GAE/100 ml) fresh juice. DPPH scavenging activity was maximum observed in fresh juice (60.19±1.39%) while at 90°C temperature was applied for 40 min it decreased significantly to (53.83±1.43%).

(Koppel *et al.*, 2018) determine the pomegranate (*Punica granatum* L.) juice flavour and aroma with the effect of processing and the results demonstrated that the pasteurized, fresh and fresh frozen, juice were not varied significantly, on the other hand the juice with brown flavours and fermented were mostly influenced.

Concentration of aromatic compounds was least than expected. Some flavours along with the total phenolic content evaluated were to be least which were not similar as reported earlier and this may be due to several conditions such as the variety, season, region of growing.

(Iuga *et al.,* 2018) studied the influence of thermal processing technologies on apple jam enriched with grapes skins and processed with microwaves and conventional methods. It was observed that the processing and the grape skins addition as a fibre source affect the quality attribute of the final product. Significant differences between the enriched samples and control samples did vary significantly. In conclusion, this innovative product can be valued for fibres proving that the grape skins can be a rich source of fibres utilized in the nutrition- rich diet.

(Patras *et al.,* 2009) reported significant loss ($p < 0.05$) in anthocyanin content of blackberry (3%) and strawberry (28%) pure processed at 70°C for two minutes. (JeustiBof *et al.,* 2012) studied antioxidant properties of strawberry (*Fragaria x Anassa*), fig (*Ficus carica L.*), apple (*Malus domestica*), pear (*Pyrus communis L.*), guava (*Psidium guajava L.*), and grape (*Vitis vinifera*) with the influence of processing technology and freezing of freezing 90 days atleast. The maximum antioxidant capacity was depicted in guava pulp (27 µmol/g) whereas there were no significant difference in fig and grape pulp under a storage temperature of -15 º C, In case of processing the antioxidant capacity of grapes were reduced by 45% while the products guava pulp and jelly had the highest antioxidant capacity with the value (27 and 25 µmol/g) followed by grape pulp (22 µmol/g) respectively.

(Fernandes *et al.,* 2011) evaluated, the effect of processing of passion fruit juice on the composition and bioactive compounds. The results obtained revealed that the chemical and physicochemical assessment is affected little by the processing methods therefore vitamin C and anthocyanin contents reduced and large quantities of carotenoids were observed even after the pasteurization stage.

(Poiana *et al.*, 2011) perceive the low sugar fruit jam and influence on antioxidant compounds along with color quality when stored and reported that thermal processing leads to the degradation in maximum. The vitamin C content in frozen fruits were estimated (54-78%), monomeric anthocyanins (92-93%, total phenolics content (25-43%) and FRAP recorded (30-41%) respectively. Vitamin C decreased by 22-33% when the jam were kept at 20°C for a period of 3 months also an anthocyanins reduction range from 33% in a strawberry jam to 22% in sour cherries jam whereas incase of FRAP values after 3 months of storage also it did not occur statistically significant alterations.

(Vijayanand *et al.*, 2015) investigated on quality characteristics and physico-chemical characterization of the mango cultivars namely (Totapuri, Sindura and Mallika) their processing effect where result revealed that during pulp processing it was noted significant carotenoids loss irrespective of the cultivar. Mallika showed higher acceptability for sensory attributes followed by Sindura and Totapuri. Among the variety, Sindura showed high acceptability followed by Totapuri and Mallika.

(Akin-Idowu *et al.,* 2009) determine some anti-nutritional factors and nutrients in yellow yam (*Dioscorea cayenensis*) with two processing methods to evaluate its effect and suggested the mean values (in mg/kg) for calcium it was depicted (169.3, 1331.3) in phosphorus, (7.2 in iron, 181.8) in phytate and (9.2) in zinc on a dry weight basis. On a fresh weight basis, total carotenoids were evaluated with the value (6.31 µg/g) and of ascorbic acid 37.3 mg/kg. Calcium, zinc, total carotenoids, vitamin C and phosphorus were varied in tuber but they were resemble with respect to the content of phytate, tannin and iron. Both cooking approaches had affected the minerals in lower content but significantly affected the contents of vitamin C, total carotenoid, phytate and tannin contents. Anthocyanin degradation were also reported in sour cherry (Cemeroglu *et al.,* 1994), strawberry (Garzon and Wrolstad 2002), raspberry (Kim and Padilla-Zakour 2004).

(Yvonne *et al.,* 2005) studied the different products of strawberries processing changing the concentrations of Vitamin C, Total Phenolics and Total Anthocyanins and suggested that during processing the content of ascorbic acid were reduced significantly due to heat and production time. (Lovera *et al.,* 2014) conducted a research on the Color of Papaya in Syrup, calcium content and Firmness with calcium impregnation (calcium lactate and calcium gluconate) with calcium concentration (0.5 and 1.5%w/w), as a pretreatment and processing effect tissue firmness showed a positive response during cooking in syrup but a decrease in calcium content. During cooking the treated fruit for calcium content were decreased in the range of 9% and 37% in syrup whereas calcium content in fresh fruit were higher (6 times).

(Rababah *et al.,* 2011) decipher the influence on antioxidant activity, anthocyanins and total phenolics of apricot, fig, orange, strawberry and cherry jam during storage (5 months at 25 °C). Among fruits, strawberry showed maximum total phenolic content (8503.1 mg GAE kg(-1) followed by cherry, apricot, fig and orange. Total phenolics, antioxidant properties and anthocyanins have been influenced during processing in all fruits. Apricot, orange and fig jam showed a decrease in total phenolic content while, comparing with other fruits maximum antioxidant activity (54.88% inhibition) was observed in fresh strawberry and during storage, it did not alter the antioxidant activity, whereas in other fruits observed reductions. Maximum anthocyanins (2323.8 mg cya-3-glu kg (-1) was also observed in fresh strawberry, followed by the remaining fruits. During storage (5months) there was a decrease in the pH value and the content of anthocyanins in fig and apricot jams were decreased during (5months) of storage. However, there was an influence of processing, it does consider a suitable method for storage atleast for 5 months respectively.

(Gil-Izquierdo *et al.*, 2002) studied the effect of different industrial processing methods at a commercial scale in orange juice (mild pasteurization, squeezing, mild pasteurization, standard pasteurization, freezing and concentration). Result possessed that the decrease of phenolics was noted during the freezing process however, the juice cloud showed the concentration process influence mild precipitation of these components. Several phenolic compounds (narirutin (5,7,4′-trihydroxyflavanone-7-rutinoside), caffeic acid derivatives and vicenin 2 (apigenin 6,8-di-C-glucoside) in pulp were decreased and loss of (28, 34.5, and 30.7%) with the pasteurization method. produced by Commercial squeezing obtained 25% more than domestic squeezing of this compound (Vit C) in orange juice. Standard, as well as mild pasteurization, increased minimally the total vitamin C content including orange solids parts, however, the concentration and freezing did not varied much. Standard, mild pasteurization, concentration as well as freezing did not influence the total antioxidant content of juice, whereas, in pulp, it was decreased by (47%).

(Levaj *et al.,* 2012) studied Strawberry fruit (*Fragaria ananassa × Duch.)* and jam processing influencing upon the contents of antioxidant capacity and phenolics in and reported that cultivar madeleine observed the greater stability of total non-flavonoids, total phenols and total flavonoids during processing, while the anthocyanin stability was observed greatest in cultivar elsanta. The antioxidant capacity of (0.20 mmol TE/kg to 0.62 mmol TE/kg) in jam whereas, in antioxidant capacity, were in the range of (0.23 mmol TE/kg to 0.67 mmol TE/kg) in fresh strawberry fruit. The strawberry jams can be a good source of antioxidants, even acknowledging the appreciable amount of phenolic compounds.

(S. Olanrewaju Arinolaand Kunle Adesina, 2014) revealed that in African walnut when thermal processing (roasting and boiling) was applied were influenced on the antioxidant properties nutritional, and antinutritional, having significantly effecting on bioavailability and all the proximate principles. Protein and ash content were decreased significantly during roasting and boiling. The phytate and tannin content was reduced in boiled (with or without shell) walnut, opposite these two antinutritional components levels, was increased during roasting. The least content of phytate and tannin (0.815 mg/100 g and 0.239 mg/100 g) were found in boiled walnut without shell respectively.

(Rattanathanalerk *et al.,* 2005) studied the quality loss of pineapple juice at temperatures ranging from 55 to 95 °C with the thermal processing effect using hydroxymethylfurfural (HMF), colorimetric hunter parameters (L, a, b and ΔE), and brown pigment formation index to estimate quality of the pineapple juice. The first order kinetics were adopted in a and b values while ΔE a combined model to ΔE which decipher the degradation of both non-enzymatic browning reaction and carotenoid concentrations. The result concluded due to temperature during processing, also pineapple juice showed a significant effect on the color.

(Aaby *et al.,* 2018) determine the effect of high-pressure processing (HPP; 400 to 600 MPa at 20 °C for 1.5 or 3 min) and heat treatment that is thermal processing (85 °C, 2 min) on strawberry juice and puree to evaluate the quality as well as shelflife. The microbiological shelf life till 49 days atleast is safe when processing of products at 500 or 600 MPa, are carried out. In HT and HPP and HT methods, colour, Vitamin C, and Anthocyanins are well preserved along with sensory attributes during storage of puree, whereas incase of juice it was observed differences between HT and HPP might be due to higher enzyme activity, and for HPP it was observed that fresh sample (juices) with least initial enzyme activity, are mostly preferred.

(Howard *et al.,* 2012) conducted research on bioactive compounds of berries with storage and processing effects where Anthocyanins and tannins in blackberries, black raspberries and blueberries, were influenced during processing, juices of these berries showed the significant loss. The procyanidins and anthocyanins and procyanidins showed a reduction in processed products at ambient temperature with losses leading to an increase in polymeric pigments. Chokeberry was used as a model, both aged juices and pasteurized juice observed the formation of polymeric pigments and as compared to aged juices, pasteurized juice obtained a greater proportion of low molecular weight polymeric pigments. During storage and the processing overall anthocyanins and procyanidins were decreased, but the actual facts for anthocyanins retarding remains unclear.

(Wang *et al.*, 2018) performed the LTLT (low- temperature long time), pasteurized - 60°C, 30 min, UHT (ultrahigh temperature) pasteurized - 135°C, 2 sec and HTST (high- temperature short time), pasteurized - 100°C, 5 min and their effect on the aroma and quality and of watermelon juice. LTLT and UHT were observed a decrease in the total flora count maintaining the pasteurized juice color, while the HTST alter in color difference was noticeable. Aroma like (3Z)-3- nonen-1-ol, 1-nonanal, (2E)-2-nonenal, (E)-2-nonen-1-ol, and (E,Z)-2,6-nonadienal, were abundantly found in the LTLT. However, the low- temperature long time method proved to be the best technique among the methods for best shelflife and quality of watermelon juice.

(Fengmei *et al.,* 2011) observed processing using blanching, HCl, alkaline and canning treatment on mandarin orange segments and their effects. The report deciphers that the loss of phenolic acids and Ascorbic acid was minimum in proportions while the loss of flavanone glycosides and total antioxidant capacity was in great proportion about fifty per cent. Keeping in view, the substantial part of phenolic compounds and ascorbic acid present in the syrup portion; the loss was not significant. Hence, it was reported that the ascorbic acid, phenolic compounds (phenolic acids and flavanone glycosides) and antioxidant properties were retained after can processing, and mandarin cans could be an alternate and serve when fresh mandarin fruits are not available in the market.

(Gaikwad *et al.*, 2017) determine the pomegranate (*Punica granatum*) (cv.*Bhagwa*) juice with extraction and thermal processing method their effect and retention of bioactive properties and result revealed that the bioactive compounds were decreased processing time and with increasing temperature during thermal treatment while maintaining sensory quality up to 7.91 (ten- point hedonic scale). Total anthocyanin, total phenolic compounds and color value in arils extracted from halved fruits were found to be nutritionally rich than juice. The thermal processing for retention for thermal processing (80˚ C for 5 minutes) for antioxidant, total anthocyanin, total phenolic compounds, color and ascorbic acid was (22.68 mg/100ml AAE, 3.18 mg/100 ml, 18.33 mg/100 ml, 2189 mg/l GAE and 18.33 mg/100) ml respectively.

2.4. Fortification and Sensory assessment

Fortification is deliberate adding of micronutrients could be one or more depending on the nature and need to processing foods depending on the nature and need, it will help preventing or correcting many defeciency providing benefit to the health of the community. It will increase the micronutrient(s) intakes among populations as they are more concerned about the nutrition rich diet. Fortification of foods will supply micronutrients in desirable amounts at a larger portion by providing with a well- balanced diet. Fortification of foods can play an essential part and strategy to improve the population nutrient status at a larger proportion. Fortification of foods can be consumed by the general population widely and globally (massfortification) and possible to fortify, designing fortification of food in various forms and ways like for population subgroups (specific), younger population indulging in complementary or rations for (targeted fortification) populations that are displaced and/or to fortify market foods voluntarily by which allow food manufacturer to do (market-driven fortification). The acceptance of any sensory changes, reasonable cost and bioavailability from the diet are some of the reasons behind choosing a fortificant compound also the consumption level that is important for fortification to be effective had to be suitable with a healthy and balanced diet for the population. Salt, wheat, corn, rice, dairy products, beverages, jam and other condiments are used for food fortification respectively.

(M. N Revathy and S Ponne, 2013) studied formulation and acceptability of calcium fortified citrus fruit squashes and reported that the standard and calcium fortified grapefruit squash was found to be highly acceptable in organoleptic evaluation than citrus fruit squashes. It was observed that in the refrigerated condition the squashes can be stored in glass bottles for up to 30 days.

(Altunkaya *et al.*, 2013) investigated the apple juice fortified with pomegranate peel extract evaluating the chemical safety and palatability and found that the addition of a maximum percentage of pomegranate peel extract in apple juice depicted maximum antioxidative capacity while by adding 0.5 g pomegranate peel extract/ 100 mL, the optimal sensory attributes were observed. The study suggested that the toxicological safety of the apple juice could be to achieve making it more healthier product, it is essential to add pomegranate peel extract in a balance, which will enhance and enrich the apple juice. The acceptable concentrations were obtained between 0.5 to 1.0 g pomegranate peel extract/ 100 mL.

(Toyin Oluyemisi Akinwale, 1999) studied the fortifying of some tropical fruit with cashew apple juice for enriching its nutritional quality and recorded that these tropical fruits when fortified with cashew apple juice enhanced its nutritional quality. It boosted the sensory qualities like taste, mouthfeel and colour, though were different it improved the overall acceptability of the products. (Bhardwaj *et al.*, 2019) reported the apple and carrot jam blended, with flaxseed giving different treatments it was fortified. The treatments were T0(apple, carrot and flaxseed) having a ratio (100:0), T_1 (apple, carrot and flaxseed) having a ratio (95:5), T_2 (apple, carrot and flaxseed) having a ratio (90:10) and T_3 (apple, carrot and flaxseed) having a ratio (85:15) and suggested that in ash from, an increase of (0.62 - 0.65%) were examined, moisture (30.42 - 31.36%), Total sugar (62.85 - 64.40 %), while TSS (°brix) reduced significantly from (69.58 - 68.64), for acidity (0.35 - 0.31%) and ascorbic acid (15.74 - 11.82 mg) was examined. Sensory analysis revealed (T_2) 90:10 were highly acceptable jam treatment with a maximum score for all the parameters nearly.

(Madhav Kumar and Parimita, 2016) investigated the sensory attributes of fortified fruit leather prepared from tomato puree fortified with Calcium (Calcium carbonate powder), sugar (30 %) & Citric acid (0.3 %). The treatment indicated as T1, T2 and T3 for leathers and the ratio were (99.5:0.5, 99:1, 98.5:1.5) respectively. The highly acceptable product was treatment T1 (99.5:0.5) making the best product among the other treatment.

(Hamid Ziena and Sahar A Nasser, 2019) conduct a research on yoghurt fortified with different iron salt and its effect and was found that in iron amino acid chelate, total solids were increased, whereas as the content was observed maximum in the ferrous sulfate, similarly in iron amino acid chelate, the protein content was maximum and in contrary to protein in ferrous fumarate and ferrous sulfate did not influence by addition of iron salts. The ferric hydroxide poly maltose and ferrous sulfate were found to have maximum acidity content while minimum in ferrous fumarate and iron amino acid chelates. All the treatments with different samples were found to be acceptable by the panellists.

(Ullah *et al.*, 2017) investigated the carrot pulp with different concentrations of apple pulp fortifying by blending preparing jam and result indicates the stability and the quality of a blended jam (carrot and apple) has greatly influenced also suggested that the quantity of carrot and apple pulp should be equal for preparing good quality jam observing the loss of sensory attributes along with physio-chemical properties were minimum as compare to other treatments after 90 days of storage. (Arise *et al.*, 2014) reported fermented millet blend and yellow maize and in a ratio 70:25:5, 70:15:15,70:30:0, 70:10:20, 100:0:0 and 70:5:25 for millet: maize: Moringa oleifera flower powder in seven blends as a fortificant *Moringa oleifera* flower powder were used evaluating the proximate analysis and sensory attributes respectively.Crude protein, crude fat, ash were observed in an increasing pattern on the other hand moisture and carbohydrates compositions were decreased. Among the blends prepared blend 6 (20% *Moringa oleifera* flower powder) were the best product in terms of nutritional and sensory analysis and can be used as an alternate or substitute for nutritional foods and hence, also used as weaning food.

(Kennas *et al.*, 2018) evaluated fortification using honey and pomegranate peel with yogurt powder evaluating its antioxidant capacity with some physicochemical properties and the result indicate that the blend of honey and pomegranate peel and yogurt in freeze-drying condition was recorded to be the suitable method which increases or improve the shelflife of the product prepared and found acceptable for its physicochemical properties. The obtained product (powder) could be used as an functional food having rich in antioxidant properties.

(Biancuzzo *et al.*, 2010) evaluated vitamin D2 and vitamin D3 as fortificant with orange juice and suggested that these fortified products have a positive effect in adults maintaining vitamin D status among them using as oral supplements with vitamin D2 or vitamin. Orange capsules and juice were also recorded to have vitamin D2 and vitamin D3 in appreciable amounts.

(Pingale Sangeeta Avinash and Dighe Nilesh Madhav, 2013) fortified bael and tomato sauce preparing with different amounts or concentrations such as Bael pulp 10, 20 and 30ml and tomato pulp 90, 80 and 70ml and denoted as A, B, and C samples. Each 100gm sauce sample materials added were ginger 2 gm, garlic 2 gm, salt 2 gm, sugar 17 gm and cardamom 2 gm. Results revealed that using bael juice as fortificant in tomato sauce improved the nutritive value and can be introduced as a commercial product. Among the different sample prepared ‘C’ sample was acceptable as sensory analysis is concerned.

(Pandit *et al.*, 2018) studied litchi juice fortified with dahi, where, milk litchi juice were added 10%, 15% and 20% and sugar was added 5% (milk weight) further sensory analysis were carried out and reported during the sensory analysis, 15% concentration of litchi juice product were more acceptable and carried out for further analysis. Accordingly, it is suggested that dahi has a functional value and adding Litchi juice to it can be beneficial.

(V. Pasupuleti and S.G Kulkarni, 2014) conduct a study on the pink flesh guava (Psidium guajava L.) with fortificant lycopene were in the form of tomato puree evaluating quality characteristics of prepared beverage formulations. Incorporation of lycopene as tomato puree altered the quality characteristics of beverages which did improves the appearance, color and biochemical properties. Lycopene concentration was observed increase from (760 μg/100 g -2010 μg/100 g) in guava beverage with an increase in tomato puree content. Beverages having 6 % tomato puree were found to be acceptable in terms of color, flavour and nutritional quality respectively. Beverages were stored for 6 months at room temperature where the product was found to be in stable condition with a sensory quality in acceptable condition.

(Sonker *et al.,* 2018) investigated the research on the fortification adding Amla and Giloy with pineapple beverage ready-to-serve (RTS) for evaluating functional value. The result revealed that the RTS fortification in terms to increase functional value with the addition of Amla and Giloy provide health-protective properties. Giloysatva were evaluated for phytochemicals compounds that allowed them to survive fruit juice processing and observed to be present in the final Pineapple RTS beverage preparation at the level of 0.5%.

(Hallim *et al.,* 2019) fortified yoghurt using fortificant as cactus pear and pomegranate juices and antioxidant activity along with physico-chemical compounds were evaluated and suggested that at the end of 15 days of storage, titratable acidity, protein content and total solids of stirred yoghurt fortified were significantly varied similarly theconcentration of antioxidant capacity and phenolic compounds were increased when cactus pear and pomegranate juices were incorporated as compare with the control sample. Among yogurt samples, the sensory evaluation showed significant differences. Moreover, the research study revealed that incorporating cactus pear and pomegranate juices to stir yoghurt, this fortified product improved the overall quality of yoghurt which will lead to increased health benefits.

(Tarek N. Soliman and Samera H. Shehata, 2019) performed a study where camel's milk fermenting it with probiotic strains using maximum viable counts of *B. lactis* and Lb. acidophilus, they were added in yoghurts fortified it with 6% avocado, the control had significantly lower viable counts. Maximum acceptable quality of the product (fermented camel's milk) was with the addition of 6% kiwi pastes or 4% avocado was observed.

(Tamer *et al.*, 2016) developed beverages made of herbal extracts (mate, heather, green tea, clove, lemon verbena, ginger, peppermint, ginger and linden,) rich in flavonoids and vitamin C with lemonade. Ascorbic acid showed a maximum value (597.9 mg/kg) in linden-added lemonade while the minimum value (486.04 mg/kg) were shown in verbena-added lemonade. Potassium was estimated within the range of (178.83-210.98 mg/kg), Sodium (33.75-39.13 mg/kg), Magnesium (22.37-27.89 mg/kg) and Phosphorus values (7.22-10.04 mg/kg) respectively in the lemonades. The maximum antioxidant activity was observed with the method Ferric reducing antioxidant power (17.13-26.79 µmol trolox/mL) and **2**,2-azinobis (3-ethylbenzothiazoline-6-sulfonic acid**)** (16.91-25.38 µmol trolox/mL) as compare to (2,2-diphenyl-1-picryl-hydrazyl-hydrate) (14.88-17.72 µmol trolox/mL) method. The total phenolic compound in peppermint-added lemonades and Linden-, ginger alter between 315.11 to 397.57 mg GAE/100 g. Fortified products were observed to be rich in ascorbic acid, antioxidant and total as compared to the control sample. However, the products (ginger- and heather added lemonade was mostly preferred whereas, least product were preferred were mate-added lemonade respectively.

(Dutta *et al.*, 2016) investigated fruit flavoured curd prepared by adding pineapple juice with different percentages that is 5%, 7.5%, 10%, 12.5% and 15% including many trials with lactic fermented milk. Raw pineapple juice was given heat treatment at 65C for 10 min. The result revealed that the fortified product having 12.5% juice were highly accepted overall and superior as compared to other products and carried out for ash, moisture, acidity, pH, total carbohydrates and total polyphenols content with the value 1.23%, 69.11%, 0.81%, 5.08, 12.19g/100g and 1.67g GAE/100g respectively. Therefore by adding pineapple juice in fruit flavoured curd can improve curd quality and promote consumption. (Pinandoyo *et al.*, 2019) design fortified product including protein from soy bean with the amount of 5%, it was isolated in papaya jam fortified and reported that the fortified products (jam) maintained the physico-chemical analysis or standard as standardized by FAO respectively.

2.5. Microbial Assessment

The microbiological analysis is generally the microorganism identification,detectionor enumeration using different methods chemical, biological, biochemical, molecular methods in any kind of materials (e.g. foods, drinks, environmental or clinical samples). It prevents microbial diseases or spoilage occur due to microbial activity. The microorganism has a great potential to affect the quality of processed products because they will deteriorate the product either by utilizing the components or by modifying the ingredients of the food composition. The food products contaminated with such microorganisms does have the effect or even inactivate the availability of nutrients available on the products. The World Health Organization and the Food and Agricultural Organization of the United Nations illustrated that one of the main reasons for health problems or illness is due to food contamination which in the contemporary world is mostly widespread (Edema *et al.*, 2005). In fruit juice, there are several factors that allow bacterial growth which includes pH, storage temperature, humidity, water activity, preservatives and sugar concentrations, UV treatments applied while preparation, types of packaging material, water quality used, machines quality used in the industries, raw materials available etc.

(Dauda *et al.,* 2017) conducted the research work on serendipity berry (*Dioscoreo phylum cumminsii*) extract with watermelon juice up to 12 weeks. The blended samples were in different concentrations (100 ml+10 ml), (100 ml+20 ml), (100 ml+30 ml), (100 ml+40 ml), and (100 ml+50 ml) denoted as sample A, B, C, D and E. The control sample (pure juice) were also stored and evaluated for microbial estimation. The results indicated that the treated samples microbial load were in the range of (0.2 x10^5 to 1.4x10^5cfu/ml), there were some with some of the treated samples having negligible growth (<10 cfu/ml) in the treated sample were also observed whereas control sample microbial load ranged between (1.1x10^5 - 9.7.6x10^7cfu (colony-forming unit/ml). Overall the study states that the treated sample with serendipity berry (*Dioscoreo phylum cumminsii*) extract can function as a preservative and sweetener also low microbial load has been observed as compared to the control in the same storage period of time.

(Marc *et al.,* 2019) investigate the research on cashew apple juice for microbial estimation or count and the result showed an absence of total coliforms in the juice samples, which reflect the effectiveness of the heat treatments. Hence, the result revealed the aerobic mesophilic germs (AMG) presence whereas total coliforms were absent in the sample (juice). Most fruit contains bacterial counts of (1×10^5 CFU/cm) on their surface (Al-Jedah *et al.,* 2002; Durgesh *et al.,* 2008, Odu and Adeniji 2013) thus; improper washing of fruits while preparing fruit juices allows the contamination of microbial bacteria (Durgesh *et al.,* 2008). Khan *et al.,* 2015) investigate the street juices sold in Dhaka University Campus in Bangladesh and the samples selected were tukmaria sherbet, lemon sherbet, papaya juice, wood apple sherbet and sugarcane juice. The research indicates a high microbial load obtained in the drinks. The total coliforms and microbial load (total viable) range from and (210–1100 cfu/100 ml and 7.7×10^3 - 9×10^8cfu/ml), revealing the heavy microorganisms present in all the drinks. Among the drinks, tukmaria sherbets attained the highest total coliforms. The major factors of contamination include unhygienic water for dilution, chemical properties, equipment, fruit flies dressing with ice, unsanitary surroundings, raw materials, and airborne dust with high risk.

(Oluwole *et al.,* 2016) documented that during the storage period, pineapple juice coliform counts ranged between (2.079 to 3.093 log10cfu/ml) and citrus juice had the maximum and minimum coliform count respectively. In juice, the total bacteria count ranged between (7.009 to 8.243 log10cfu/ml). Highest staphylococcal count was observed in citrus fruit juice while however had the highest staphylococcal count whereas the least (2.344 to 3.881 log10cfu/ml) were observed in pineapple juice.Osmophilic yeast count also ranged from (2.017 to 3.903 log10cfu/ml), having the highest load in orange fruit juice and lowest load in citrus fruit juice. The study revealed that after 5 days of opening the quality of the samples were degraded and found that despite refrigeration they can degrade the juice samples with both pathogenic activity and spoilage.

(Chandel *et al.,* 2017) reported that higher microbial activity and the count was observed in nectar and ready to serve products. Although, the microbial growth and its increased level were within the permissible level might be due to heat treatment during processing and holding time.

(Muchie Shiferaw and MulugetaKibret, 2018) investigate the juices prepared from houses of Bahir Dar town, Ethiopia and their microbial quality. The study reported that as compared to guava fruit, avocado fruits was evaluated higher mean microbial countsalso more than fruit peel, the fruit surfaces were recorded higher. The contamination of microbes might be due to lack of wareness, hygiene maintenance with proper sanitation, quality of water etc in those houses probably. However, by providing training programmes to fruit handlers might be a step towards solving microbial safety and quality promoting shelf-life of the products.

(Makanjuola *et al.,* 2019) conducted research on date fruit jam with orange and apple fruit at different proportions and for reference strawberry jam were bought, jams were blended and denoted as date fruit jam with orange (DO), date fruit jam with apple (DOA) and (DA) date fruit. For microbial estimation of date fruit jam with orange (DO) total plate count was (13.67×10^4cfu/g), for date fruit jam with apple

(DOA) (55.00×10^4cfu/g) and for (DA) date fruit (17.67×10^4cfu/g) while the reference sample (strawberry jam) (10.33×10^4cfu/g) of total plate count estimated. All the samples were also observed for the fungal count with the value (44.00×104 cfu/g), (8.33×10^4cfu/g), (13.33×10^4cfu/g) and (19.33×10^4cfu/g). The presence of microbes such as staphylococcus spp., streptococcus spp., bacillus spp. and pseudomonas spp. were indicated during the biochemical tests in all four samples.

(Pilooet *et al.,* 2018) studied Carambola (*Averrhoa carambola* L.) nectar for microbiological estimation of Carambola (*Averrhoa carambola L.*) at ambient temperature and decipher that the association of bacteria (Pseudomonas species) was detected on storage of 45th and 60th days old fruit juice with (1.05 x10^3 log cfu/ml and log cfu/ml = 2.12 x 10^3) respectively. However, without adding preservatives in nectar, mould and yeast were not detected for up to 45 days. The study indicated that till 45 days we can store the nectar without any kind of preservatives also was acceptable with good sensory attributes.

(Noah, A. Aduke, 2020) investigated mixed fruit juice in ratios with different methods of preservations (sodium metabisulphite, using high-temperature pasteurization at 80oC for 15 minutes and, Low- temperature pasteurization (LPS)at 60oC for 30min and evaluated for microbial quality. The result deciphers the total viable count were range between (3.2×10^3 - 4.5×10^3cfu/ml). The total fungal count in all the samples was in a range of (1.5×10^3 - 2.6×10^3cfu/ml) and coliform count was in a range of (1.0 - 2.8×10^3cfu/ml). Salmonella count was absent in all the samples and the most acceptable sample was a high pasteurized sample among all the samples.

(Kumar *et al.*, 2017) investigated the papaya guava fruit bar for microbial quality and revealed that the highest mould and yeast growth (0.6×10^2) at 30days and (0.6×10^2) at 60days were recorded with a fruit bar prepared with 100 per cent papaya pulp during storage when compared to other treatments. However, the acceptable number of microbes (yeast and mould) was observed at the end of 30 and 60 days of storage, which were negligible in number and safe to consume according to World Health Organization proving the papaya guava fruit bar more stable and promotes consumption adding a new product**.**

(Iqbal *et al.*, 2015) reported that the unpasteurized fruit juices contain a heavy microbial load which seems to be higher than standard permissible limits leading to the food borne illness and spoilage of the juices. To make consumption of these juices safe should be given priority by periodic monitoring of packed fruit juices. Honey can act as a substitute for the treatment of numerous infections, especially contentious by antibiotic-resistant bacteria. Onuoha *et al.,* 2018) conducted research in Owerri metropolis, Nigeria selling multiple fruit juices and 21 packaged single fruit juices and evaluating their microbiological safety and quality following standard methods. The sample was contaminated where total heterotrophic bacterial counts were observed ranging from (0.01×10^2 to 2.45×10^2cfu/mL), (0.70×10^2 to 2.00×10^4cfu/mL) for total fungal counts and (7.00×10^3 to 1.25×10^4cfu/mL) for total coliform count. The contamination of such microbes might be due to production process, raw material quality equipment etc.

(Bello *et al.,* 2014) studied fruit juices (24 each of pineapple, avocado, grape, orange and papaya) and evaluated microbiological quality. The highest total viable count was ($6.5x10^4$cfu/ml) in papaya juice, yeast count ($3.5x10^4$cfu/ml) in orange juice whereas total viable count ($4.0x10^4$cfu/ml) in grape juice were lowest and in grape juice ($2.0x10^4$cfu/ml) lowest yeast count was obtained. The lowest mould count was observed in grapes and papaya juices ($2.7x10^4$cfu/ml) which indicated that there is heavy microbial loads in fruit juices than the specifications available in the world.

(Kulkarani *et al.,* 2017) revealed the microbial analysis of the fresh juice of aonla as (1×10^3cfu/ml) of the total plate count, yeast count was 301×103 cfu/ml and mould was not present or observed respectively. (Adedeji TO 2017) conducted research on microbiological examination of jam samples from Watermelon (*Citrullus Lanatus*) and Pawpaw (*Carica Papaya*) juice which had total plate count ranging from ($4.10x10^1$ to $2.00\ x10^1$cfu/g), yeast and mould count ranged from ($2.10x10^1$ to $1.00\ x10^1$cfu/g) with no observable coliform count.

(Aneja *et al.,* 2014) conducted a study on orange, carrot and sweet lime juices total of 30 juice samples and their microbiological assessment were carried out where the result indicated the heavy load of contamination including 9 bacterial isolates, 5 yeast isolates and 11 mould isolates from juices were isolated. The main cause leading to Spoilage of juices were yeasts and moulds leading to cause health problems. For the improvement of microbial quality there should be proper set of guidelines.

(Batool *et al.,* 2017) studied the fruit juices prepared freshly as well as in the pasteurized form sold in Rawalpindi city at the market and the samples were taken from 10 locations for microbiological assessment. The juices that were available in the cityin open conditions were highly contaminated with bacteria, fungi. Some of the microbial isolated were Salmonella, Staphylococcus, Pseudomonas and E. coli. High percentage of Aspergillus were observed as compared to Rhizopus and Penicillum. Results decipher that freshly squeezed fruit juices of popular types of market are of unhygienic quality with increasing risk to the consumers and unsafe.

(Sharma *et al.,* 2013) investigated fruit juices Vidarbha at various locations for bacteriological estimations and the study revealed that at different cities locations (e.g.Vegetable market, Bus Stand, Railway Station etc.) fruit juices are highly contaminated and unhygienic for consumption. The presence of pathogenic Shigella, Salmonella, *S.aureus*, and *E. coli* was observed making the juices unsafe for human consumption required a standardised guideline to be followed. Regular monitoring is suggested to maintain fruit juice quality for human consumption which will further protect any future pathogen outbreaks.

Nayik *et al.*, 2013) analyzed the fruit juices of Kashmir valley which were for immediate consumption and sold in the local markets. Fruit juice samples including (3 from each mango, pineapple, apple and orange) juices from different markets were taken for further analysis. The microbiological quality guidelines for ready to eat foods were set and orange juice (about 25%) of the samples did not comply with the standards whereas for pineapple juices apple and orange complied with the standards. Mango, apple, pineapple juice were observed to have less microbial load having an acceptable limit making safe for consumption opposite orange juice procure higher microbial load which were unsafe for drinking purposes.

(Tasmina Rahman *et al.*,2011) reported the total viable bacterial count in most of the fresh juice samples was found as ($2.4x10^4$cfu/ml and $3.2x10^3$cfu/ml) in fresh and packed juice and the total fungal count varied from (2.2×10^3 to 9.0×10^6).

The current study, titled "**Processing effect on nutritional qualities of value added products from select underutilized fruits of Sikkim**"was conducted in the laboratory between 2017 and 2020 at the Department of Horticulture, 6th Mile Sikkim University, Gangtok, Samdur, Tadong. This chapter describes the procedures and materials used during the research.

3.1. Collection of Plant Material:

The fruit samples were gathered from the four districts of Sikkim i.e., North, West, South, and East Sikkim, between the months of February and December.

Table no. 1. LIST AND DETAILS OF UNDERUTILIZED FRUITS

S. No.	Local name **(Nepali vernacular)**	Scientific name
1	Chuirri	*Diploknema butyraceae*
2	Seabuckthorn (Achuk)	*Hippophae salicifolia*
3	Mehel	*Docynia indica*
4	Muslendi	*Elaeagnus latifolia*
5	Famphal	*Machilus edulis*

1. ***Diploknema butyraceae* (Sapotaceae)**

It is known as Chuirri in Sikkim and grows to a height of 15 to 30 metres. It blooms in the winter and bears fruit from June to July. Fruits are ellipsoid drupes (0.8-1.8 cm) with a fleshy layer at outer side that covers the single seed. Fruit pulp is juicy and has a low shelf life (Bhutia, 2013). The species has been used to treat asthma, stomachaches, and other ailments. Butter is extracted from the fruits that are used to treat rheumatism.

2. ***Hippophae salicifolia* (Elaeagnaceae)**

In Sikkim, it is known as Seabuckthorn or Achuk. It is grown at high altitudes ranging from 1500 to 3600 metres above sea level in Sikkim, Jammu and Kashmir, Uttar Pradesh, and Himachal Pradesh (Pant *et al.*, 2014). It is a thorny, deciduous, dioecious fruit plant that grows to a height of 2 to 6 metres. They are pale green when young, but turn golden-brown when ripe around the end of December. The berries have a tough skin that protects the juicy pulp and a small hard oval seed, and they are difficult to harvest. It is thought to prevent or treat diseases such as cancer and skin cancer.

3. ***Docynia indica* (Rosaceae)**

In Sikkim, it is known as Mehel and Indian crab apple. It has been widely available in some parts of the North – East region, namely Sikkim, Darjeeling, and Meghalaya. It is a lower temperate zone tree that grows between 900 and 1900 MSL. A tree can grow to be 9-12 m tall. When ripe, the fruits are round and pear-shaped, with a pale green colour (Sundriyal, 2003). They are also consumed as raw or processed pickles and jelly preparations. In Sikkim, the price of the fruit is quite reasonable @ Rs. 50/kg. The bark is used to treat piles, and fruit extracts are used by locals to treat blood dysentery.

4. ***Elaeagnus latifolia* (Elaeagnaceae)**

In Sikkim, the fruit is known as Mallero or Muslendi. It can be found at an elevation of 1500 metres in the Himalayan region in all North East regions. The fruit can reach a height of 300cm and is covered in thorny scales on well-branched, spreading evergreen shrubs. The fruit of *E. latifolia* blooms from September to December and is harvested from March to April (Sundriyal, 2003). The fruits are consumed fresh in raw form by the locals, but processed products such as pickles, jam, and refreshing drinks are more preferred. The fruits are rich in essential minerals, vitamins such as vitamin C, A, and E, as well as flavonoids and phenol compounds (De, 2017).

5. ***Machilus edulis* (Lauraceae)**

It is an evergreen tree with spreading branches that grows to be about 15-20m tall. It is common in the Northeast, particularly in Sikkim and Arunachal Pradesh. It is regarded and consumed as a type of avocado *(Persea americana)* in the community, and it is sold at a reasonable price in the local market under the names Famphal or Pumsi. Fruits are readily available in the local market from November to March. Fruit yield ranges from 5-75 kg/tree, with a fruit weight of 31.72 g (De, 2017). The fruits are highly nutritious, with a high fat and carbohydrate content.

Figure No. 1. *Docynia indica*

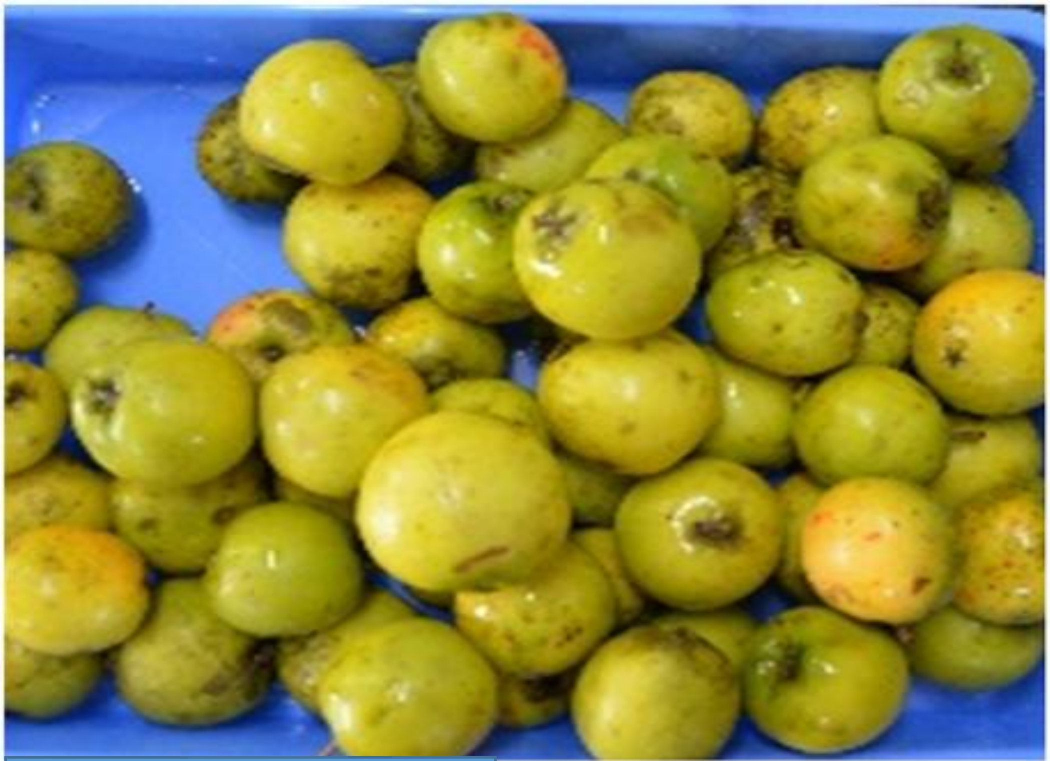

Figure No. 2. *Diploknemabutyraceaa*

Figure No. 3. *Hippophae salicifolia*

Figure No. 4. *Machilus edulis*

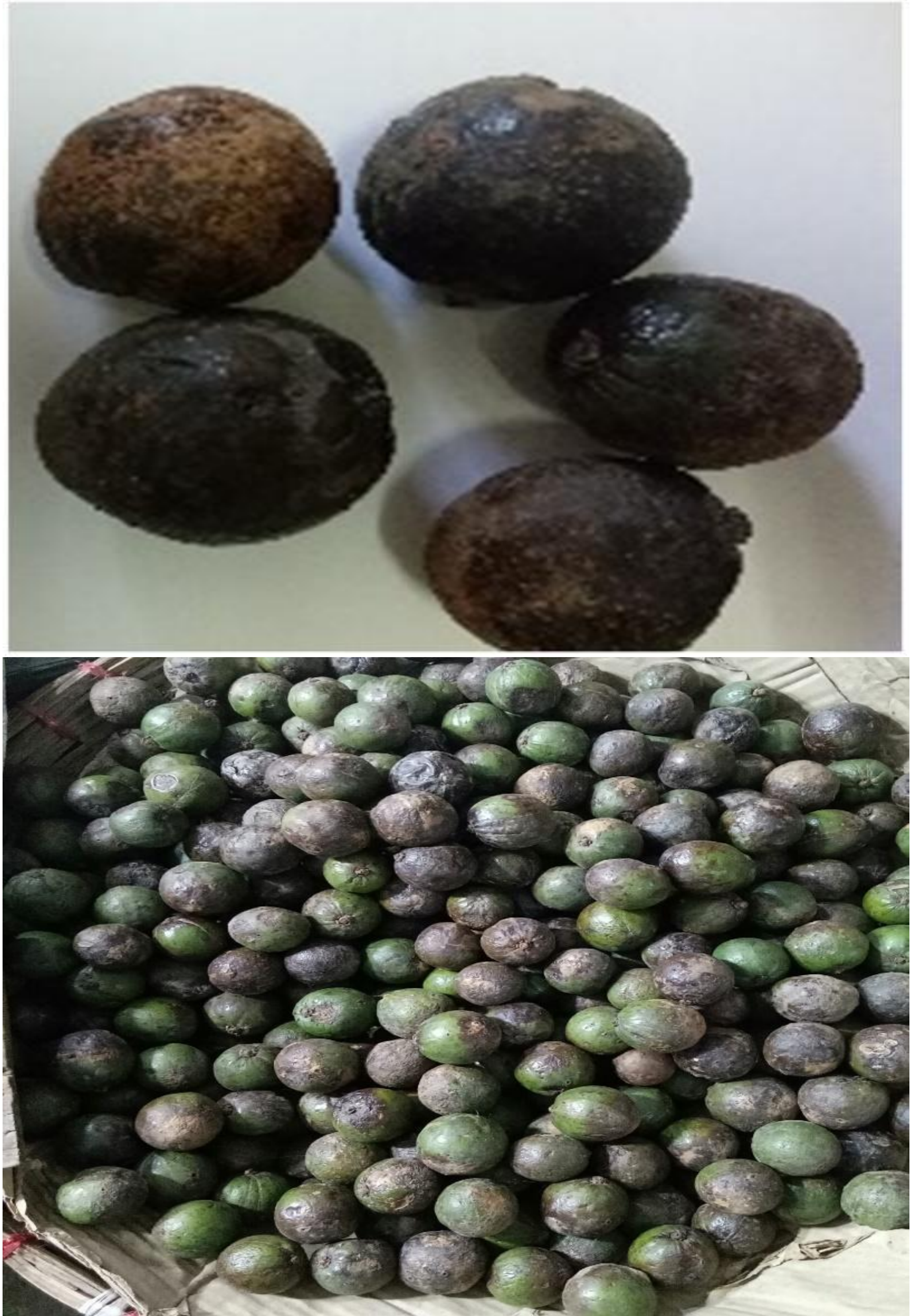

Figure No. 5. *Elaeagnus latifolia*

3.2. Observations recorded and their procedure

3.2.1. Nutritional composition

3.2.1.1. Determination of Ascorbic acid

Estimated by volumetric estimation method as suggested by (AOAC 2000). Juice of 10 ml was prepared and with 0.4% HPO_3 it was blended. Volume was made up to 100ml finally with 0.4% HPO_3 and then 10 ml juice was taken to titrate against standardized dye which further pink colour appears that last for 15 seconds. It was calculated as:

$$\text{Mg of ascorbic acid/100gm} = \frac{\text{titre x dye factor x dilution}}{\text{Wt. of sample estimated}} \text{ x100}$$

3.2.1.2. Estimation of carotenoids:

Fruit sample one (1gm) was taken and grounded in motor and pestle with acetone using acid and alkali washed sand (AOAC 2000). The conical flask is filled with extracted sample. The procedure was continued till the residue appear colourless. The acetone extract was decanted to a separate funnel which is having 10-15 ml of petroleum ether and mixed gently. sodium sulphate solution was added (25 ml of 5 percent). It was shaken and kept for a few minutes and yellow colour pigment was decanted later into the conical containing petroleum ether. Layer was collected in a volumetric flask and the acetone layer containing 5 % sodium sulphate was separated, 15 ml petroleum ether was kept on added to the acetone layer containing Na_2SO_4 until the colour gets transferred into the petroleum ether and measured the colour intensity with the spectrophotometer at 452 nm.

Total carotenoids was calculated with the formula given:

Total carotenoids (mg/100 g) = $\frac{3.857 \times \text{O.D} \times \text{Volume made up} \times 100}{\text{Weight of the sample} \times 1000}$

3.2.1.3. Estimation of total phenols:

One gram of sample was taken and with the help of mortar and pestle, it was grounded with ten (10ml) of 80% ethanol. The homogenate was centrifuged for 20 minutes at 10,000 rpm. The remaining supernatant was taken further and evaporated those supernatants to dry. The residue was transferred in a conical and the volume made up to 5ml with distilled water. In a test tube, 1 ml sample was Pipette out finally volume made up to 3 ml with distilled water. Folin-Ciocalteu reagent (0.5ml) was added. 2 ml of 20% Na_2CO_3 solution was added into each tube after 3 minutes. Mixed thoroughly and tubes were kept in boiling water for 1 minute, allowing it to cool down and 650 nm (absorbance) was measured against a reagent blank (Thimmaiah, 1999).

3.2.1.4. Estimation of Total Anthocyanin:

Total Anthocyanin content was evaluated by following the pH differential method and the absorbance of anthocyanin samples at pH 1.0 and 4.5 are recorded (Rodriguez-Saona and Wrolstad, 2001). Monomeric anthocyanins are highly coloured at pH 1.0 and colourless at pH 4.5 (Wrolstad *et al*., 2005). Since the visible spectrum

showed the anthocyanin maximum absorbance to be at 512 nm, the difference in absorbance (ΔA) was calculated from (A512 nm pH 1.0 – A700 nm pH 1.0) – (A512 nm pH 4.5 - A700 nm pH 4.5). Absorbance at 700 nm was used to account for any turbidity in the samples.

3.2.1.5. Estimation of Antioxidant:

It was determined according to (Singleton *et al.*,1999) DPPH (1,1-Diphenyl-2-picrylhydrazyl) scavenging activity also with slight modification. Briefly, sample extract of 2.0 mL were taken and standards was added to the 5 mL of DPPH solution (0.1 mM with methanol) and vigorously vortexes; for 40 minutes at room temperature in dark it was kept for incubation. It was measured at 517 nm against blank. Estimated results were expressed as Gallic acid equivalents and % inhibition was calculated by the following formula:

$$\% \text{ scavenging activity} = \frac{\{(A0-A1)\}}{A0} \text{ x } 100$$

Where, A0 = Absorbance of control

A1= Absorbance of sample extract or standard

3.2.1.6. Estimation of Total flavonoids:

Total flavonoids estimation were carried out using the method of (Ordonez,2006) in the extract. In the extracted sample 0.5 ml of 2%, $AlCl_3$ ethanol solution was added. After 1 hour, using a UV-Vis Spectrophotometer, it was measured at 420 nm. Total flavonoids were estimated in these underutilized and their processed products were calculated as quercetin (mg/g) using the following equation based on the calibration (standard) curve: $y = 0.0255x$, $R2 = 0.9812$, where y was the quercetin equivalent (mg/g) and x was the absorbance.

3.2.1.7. Estimation of Total sugar:

It was estimated as described by Lane and Eynon in A.O.A.C. (2000). Fresh Fehling A and B solutions mixed 10ml was prepared each time for determination of content present with methylene blue indicator. Reducing sugar was calculated as:

$$\%\text{Total sugar} = \frac{\text{factor x dilution}}{\text{Wt. of sample x titre reading}} \text{x100}$$

3.2.1.8. Estimation of reducing sugar:

It was estimated as described by Lane and Eynon in A.O.A.C. (2000). Fresh Fehling A and B solutions mixed 10ml was prepared each time for determination of content present with methylene blue indicator. Reducing sugar was calculated as:

$$\%\text{Reducing sugar} = \frac{\text{factor x dilution}}{\text{Wt. of sample x titre reading}} \text{x100}$$

3.2.1.9. Estimation of Non Reducing sugar:

It was determined by subtracting the reducing sugar content from total sugar and further multiplication with 0.95 is done.

3.2.1.10. Estimation of Acidity

Titration of the juice with 0.1 N NaOH by using phenolphthalein indicator solution it was evaluated and expressed in g of citric acid per 100 ml of juice. Titratable acidity was calculated as:

$$\text{Total acidity\%} = \frac{\text{Titre x Normality of NaOH x Volume made up x Eq wt of acid x100}}{\text{Volume of sample taken for estimation x wt of sample taken x 1000.}}$$

3.2.1.11. Estimation of Total soluble solids (TSS):

It was recorded with a hand refractometer calibrated in ^{0}brix at 20 °C with the help of a temperature correction correlation chart (Mazumdar and Majumdar, 2003).

3.2.1.12. Estimation of β-carotene

The procedure followed was as described by (Ranganna, 2009). The sample or extract (pulp or paste) was kept in 5ml of methanol for soaking purpose for 2 h at room temperature. It was kept in a dark condition so that complete extraction could be done. With the use of hexane β -carotene layer was separated through a separating funnel and with hexane final volume was made up to 10 ml, then this layer had to pass by sodium sulphonate through a separate funnel to remove any moisture if present from the layer. The β -carotene was measured at 436 nm (absorbance) against a blank as hexane and was calculated following formula:

Beta-carotene (µg/100g) = Absorbance x Vol of extract x Dilution x 100 x 100/Weight of extract x % of dry matter of extract

3.3. Ionome profiling

The Multi-wave digestion system (Anton Par microwave 3000) for sample digestion and ICP-MS (Inductively Coupled Plasma Mass Spectrophotometry) Perkin Elmer Nex ION 300X for estimation was used. The sample will be taken separately in form of juice(3ml) or powder (0.5g) with di-acid mixture of nitric acid and Hydrochloric acid in the ratio of 9:4. The sample will then be placed in hot plates for open-air digestion. Once the clear white fumes will be appeared, the digested samples will be cooled and made up to the volume of 50ml with DDW in a volumetric flask and then transferred to a narrow mouth bottle with details of the sample in Central Research Facility Indian Institute of Technology Delhi for further analysis. The value of the elements is expressed as μg/100gm.

3.4. Value added products prepared

The diverse processed product development was prepared from these underutilized fruits namely (*Diploknema butyraceae, Hippophae salicifolia, Docynia indica*, *Elaeagnus latifolia* and *Machilus edulis*) of Sikkim following standard procedure and according to their nutritional properties (FPO specification, 1955).

3.5.Criteria for product diversification:

1 Use of indigenous raw material in the formulation of products.

2 Organoleptic, consumer and cultural acceptability of the products.

3 Balanced nutritional content.

4 Low costs of products.

5 Consumer preference.

3.6. The value added products prepared were:

- **Seabuckthorn (*Hippophae salicifolia*)*:*** juice, jam and jelly.
- **Mehel (*Docynia indica*):** pickle, jam and powder.
- **Muslendi (*Elaeagnus latifolia*)**: ketchup, chutney and jam.
- **Famphal (*Machilus* edulis)**: mayonnies, powder and puree.
- **Chuirri (*Diploknema butyraceae*)**: candy, jam and juice.

3.7. The stages in product Development:

The new product development evolved a general sequence of logical steps that are described below:

1. Exploration: Objectives for the development is search for new product ideas, or process improvements.
2. Development: Ideas are transformed to the physical product, in the laboratory. Evaluation of these products for consumer acceptability is carried out.
3. Testing: Developedproducts areevaluated on the basis on nutrient, ionome and sensory analysis further can be commercialize by applying liscence.
4. Commercialization: Full scale production as well as marketing programmes can be set up for launch as well as promotion of the products in the market.

3.8. PROCEDURE OF VALUE ADDED PRODUCTS PREPARED

3.8.1. FLOW SHEET OF CANDY PREPARATION

fruits or their slice impregnated with glucose syrup or cane sugar

↓

subsequently free of syrup(drained) also dried

↓

impregnated with sugar syrup containing a higher percentage

↓

25-30% of sugar (invert) or glucose or crystal, corn and commercial glucose) used.

↓

The impregnated fruit or their slice is kept at 75%to avoid or suppress the fermentation.

3.8.2. FLOW SHEET OF JELLY PREPARATION

Fruit (ripe stage)

↓

Boiling with water for 20-30 minutes

↓

Addition of citric acid (2g/kg of fruit)

↓

Straining of extract

↓

Addition of sugar (1:1)and pectin (0.2-1%)

↓

Judging the end point

↓

(sheet/drop/flake test)

↓

Removal of scum and foam and add remaining citric acid

3.8.3. FLOW SHEET OF JAM PREPARATION

Ripe firm fruit

↓

Washed and peel

↓

Remove the seed and core of the fruit

↓

Addition of sugar (1 – 2kg as per fruit weight)

↓

Boiling and stir it continuously

↓

Add citric acid (2g/kg of fruit)

↓

Judging of end point

↓

Filling in sterilized bottle

↓

Storage at ambient temperature

3.8.4. FLOW SHEET OF POWDER PREPARATION

washing, cleaning and pulping of fruits

↓

Drying of fruit concentrates converting it to powders

↓

Add dried sugar for its taste

↓

Blend it with dried sugar properly

↓

Grind by blending in pin mill for equal mixture of ingredients

↓

Obtain to desired fruit juice powder by adding flavour and fill in containers

3.8.5. FLOW SHEET OF JUICE PREPARATION

Ripe firm fruit

↓

Washing and peeling

↓

Remove seed and cut it into segments

↓

Add water while cooking (1:1)

↓

Addition of sugar

↓

Filtering

↓

Boiling

↓

Cool it down and fill in the sterilized bottles

3.8.6. FLOW SHEET OF PICKLE PREPARATION

Select fruits either raw or ripe form

↓

Washing and sorting it

↓

Blanch it minimum for 10 minutes

↓

Sun drying atleast for 2 hrs for removal of moisture

↓

Mix various ingredient (oil, spices, salt and vinegar)

↓

Packaging done in glass bottles (500 g)

↓

Store at room or ambient temperature

3.8.7. FLOW SHEET OF KETCHUP PREPARATION

Fruit fully ripe

↓

Washing and Sorting

↓

Cutting and Chopping

↓

3-5 minutes cooking done to soften/blanching

↓

Straining with muslin cloth or strainer

↓

Cook pulp along one- third quantity of sugar

↓

Spice bag is put during cooking

↓

Cook it to one-third of original volume of pulp

↓

Spice bag is removed by squeezing it in pulp for leftover

↓

Cooking and addition of remaining salt and sugar

↓

Judge end point (by volume or hand refractometer)

↓

Addition of vinegar

↓

Filling and cooling

↓

Storage at ambient temperature (cool and dry place)

3.8.8. FLOW SHEET OF CHUTNEY PREPARATION

Fruit fully ripe

↓

Washing and Sorting

↓

Blanching for 2 minutes

↓

Putting quickly in cold water (to crack skin)

↓

Peeling and crushing

↓

Addition of ingredient except for salt and sugar and cook gently to desired consistency

↓

Addition of salt and vinegar and cook for 5 minutes

↓

Filling in hot bottles

↓

Sealing

↓

Store at ambient temperature

3.8.9. FLOW SHEET OF PUREE PREPARATION

Fruit fully ripe

↓

Washing and Sorting

↓

Remove seed and take flesh with fork

↓

Mash with a blender to reach the desired consistency

↓

Store into a food storage containers

↓

squeeze few amount of fresh lemon juice to reduce the incidence of browning with better quality.

3.8.10. FLOW SHEET OF MAYONNAISE PREPARATION

Fruit fully ripe

↓

Washing and Sorting

↓

Remove the flesh or pulp and blend

↓

Addition of salt, lemon juice and cayenne pepper

↓

Blend all the ingredient with blender

↓

Addition of olive oil slowly depending on the quantity

↓

Fill it in container and store it

3.9. SENSORY EVALUATION

On a 9-point hedonic rating scale, approximately 30 semi-trained panellists evaluated the sensory attributes of the value-added products (Peryam*et al.,* 1952). Scoring was based on the color, flavour, aroma, taste, and overall acceptability as these are the principal component. For the evaluation of various products, a total of 30 panellists were chosen. Among the chosen panellists, the male/female ratio was equal. The panellists ages ranged from 18 to 28 years old, with the majority of them pursuing B.Sc. degrees in Horticulture and some also M.Sc. and Ph.D Scholars from Sikkim University's Department of Horticulture. At a room temperature (23 to 24℃), Petri plates were used to serve the products with a code name. Purified water was provided for mouth-rinsing between different samples. On a large table in a laboratory room, 15 products were served. Samples were evaluated by keeping them in order from left to right in accordance with a signal provided by a test conductor.

Category	**Sensory score**
Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

3.10. ESTIMATION OF FORTIFICATION

Based on the sensory evaluation results, the two highest overall acceptance value added products were fortified with calcium and vitamin C, depending on the nature of the component. In case of β-carotene in the processed foods was insufficient to meet the dietary allowance. Fortification with calcium citrate malate at 100mg/100ml in *Hippophae salicifolia* juice and 100mg/100ml in *Elaeagnus latifolia* jam was evaluated. Calcium citrate malate has an excellent bioavailability and has been used as a calcium form for addition to the diet either as food fortification or supplements nowadays (Springer, 2007), whereas for Vit C, Asorbyl palmitate 28mg/100ml in *Hippophae salicifolia* juice and *Elaeagnus latifolia* jam 38mg/10ml was added. The iron fortifier asorbyl palmitate improves iron availability and stability. It does not change the food's characteristics such as taste, aroma, and texture, which is the primary purpose of food. Commercially available products were taken based on the outcomes of panelist preference for further comparison which were done on basis of the nutritional, ionome and sensory qualities.

3.11. MICROBIOLOGICAL EXAMINATION

For each product sample, the total viable counts agar plate technique was used to determine the fortified *Hippophae salicifolia* juice and *Elaeagnus latifolia* jam samples (10^{1} to 10^{10}). Ten (10) ml of each product's fortified sample was diluted with 90ml of distilled water and plated on nutrient agar for bacterial growth and potato dextrose agar (PDA) for fungal growth (Tournas*et al.,* 2006). The experiment included three replications for each of the samples. All petriplates were incubated at 37°C for 24 hours for bacterial growth and 48 hours for fungal growth (Gilbert *et al.,* 2000), and the mean value was calculated as colony-forming unit per ml (cfu/ml).

3.12. **Statistical Evaluation.**

It was subjected to ANOVA with a CRD (Completely randomised design) with probability levels (p 0.05). The OPSTAT statistical software was used to test the data (Sheoran, 1998). Except for the ionome analysis, all of the analyses were done in triplicate and recorded as mean standard deviation (SD). MS Excel 2019 was used to analyse all of the data. SPSS 20.0 was used to perform sensory evaluations.

CHAPTER-4 RESULTS

The current study, titled "**Processing effect on nutritional qualities of value added products from select underutilized fruits of Sikkim**"was conducted between 2016 and 20 at the Department of Horticulture Laboratory, 6th Mile, Sikkim University, Gangtok.The following subheads include the estimated results from the current research study:-

4.1. Nutritional assessment of underutilized fruits.

4.2. Ionome profiling of underutilized fruits.

4.3. The impact of processing on the nutritional assessment and ionome profiling of value added foods.

4.4. Evaluation of a value added products from a sensory standpoint.

4.5. Nutritional assessment and Ionome profiling of a vitamin C and calcium fortified processed product.

4.6. Commercial product nutritional assessment and ionome profiling.

4.7. Sensory assessment following fortification.

4.8. Microbial assessment.

4.1. Nutritional assessment of underutilized fruits

Fruits are a natural source of micronutrients like minerals, vitamins as well as secondary metabolites like polyphenols (Sundriyal, 1999). Underutilized fruits been growing attention and interest in this area widely nowadays especially for their nutritionand various mineral compositions (Arora and Pandey, 1996) also have economical benefit as various part of these fruit trees are also used for medicinal purpose. These underutilized fruits have been used as curative foods in traditional Indian ayurveda and medicine since, ancient (Vino *et al.*, 2016).

4.1.1. Total Soluble Solids (TSS)

TSS is regarded as an energy source and is abundant in this evaluated underutilized fruits. The TSS estimation for fruits differed significantly between species. The fruits of *Diploknema butyraceae*(16.75 ± 0.44 ° Brix) and *Elaeagnus latifolia* (7.12 ± 0.27 ° Brix) had the highest TSS, followed by *Docynia indica, Hippophaesalicifolia*(5.24 ± 0.07° Brix), (4.95 ± 0.27° Brix), and *Machilus edulis* (3.46 ± 0.05° Brix).

4.1.2. Titratable Acidity

Titratable Acidity is a significant component of fruits that determines the acidity level of these underutilized fruits. *Diploknema butyracea, Hippophae salicifolia, Docynia indica, Elaeagnus latifolia, Machilus edulis* fruits were examined for titratable acidity, which differed significantly between species. *Diploknema butyraceae* had the lowest acidity (0.64 ± 0.02 percent), while *Docynia indica* had the highest acidity (2.49 ± 0.07 percent), followed by *Hippophae salicifolia, Machilus edulis,* and *Elaeagnus latifolia* with (2.30 ± 0.12 percent), (2.20 ± 0.12 percent), and (1.06 ± 0.01 percent) acidity, respectively.

Table No 2. Nutritional assessment of underutilized fruits

Underutilized fruits	**TSS^0** Brix	**TA %**	**TS %**	**RS%**	**NRS%**
Diploknema butyraceae	16.75 ±0.44	0.64 ± 0.02	9.04 ± 0.80	6.26 ± 0.10	3.04 ± 0.54
Docynia indica	5.24 ± 0.07	2.49 ± 0.07	9.45 ± 0.36	5.59 ± 1.11	3.86 ± 0.05
Machilus edulis	3.46 ± 0.05	2.20 ± 0.12	4.21 ± 0.13	2.5 ±0.05	2.18 ± 0.29
Hippophaesalic ifolia	4.95 ± 0.27	2.30 ± 0.12	4.70 ± 0.10	3.34 ± 0.18	1.49 ± 0.50
Elaeagnus latifolia	7.12 ± 0.27	1.06 ± 0.01	5.37 ± 0.15	4.30 ± 0.05	1.006 ± 0.00
SE(m)	0.154	0.050	0.236	0.294	0.207
CD **(P<0.05)**	0.493	0.159	0.753	0.937	0.659

(Values are expressed as mean ±SD)

(TA= Titratable acidity, TS= Total Sugar, RS= Reducing sugar, NRS= Non Reducing Sugar)

4.1.3. Sugars (total, reducing, and non-reducing)

They have a crucial role in a new product's sensory features and consumer adoption. The sugar evaluated (total, reducing, and non-reducing) fluctuated significantly between species. *Docynia indica* fruits had the most total sugar (9.45 ± 0.36 percent), followed by *Diploknema butyraceae* (9.04 ± 0.80 percent), while *Elaeagnus latifolia, Hippophae salicifolia*, and *Machilus edulis* had the least total sugar (5.37 ± 0.15 percent), (4.70 ± 00.10 percent) and(4.21 ± 0.13 percent) respectively. *Diploknema butyraceae* had the largest quantity of reducing sugar (6.26 ± ± 0.10 percent), followed by *Docynia indica* (5.29 ± 1.11 percent), and *Elaeagnus latifolia* (4.30 ± 0.05 percent), while *Hippophae salicifolia* and *Machilus edulis* had the lowest (3.34 ± 0.18 percent) and (2.50 ± 0.05 percent) correspondingly. *Elaeagnus latifolia, Diploknema butyracea, Hippophae salicifolia, Docynia indica, and Machilus edulis* had non-reducing sugars that ranged from (1.006 percent to 3.86 percent). Among these wild fruits *Docynia indica* (3.86 ± 0.05 %) recorded maximum amount of non-reducing sugar followed by *Diploknema butyraceae* (3.04 ± 0.54 %) and *Machilus edulis* (2.18 ± 0.29%) while minimum obtained from *Elaeagnus latifolia* and *Hippophae salicifolia.*

4.1.4. Total Anthocyanin

Total anthocyanin is naturally present in fruits and vegetables and has anti-cancer properties. Fruits were found to have varying levels of total anthocyanin. The total anthocyanin content was measured highest in *Elaeagnus latifolia* (1.26 ± 0.16 mg/100gm) followed by *Hippophae salicifolia* (0.34 ± 0.02 mg/100gm),

Table no. 3. Nutritional assessment of underutilized fruits

Underutilized fruits	**TA mg/100gm**	**TAN µg/Ml**	**TF mg/g/QE**	**TP mg/g/GAE**	**TC mg/100gm**	**AA mg/100gm**
Diploknema butyraceae	0.27 ± 0.01	7.60 ± 0.00	22.89 ± 0.76	17.67 ± 0.38	2.56 ± 0.50	32.69 ± 0.55
Docynia indica	0.07 ± 0.005	82.0 ± 0.89	49.05 ± 0.75	57.24 ± 0.11	15.71 ± 0.53	1.14 ± 0.03
Machilus edulis	0.05 ±0.005	60.47 ± 0.51	17.62 ± 0.38	17.04 ± 0.35	61.65 ± 0.68	4.17 ± 0.46
Hippophaesalicifolia	0.34 ± 0.02	92.69 ± 0.55	39.11 ± 0.38	71.15 ± 0.54	4.45 ± 0.01	37.44 ± 0.52
Elaeagnus latifolia	1.26 ± 0.16	15.92 ± 0.30	22.72 ±0.42	27.90 ± 0.70	3.27 ± 0.01	9.93 ± 0.56
SE(m)	0.044	0.313	0.371	0.269	0.267	0.274
CD **(P<0.05)**	0.141	0.999	0.999	0.858	0.859	0.873

(Values are expressed as mean ±SD)

TA= Total Anthocyanin, TAN=Total Antioxidant, TC= Total Carotenoids, TF=Total flavonoids, TP= Total Phenol, AA= Ascorbic Acid

Diploknema butyraceae (0.27 ± 0.01 mg/100gm) while least was observed in *Docynia indica* and *Machilus edulis* with (0.07 ± 0.005 mg/100gm) and (0.05 ± 0.005 mg/100gm) respectively.

4.1.5. Total Antioxidant

Antioxidants have been shown to protect against diseases, including cancer, high blood pressure, wrinkles, and heart disease. The nutritional value of five different species of wild fruits from the Sikkim Himalayas was assessed, and the results revealed that total antioxidant content varied. The fruit *Hippophae salicifolia* (92.69 ± 0.55 µg/ml) had the highest total antioxidant content, followed by *Docynia indica* (82.00 ± 0.89 µg/ml) and *Machilus edulis* (60.47 ± 0.51 µg/ml), and *Elaeagnus latifolia* (15.92 ± 0.30 µg/ml) and *Diploknema butyraceae*(7.60 µg/ml).

4.1.6. Total Flavonoids

Flavonoids are compounds able to reduces the risks of cardiovascular disease, diabetes, and some cancers. The total flavonoids content of *Machilus edulis*, *Diploknema butyracea*, *Hippophae salicifolia*, *Docynia indica* and *Elaeagnus latifolia*, depicted significantly different. Result showed that the maximum content was noticed in *Docynia indica* (49.05 ± 0.75 mg/g/QE) along with *Hippophae salicifolia* (39.11 ± 0.38 mg/g/QE), *Diploknema butyraceae*(22.89 ± 0.76 mg/g/QE), *Elaeagnus latifolia* (22.72 ± 0.42 mg/g/QE) and(17.62 ± 0.38 mg/g/QE) in *Machilus edulis* with least respectively.

4.1.7. Total Phenol

All plants produce phenolics, which are classified as secondary metabolites. The total phenol content of the selected wild fruits differed substantially. Results revealed that the *Hippophae salicifolia* had the greatest total phenol content (71.15 ± 0.54 mg/g/GAE) followed by *Docynia indica* (57.24 ± 0.11 mg/g/GAE), *Elaeagnus latifolia* (27.90 ± 0.70 mg/g/GAE), *Diploknema butyraceae* (17.67 ± 0.38 mg/g/GAE), while least was noticed in *Machilus edulis* (17.04 ± 0.35 mg/100g).

4.1.8. Total Carotenoids

Carotenoids are powerful antioxidants that trap singlet oxygen and remove the peroxyl radical. They play a significant role in human health and nutrition (Al-Duais, 2009). For *Diploknema butyracea, Hippophae salicifolia, and Docynia indica, Elaeagnus latifolia,* and *Machilus edulis,* significant variation in carotenoid content of fruits was estimated. The highest total carotenoid content was found in *Machilus edulis* (61.65 ± 0.68 mg/100gm), followed by *Docynia indica* (15.71 ± 0.53 mg/100gm), *Hippophae salicifolia* (4.45 0.01 mg/100gm), *Elaeagnus latifolia* (3.27 ± 0.01 mg/100gm), and *Diploknema butyraceae* (2.56 ± 0.50 mg/100gm).

4.1.9. Ascorbic acid

Ascorbic acid is a natural antioxidant also most widely used in the food industries in form of ascorbic acid with a varied chemistry. The content of Ascorbic acid was noticedhighest in the fruit *Hippophae salicifolia* (37.44 ± 0.52 mg/100g) followed by *Diploknema butyraceae* (32.69 0.55 mg/100g) and appreciable content was observed in *Elaeagnuslatifolia* (9.93 ±0.56 mg/100gm), *Machilus edulis* (4.17 ± 0.46 mg/100gm) and *Docynia indica* (1.14 ± 0.03 mg/100gm).

4.2. Ionome profiling of underutilized fruits

4.2.1. Potassium (K)

Potassium are electrolytes that help your body maintain fluid and blood volume so it can function normally. However, consuming too little potassium and too much sodium can raise your blood pressure (Dietary Guidelines Advisory Committee, 2020). The Potassium content of underutilized fruit species revealed that it varied between (71.832 to 119.583 µg/100gm). Potassium content for *Machilus edulis* (119.583 µg/100gm) which was highest among those underutilized fruit species followed by *Elaeagnus latifolia* (98.829 µg/100gm), *Docynia indica* (90.416 µg/100gm), *Hippophae salicifolia* (76.944 µg/100gm), whereas lowest potassium content was noticed in the fruit of *Diploknema butyraceae*(71.832 µg/100gm).

4.2.2.Magnesium (Mg)

Magnesium exists as the fourth most abundant mineral in the body regulating enzyme processes, which make the trillions of chemical reactions in the body possible. The magnesium concentration recorded a range between (1.528 to 4.132 µg/100gm). *Elaeagnus latifolia* (4.132 µg/100gm) was observed maximum in magnesium content followed by *Machilus edulis* (3.309 µg/100gm), while, the magnesium content in the fruit *Hippophae salicifolia* (1.854 µg/100gm), *Diploknema butyraceae*was recorded at par whereas lowest was observed in the *Docynia indica* fruit (1.528 µg/100gm).

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4.2.3. Calcium (Ca)

Calcium is a mineral that's well-known for its essential role in bone health, maintaining heart rhythm and muscle function. The calcium content of five different underutilized fruit species have been shown in the table no. 4. and the data recorded calcium content in those underutilized fruit species was ranged from (0.002 to 1.501 µg/100gm).Maximum calcium content was obtained in *Hippophae salicifolia* fruit (1.501 µg/100gm) among the underutilized fruits evaluated while the fruit of *Elaeagnus latifolia* and *Diploknema butyraceae*, was recorded at par with the value (0.139 µg/100gm) and (0.019 µg/100gm). The least content of calcium was recorded in the fruit *Docynia indica* and *Machilus edulis* with the value (0.003 µg/100gm) and (0.002 µg/100gm).

4.2.4. Sodium (Na)

Sodium (Na) is a mineral as essential to life alsocontrol blood pressure and blood volume. The sodium content of underutilized fruits studied are presented in the table no.4. The sodium contentwas found with a range between (1.813 to 50.728 µg/100gm) in select underutilized fruit species. The sodium content was recorded in the fruit of *Hippophae salicifolia* followed by *Machilus edulis* and *Docynia indica* with the value (50.728 µg/100gm), (26.788 µg/100gm) and (14.884 µg/100gm) exhibited highest content whereas, least amount of sodium content was recorded in *Elaeagnus latifolia* along with *Diploknema butyraceae* fruit (2.012 µg/100gm) and (1.813 µg/100gm).

Table no. 4. Ionome profiling (µg/100gm) of underutilized fruits

Underutilized fruits	Potassium (K)	Magnesium (Mg)	Calcium (Ca)	Sodium (Na)	Iron (Fe)	Zinc (Zn)	Manganese (Mn)
Diploknema butyraceae	71.832	1.745	0.019	1.813	2.565	0.103	0.037
Docynia indica	90.416	1.528	0.003	14.884	0.031	0.273	0.002
Machilus edulis	119.583	3.309	0.002	26.788	Nd	0.064	0.002
Hippophae salicifolia	76.944	1.854	1.501	50.728	1.936	0.289	0.008
Elaeagnus latifolia	98.829	4.132	0.139	2.012	0.034	0.254	0.006

Underutilized fruits	Copper	Boron (B)	Lead (Pb)	Chromium (Cr)	Nickel (Ni)	Aluminium (Al)
Diploknema butyraceae	0.013	0.006	0.079	0.032	0.004	Nd
Docynia indica	Nd	0.014	Nd	0.006	Nd	Nd
Machilus edulis	0.003	0.015	0.028	0.015	Nd	Nd
Hippophae salicifolia	Nd	0.019	Nd	0.244	Nd	0.014
Elaeagnus latifolia	Nd	0.153	0.004	Nd	0.003	0.025

Table no. 5. Highest RDA (Food and Nutrition Board, Institute of Medicine, National Academies), FSSAI and WHO

Elements	Potassium (K)	Magnesium (Mg)	Calcium (Ca)	Sodium (Na)	Iron (Fe)	Zinc (Zn)	Manganese (Mn)
Highest RDA	4700 mg	420mg	1300mg	1.5g	18mg	11mg	2.3mg

Copper	Boron (B)	Lead (Pb)	Chromium (Cr)	Nickel (Ni)	Aluminium (Al)
0.9mg	Nd	0.1ppm	0.35 mg	0.3mg	Nd

4.2.5. Iron (Fe)

Iron is an essential mineral for the production of the red blood cells delivering oxygen throughout every one of our body.The iron content for all the underutilized fruits is presented in table no. 4. It is noticed that the samples of *Diploknema butyraceae*contain highest iron (2.565 µg/100gm) followed by *Hippophae salicifolia* (1.936 µg/100gm). The lowest iron content was observed in fruits of *Elaeagnus latifolia* (0.034 µg/100gm) followed by *Docynia indica* (0.031 µg/100gm) whereas in the fruit of *Machilus edulis* iron content was not detectable.

4.2.6. Zinc (Zn)

Zinc is an essential trace element, influencing growth and affecting the development and integrity of the immune system and many more physiological functions in human body (Soni*et al.,* 2017). The zinc content of the studied underutilized fruits is illustrated in table no. 4. *Hippophae salicifolia* (0.289 µg/100gm) exhibited the maximum zinc content among five studied underutilized fruits followed by *Docynia indica* (0.273 µg/100gm), *Elaeagnus latifolia* (0.254 µg/100gm), *Diploknema butyraceae* (0.103 µg/100gm) while minimum amount of zinc content was recorded in the *Machilus edulis* fruit (0.064 µg/100gm).

4.2.7. Manganese (Mn)

Manganese is also known for bone health, including bone development and maintenance as Calcium.The manganese content was recorded maximum in the fruit of *Diploknema butyraceae*(0.037 µg/100gm) than other underutilized fruits under study while in the fruit of studied underutilized fruit species the manganese content was present in smaller quantity, *Hippophae salicifolia* (0.008 µg/100gm), *Elaeagnus* *latifolia* (0.006µg/100gm) whereas the least was recorded in the fruit of *Machilus edulis* and *Docynia indica* with the value (0.002µg/100gm).

4.2.8. Copper (Cu)

Copper, an essential mineral, is a cofactor for several enzymes (known as "cuproenzymes") involved in energy production, iron metabolism, neuropeptide activation, connective tissue synthesis, and neurotransmitter synthesis (Institute of Medicine, Food and Nutrition Board, 2001). The amount of copper content in select underutilized fruits are evaluated in table.no.4.The fruit of *Diploknema butyraceae*possessed copper highest with the value (0.013 µg/100gm) and the lowest amount was depicted in the fruit of *Machilus edulis* (0.003 µg/100gm) incaseof *Hippophae salicifolia, Elaeagnus latifolia* and *Docynia indica* fruits the copper content was not detectable.

4.2.9. Boron (B)

Boron is associated with benefits like hormone regulation, reduced arthritis symptoms, supports bone health (healthy bones) also boost immune function. Table no.3. depicts the boron content in different underutilized fruits. Highest boron content was recorded in the fruit of *Elaeagnus latifolia* (0.153 µg/100gm) whereas in the case of *Hippophaesalicifolia, Machilus edulis* and *Docynia indica* there was non-significant with the value (0.019 µg/100gm), (0.015 µg/100gm) and (0.014 µg/100gm). While, *Diploknema butyraceae* (0.006 µg/100gm), has least content of boron.

Lead, Chromium, Nickel and Aluminium are heavy metal proven to be a major threat with health risks. The toxic effects of these metals, even though they do not have any biological role, remain present in some or the other form harmful for the human body and its proper functioning. Although the present study indicate the presence of these element in trace amount.

4.2.10. Lead (Pb)

The lead content of all the studied underutilized fruits are presented in table no.4.*Diploknema butyraceae*(0.079 µg/100gm) recorded highest amount followed by *Machilus edulis* (0.028 µg/100gm) while in *Elaeagnus latifolia* (0.004 µg/100gm) it was recorded least, whereas in the fruit of *Docynia indica* and *Hippophae salicifolia* the lead content was not detectable.

4.2.11. Chromium (Cr)

The chromium content of all the studied underutilized fruits are depicted in table.no.4. From the table it was shown that chromium content was recorded highest in *Hippophae salicifolia* (0.244 µg/100gm) followed by *Diploknema butyraceae* (0.032 µg/100gm). The lowest was obtained in *Machilus edulis* fruit (0.015 µg/100gm) followed by *Docynia indica* fruit (0.006 µg/100gm). The chromium content was not detectable in the fruit of *Elaeagnus latifolia.*

4.2.12. Nickel (Ni)

The nickel content in all the underutilized fruits was recorded to be very low in content and presented in table.no.3. Nickel in *Diploknema butyraceae*, *Elaeagnus latifolia* was (0.004 µg/100gm) and (0.003 µg/100gm). It was not detectable in the case of *Docynia indica*, *Machilus edulis* and *Hippophae salicifolia* fruits respectively.

4.2.13. Aluminium (Al)

The aluminium content of all five underutilized fruits studied are represented in table.no.3. Among the five underutilized fruits, *Elaeagnus latifolia* (0.025 µg/100gm) was tested to have highest content whereas lowest was depicted in the fruit of *Hippophae salicifolia* (0.014 µg/100gm) while in the fruit of *Diploknema butyraceae*, *Docynia indica* and *Machilus edulis* the aluminium content was not detectable.

4.3. Impact of processing on nutritional assessment and ionome profiling of value added foods.

4.3.1. Total Soluble Solids

The result revealed total soluble solid processed product in table no. 6. The highest content was found in the *Elaeagnus latifolia* jam (47.40 ± 0.57 ^{0} Brix) followed by*Hippophae salicifolia* jelly (45.30 ± 0.46^{0} Brix), *Elaeagnus latifolia* chutney (48.59 ± 0.12 ^{0} Brix) , *Hippophae salicifolia* jam (48.00 ± 0.02 ^{0} Brix) , *Hippophae salicifolia*juice (47.30 ± 0.55 ^{0} Brix) , *Elaeagnus latifolia* ketchup (43.30 ± 0.12 ^{0} Brix), *Docynia indica* jelly (33.80 ± 0.58 ^{0} Brix) , *Docynia indica* jam (31.40 ± 0.55 ^{0} Brix), *Diploknema butyraceae* candy (11.56 ± 0.09 ^{0} Brix), (19.07 ± 0.17 ^{0} Brix) juice *Diploknema butyraceae*, *Diploknema butyraceae* jam (17.30 ± 0.29 ^{0} Brix) and minimum was noticed in *Docynia indica* pickle (14.99 ± 0.03 ^{0} Brix) , *Machilus edulis* mayonnaise (2.40 ± 0.53 ^{0} Brix) and *Machilus edulis* puree (2.10 ± 0.10 ^{0} Brix). The difference may be due to the different species of fruits and its composition.

Table no. 6. Impact of processing on Nutritional assessment on value added foods

Value added Products	TSS ^{0} Brix	TA %	TS %	RS%	NRS%	β-carotene mg/100g
Diploknema butyraceae candy	19.20 ± 0.51	0.25 ± 0.01	4.16 ± 0.04	2.91 ± 0.09	1.18 ± 0.06	0.95 ± 0.05
Diploknema butyraceae juice	25.07 ± 0.84	0.40 ± 0.01	5.62 ± 0.19	3.56 ± 0.45	1.95 ± 0.16	1.28 ± 0.54
Diploknema butyraceae jam	21.30 ± 0.86	0.19 ± 0.02	4.85 ± 0.30	2.65 ± 0.11	2.09 ± 0.05	1.29 ± 0.31
Docynia indica pickle	14.99 ± 1.59	2.17 ± 0.01	9.37 ± 0.13	5.11 ± 0.09	4.15 ± 0.12	0.64 ± 0.40
Docynia indica Jam	31.40 ± 0.55	1.38 ± 0.11	8.94 ± 0.14	4.46 ± 0.31	5.28 ± 0.09	1.23 ± 0.17
Docynia indica Powder	33.80 ± 0.58	1.09 ± 0.03	8.64 ± 0.07	4.02 ± 0.10	4.69 ± 0.20	1.09 ± 0.06
Machilus edulis Puree	2.10 ± 0.10	1.38 ± 0.06	3.86 ± 0.13	2.16 ± 0.05	1.72 ± 0.01	0.95 ± 0.05
Machilus edulis mayonnaise	2.40 ± 0.53	1.27 ± 0.01	4.26 ± 0.04	2.14 ± 0.03	1.94 ± 0.09	1.06 ± 0.04
Machilus edulis powder	1.35 ± 0.01	1.44 ± 0.07	1.32 ± 0.20	0.75 ± 0.19	0.54 ± 0.19	0.68 ± 0.02
Hippophae salicifolia juice	35.30 ± 0.55	2.13 ± 0.05	4.19 ± 0.05	2.02 ± 0.10	2.00 ± 0.08	6.14 ± 0.80
Hippophae salicifolia jam	33.00 ± 0.02	1.45 ± 0.05	3.63 ± 0.04	1.37 ± 0.05	2.05 ± 0.02	4.71 ± 0.55
Hippophae salicifolia jelly	30.30 ± 0.46	1.69 ± 0.06	3.56 ± 0.01	1.25 ± 0.03	2.19 ± 0.02	4.93 ± 0.57
Elaeagnus latifolia ketchup	23.30 ± 0.12	0.79 ± 0.56	4.26 ± 0.03	3.26 ± 0.08	0.14 ± 0.03	4.69 ± 0.49
Elaeagnus latifolia chutney	48.59 ± 0.19	0.96 ± 0.12	4.19 ± 0.03	3.67 ± 0.09	0.52 ± 0.03	5.30 ± 0.89
Elaeagnus latifolia jam	47.40 ± 0.57	0.13 ± 0.02	4.13 ± 0.01	3.06 ± 0.02	1.02 ± 0.01	6.32 ± 0.32
SE(m)	0.273	0.261	0.074	0.097	0.059	0.261
CD **(P<0.05)**	0.793	0.090	0.215	0.282	0.172	0.756

(TA=Titratable acidity, TS= total sugar, NRS =Non-Reducing sugar, RS=Reducing sugar). (Values are expressed as mean ±SD).

4.3.2. Titratable Acidity

The titratable acidity content was found significantly different of all the studied value added products. The titratable acidity content was found highest in *Docynia indica* pickle (2.17 ± 0.01 percent) followed by (2.13 ± 0.05 percent), (1.45 ± 0.05 percent), *Hippophae salicifolia Hippophae salicifolia* juice, (1.44 ± 0.07 percent) *Machilus edulis* powder, (1.38 ± 0.11 percent), *Machilus edulis* puree (1.38 ± 0.06 percent), *Machilus edulis* mayonnaise (1.27 ± 0.01 percent), *Docynia indica* jelly (1.09 ± 0.03 percent) and minimum was observed in *Elaeagnus latifolia* chutney (0.96 ± 0.12 percent), *Elaeagnus latifolia* ketchup (0.79 ± 0.56 percent), *Diploknema butyraceae* juice (0.40 ± 0.01 percent), *Diploknema butyraceae* candy (0.25 ± 0.01 percent), *Diploknema butyraceae* jam (0.19 ± 0.02 percent) and ketchup of *Elaeagnus latifolia* (0.13 ± 0.02 percent).

4.3.3. Total, Reducing and Non-reducing sugars

The sugar content evaluated had significantly varied in value added products (table no.5). Among the products highest total sugar was obtained in the product pickle prepared from *Docynia indica* (9.37 ± 0.13 %) followed by *Docynia indica* jam (8.94 ± 0.14 %), *Docynia indica* jelly (8.64 ± 0.07 %), while in remaining processed product it ranged from (1.32 ± 0.20 % to 5.62 ± 0.19 %). Reducing sugar was evaluated maximum in *Docynia indica* pickle (5.11 ± 0.09 %) followed by *Docynia indica* jam (4.46 ± 0.31 %) while for *Machilus edulis* powder with the value (0.75 ± 0.19 %) was decipher lowest. Reducing sugar of remaining value added products ranged from (1.25 ± 0.03 % to 4.02 ± 0.10 %) to 13 %. Non-reducing sugars in value added products of different wild edible fruits ranged from (0.52 ± 0.03 % to 5.28 ± 0.09 %). Non-reducing sugar was found highest in *Docynia indica* jam (5.28 ± 0.09

%) followed by *Docynia indica* jelly (4.69 ± 0.20 %) and *Docynia indica* pickle (4.15 ± 0.12 %) while minimum recorded for *Machilus edulis* powder (0.54 ± 0.19%), *Elaeagnus latifolia* chutney (0.52 ± 0.03%) and *Elaeagnus latifolia* ketchup (0.14 ± 0.03%).

4.3.4. β-carotene

The β-carotene content was evaluated in different value added or value added products of underutilized fruits as shown in table no.6. Maximum content of β-carotene was depicted in *Elaeagnus latifolia* jam (6.32 ± 0.32mg/100g) followed by *Hippophae salicifolia* juice (6.14 ± 0.80 mg/100g), *Elaeagnus latifolia* chutney (5.30 ± 0.89 mg/100g), *Hippophae salicifolia* jelly(4.93 ± 0.57 mg/100g), *Hippophae salicifolia* jam (4.71 ± 0.55 mg/100g), *Elaeagnus latifolia* ketchup (4.69 ± 0.49 mg/100g),*Diploknema butyraceae*jam (1.29 ± 0.31 mg/100g), *Diploknema butyraceae*juice (1.28 ± 0.54 mg/100g), *Docynia indica* jam (1.23 ± 0.17 mg/100g), *Machilus edulis* mayonnaise (1.06 ± 0.04 mg/100g) whereas least was observed in the products of *Diploknema butyraceae* candy (0.95 ± 0.05 mg/100g), *Machilus edulis* powder (0.68 ± 0.02 mg/100g) and *Docynia indica* pickle (0.64 ± 0.40 mg/100g).

4.3.5. Total Anthocyanin

The result varied among the value added products of wild edible fruits as illustrate in table no.7. The highest content of total anthocyanin was observed in the processed product of *Elaeagnus latifolia* ketchup (1.13 ± 0.03 mg/100gm) among all the fifteen processed fruit products followed by *Elaeagnus latifolia* chutney (1.09 ± 0.03 mg/100gm) and *Elaeagnus latifolia* jam(1.06 ± 0.05 mg/100gm), *Diploknema*

Table no. 7. Impact of processing on Nutritional assessment of value added foods

Value added products	**TA mg/100gm**	**TAN µg/ml**	**TF mg/ g/QE**	**TP mg/g/GAE**	**TC mg/100gm**	**AA mg/100gm**
Diploknema butyraceae candy	0.21 ± 0.01	6.28 ± 0.41	18.33± 0.06	14.53± 0.48	1.33± 0.04	26.32± 0.57
Diploknema butyraceae juice	0.22 ± 0.02	6.84 ± 0.80	16.37± 0.02	15.49± 0.53	1.08± 0.02	26.34± 0.63
Diploknema butyraceae jam	0.21 ± 0.03	4.65 ± 0.42	12.69± 0.05	11.98± 0.61	1.45± 0.03	28.06± 0.50
Docynia indica pickle	0.36 ± 0.03	80.32 ± 0.01	41.58± 0.55	51.50± 0.53	13.92±0.06	1.02 ± 0.01
Docynia indica Jam	0.31 ± 0.03	48.44 ± 0.51	33.43± 0.54	36.13± 0.88	8.32± 0.02	0.23 ± 0.01
Docynia indica Powder	0.21 ± 0.03	43.87 ± 0.28	32.03± 0.54	38.41± 0.70	9.12± 0.02	0.89 ± 0.06
Machilus edulis Puree	0.04± 0.02	51.75 ± 0.97	14.23± 0.03	16.54± 0.48	45.37± 0.02	3.47 ± 0.55
Machilus edulis mayonnaise	0.03 ± 0.01	51.96 ± 0.37	12.26± 0.03	15.06± 0.48	48.53± 0.01	3.01 ± 0.07
Machilus edulis powder	0.03 ± 0.01	55.07 ± 0.53	13.17± 0.25	14.71± 0.35	56.80± 0.26	2.83 ± 0.81
Hippophae salicifolia juice	0.25 ± 0.04	82.01 ± 0.42	32.67± 0.01	69.26± 0.06	3.16± 0.03	30.53± 0.86
Hippophae salicifolia jam	0.18 ± 0.03	75.14 ± 0.05	28.90± 0.70	53.94± 0.27	2.05± 0.02	28.80± 1.19
Hippophae salicifolia jelly	0.26 ± 0.01	73.63 ± 0.34	29.62± 0.01	51.99± 0.05	2.00± 0.09	28.04± 0.89
Elaeagnus latifolia ketchup	1.13 ± 0.03	10.16 ± 0.62	16.42± 0.02	21.55± 0.01	2.96± 0.03	7.54 ± 0.43
Elaeagnus latifolia chutney	1.09 ± 0.03	8.61 ± 0.92	15.73± 0.65	19.07± 1.02	2.84± 0.02	5.88 ± 0.67
Elaeagnus latifolia Jam	1.06 ± 0.05	6.92 ± 0.18	12.42± 0.50	23.01± 0.16	2.51± 0.04	5.60 ± 0.35
SE(m)	0.026	0.301	0.270	0.306	0.046	0.357
CD **(P<0.05)**	0.076	0.900	12.696	0.784	0.135	1.036

(TA= Total Anthocyanin, TAN=Total Antioxidant, TC= Total Carotenoids, TF=Total flavonoids, TP= Total Phenol, AA= Ascorbic Acid)

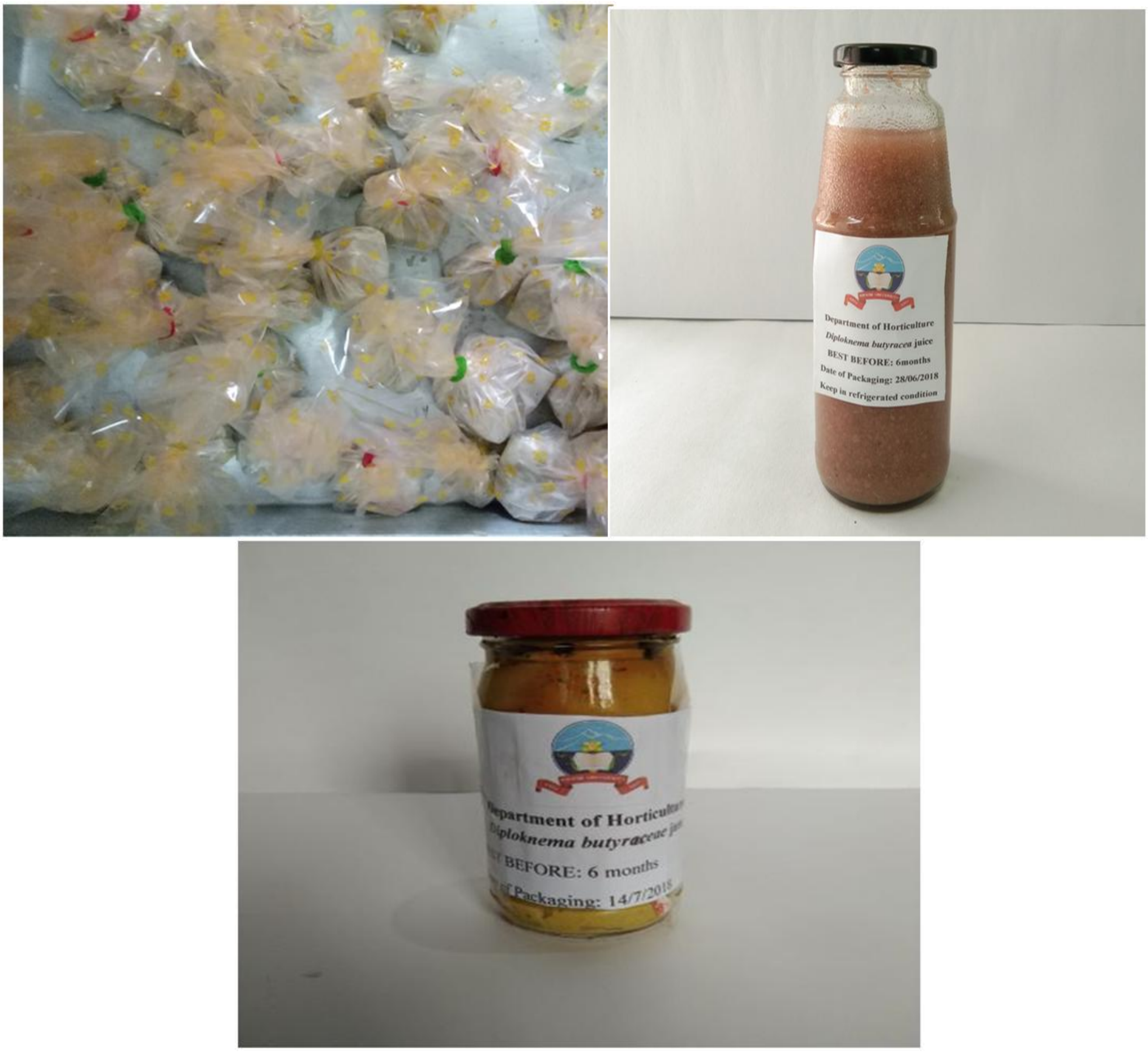

Fig.no.6. Glimpse of diversified value added products from *Diploknema butyraceae*

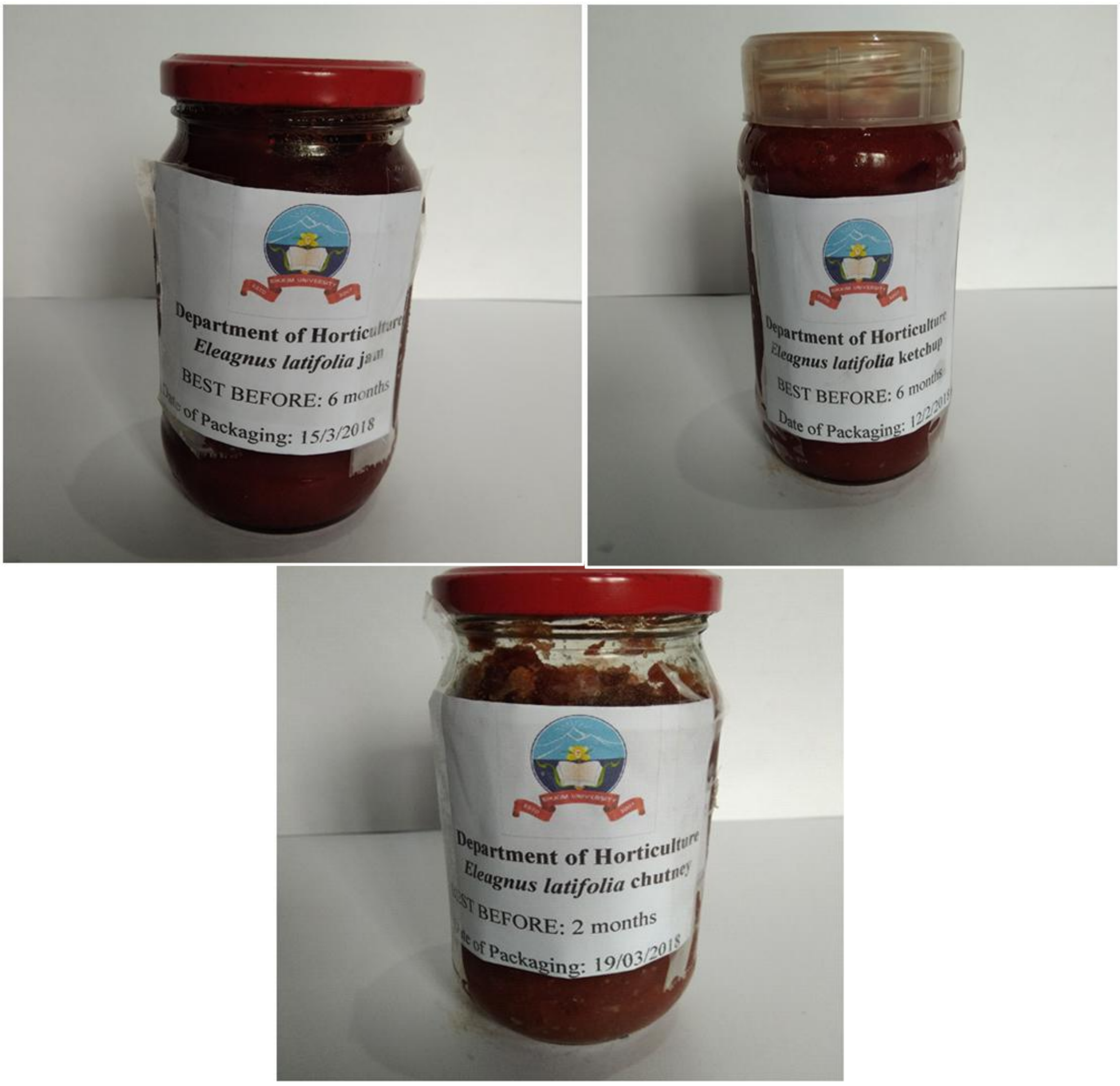

Fig.no.7. Glimpse of diversified value added products from *Elaeagnus latifolia*

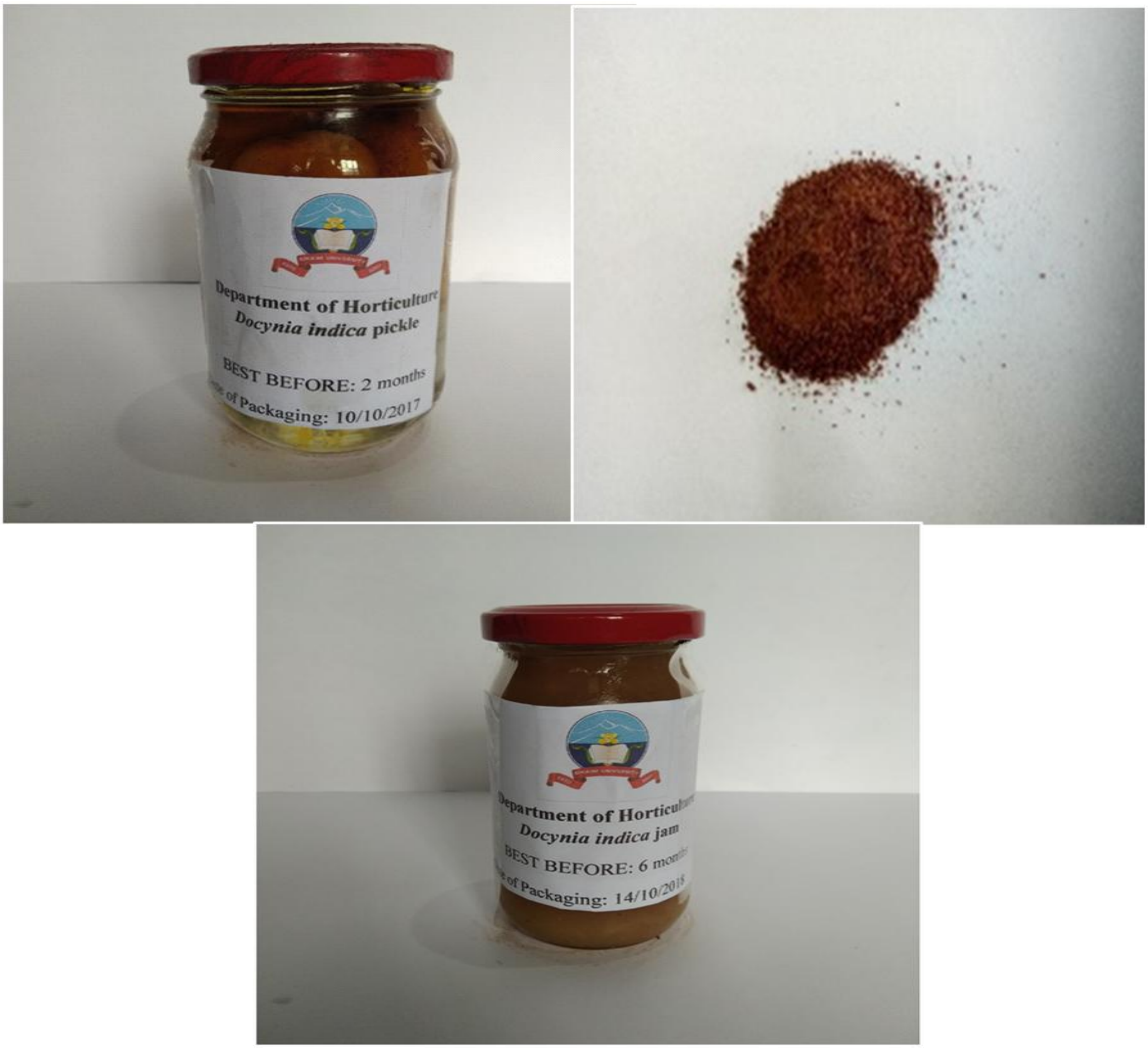

Fig.no.8. Glimpse of diversified value added products from *Docynia indica*

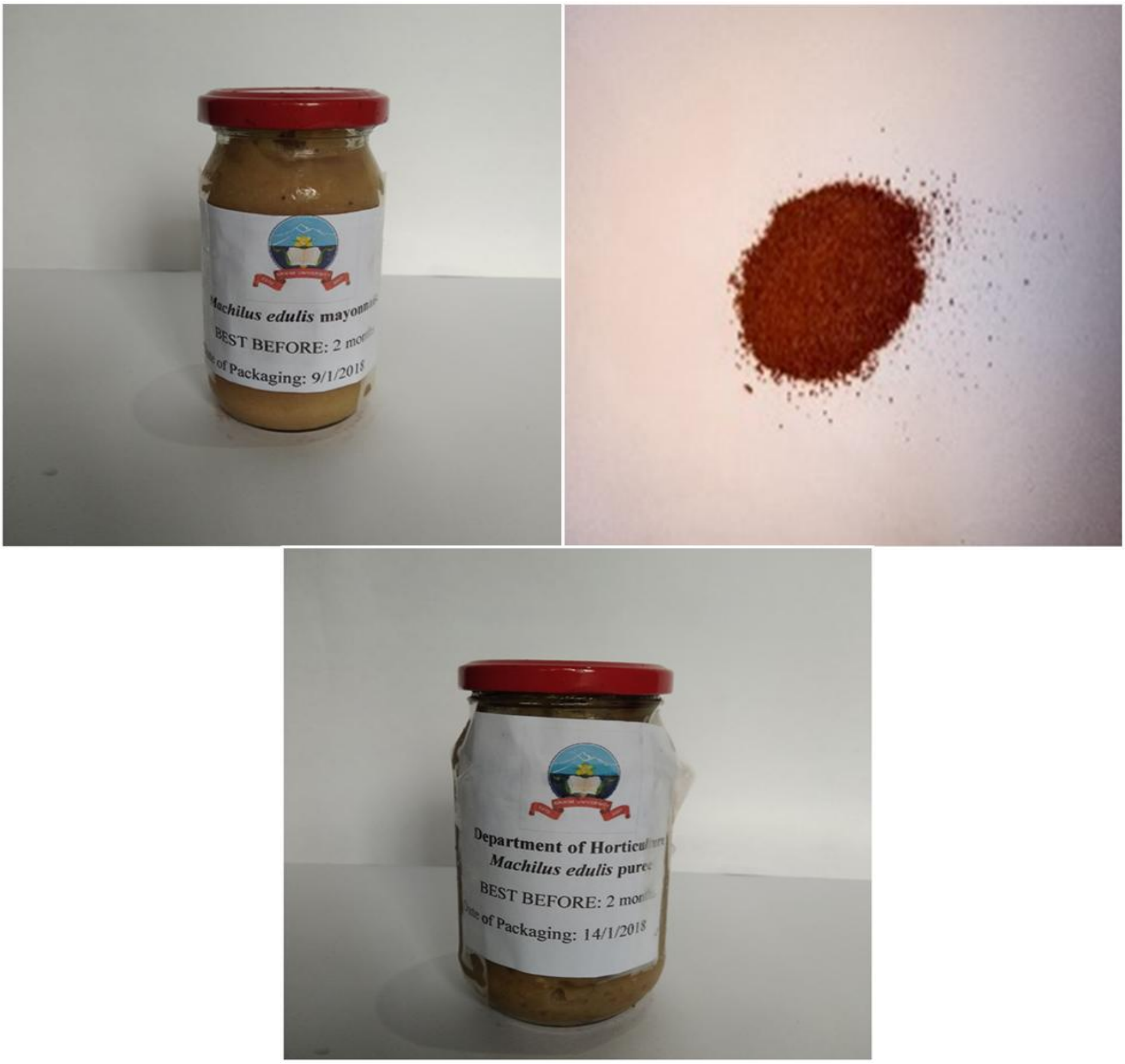

Fig.no.9. Glimpse of diversified value added productsfrom *Machilus edulis*

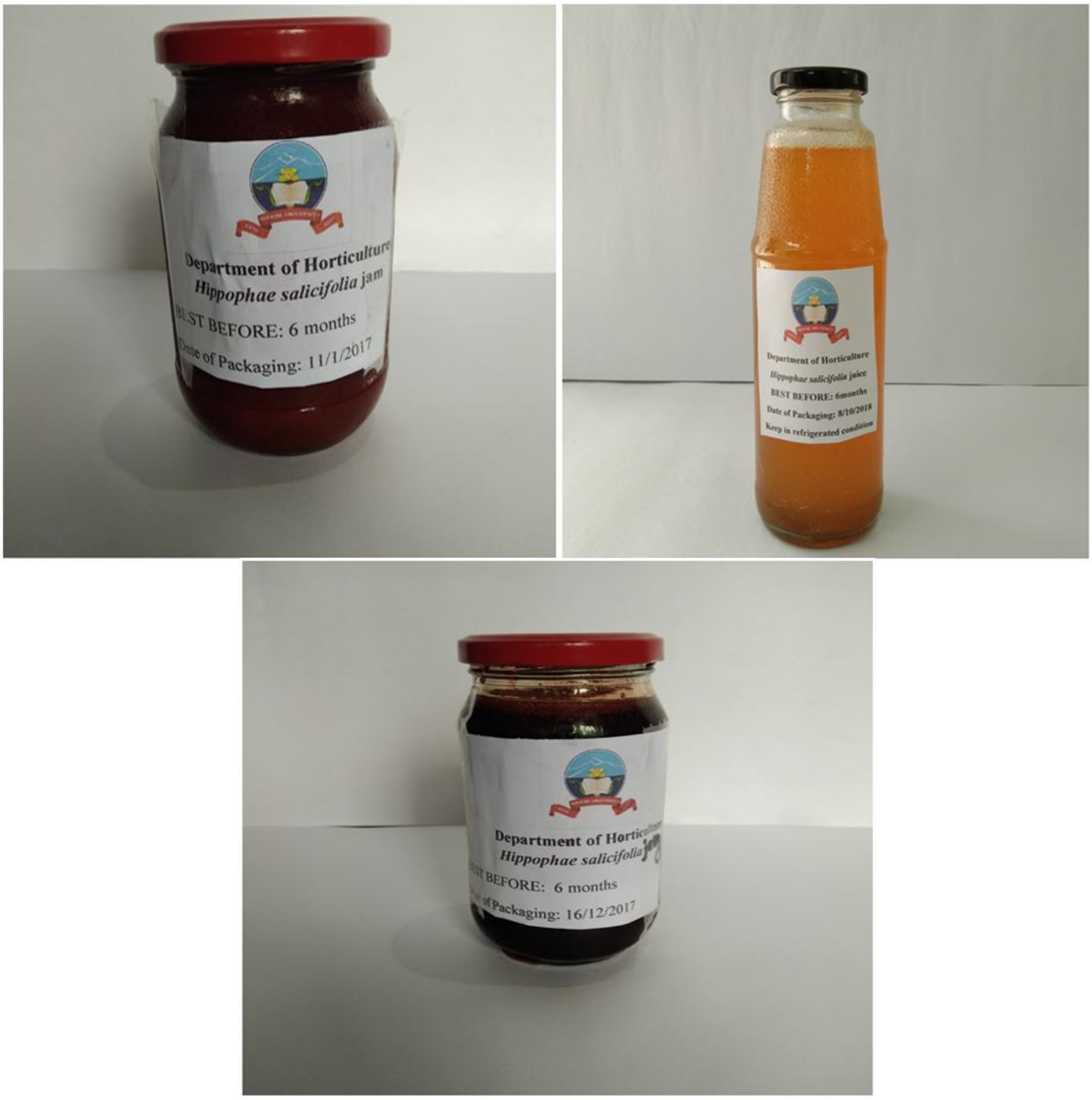

Fig.no.10. Glimpse of diversified value added productsfrom *Hippophae salicifolia*

butyraceae candy (0.21± 0.01 mg/100gm), *Diploknema butyraceae* juice (0.22 ± 0.02 mg/100gm), *Diploknema butyraceae*jam ((0.21 ± 0.01 mg/100gm), *Hippophae salicifolia* juice ((0.25 ± 0.04 mg/100gm), *Hippophae salicifolia* jam (0.18 ± 0.03 mg/100gm), *Hippophae salicifolia* jelly (0.26 ± 0.03 mg/100gm), *Docynia indica* pickle (0.36 ± 0.03, *Docynia indica* jam(0.31 ± 0.03 mg/100gm) and *Docynia indica* powder (0.21 ± 0.03 mg/100gm), *Machilus edulis* puree (0.04 ± 0.02 mg/100gm), *Machilus edulis* mayonnaise, *Machilus edulis* powder was found at par.

4.3.6. Total Antioxidant

As depicted in table no.6. the total antioxidant content was found to be significantly different for all the studied value added products. Maximum content of total antioxidant was exhibited by *Hippophae salicifolia* juice (82.01 ± 0.42 µg/ml) followed by *Docynia indica* pickle (80.32 ± 0.01 µg/ml), *Hippophae salicifolia* jam (75.14 ± 0.05 µg/ml), *Hippophae salicifolia* jelly (73.63 ± 0.34 µg/ml), *Machilus edulis* powder (55.07 ± 0.53 µg/ml), *Machilus edulis* mayonnaise (51.96 ± 0.37 µg/ml), *Machilus edulis* puree (51.75 ± 0.97 µg/ml), *Docynia indica* jam (48.44 ± 0.51 µg/ml), *Docynia indica* powder (43.87 ± 0.28 µg/ml) whereas lowest value was evaluated in *Elaeagnus latifolia* ketchup (10.16 ± 0.62 µg/ml), *Elaeagnus latifolia* chutney (8.61± 0.92 µg/ml), *Elaeagnus latifolia* jam (6.92 ± 0.18 µg/ml), *Diploknema butyraceae*juice (6.84 ± 0.80 µg/ml), *Diploknema butyraceae* candy (6.28 ± 0.41 µg/ml) and *Diploknema butyraceae* jam (4.65 ± 0.42 µg/ml).

4.3.7. Total Flavonoids

The total flavonoids content in all the processed under study did varied significantly and was recorded in the range of (12.26 ± 0.03 mg/g/QE to 41.58 ± 0.55

mg/g/QE). Among all the value added products the total flavonoids content observed maximum in pickle prepared in *Docynia indica* (41.58 ± 0.55 mg/g/QE) followed by *Docynia indica* jam (33.43 ± 0.54 mg/g/QE), *Hippophae salicifolia* juice (32.67 ± 0.01 mg/g/QE), *Docynia indica* powder (32.03 ± 0.54 mg/g/QE), *Hippophae salicifolia* jelly (29.62 ± 0.01 mg/g/QE), *Hippophae salicifolia* jam (28.90 ± 0.70 mg/g/QE), *Diploknema butyraceae* candy (18.33 ± 0.06 mg/g/QE), *Elaeagnus latifolia* ketchup (16.42 ± 0.02 mg/g/QE), *Diploknema butyraceae* juice (16.37 ± 0.02 mg/g/QE), *Elaeagnus latifolia* chutney (15.73 ± 0.65 mg/g/QE), *Machilus edulis* puree (14.23 ± 0.03 mg/g/QE) and *Machilus edulis* powder (13.17 ± 0.25 mg/g/QE) while *Elaeagnus latifolia* jam 12.42± 0.50 mg/g/QE), *Diploknema butyraceae* jam 12.69± 0.05 mg/g/QE), *Machilus edulis* mayonnaise 12.26± 0.03 mg/g/QE), was recorded least and at par.

4.3.8. Total Phenol

The data of total phenol are presented in table no.7. pertaining the highest value was noted in *Hippophae salicifolia* juice (69.26 ± 0.06 mg/g/GAE) along with *Hippophae salicifolia* jam (53.94 ± 0.27 mg/g/GAE), *Hippophae salicifolia* jelly(51.99 ± 0.05 mg/g/GAE), *Docynia indica* pickle (51.50 ± 0.53 mg/g/GAE), *Docynia indica* powder (38.41 ± 0.70 mg/g/GAE), *Docynia indica* jam (36.13 ± 0.88 mg/g/GAE), *Elaeagnus latifolia* jam (23.01 ± 0.16 mg/g/GAE), *Elaeagnus latifolia* ketchup (21.55 ± 0.01 mg/g/GAE), *Elaeagnus latifolia* chutney (19.07 ± 1.02 mg/g/GAE), *Machilus edulis* puree (16.54 ± 0.48 mg/g/GAE), *Machilus edulis* mayonnaise, *Diploknema butyraceae* juice, *Diploknema butyraceae* candy, *Machilus edulis* powder was at par (table no.6) whereas lowest value was evaluated in *Diploknema butyraceae* jam (11.98 ± 0.61 mg/g/GAE).

4.3.9. Total Carotenoids

Powder prepared from *Machilus edulis* obtained highest total carotenoids content (56.80 ± 0.26 mg/100gm) among the value added products. The carotenoids for *Machilus edulis* mayonnaise (48.53 ± 0.01 mg/100gm mg/100gm), *Machilus edulis* puree (45.27 ± 0.02 mg/100gm), *Docynia indica* pickle (13.92 ± 0.06 mg/100gm), *Docynia indica* powder (9.12 ± 0.02 mg/100gm), *Docynia indica* jam (8.32 ± 0.02 mg/100gm) was recorded while in remaining products *Hippophae salicifolia* juice, *Hippophae salicifolia* jam, *Hippophae salicifolia* jelly, *Elaeagnus latifolia* jam, *Elaeagnus latifolia* chutney, *Elaeagnus latifolia* ketchup, *Diploknema butyraceae*juice, *Diploknema butyraceae* candy, *Diploknema butyraceae* jam was at par.

4.3.10. Ascorbic acid

Ascorbic acid content in processed wild edible fruit products did varied. Among the products prepared the maximum content depicted in *Hippophae salicifolia* juice (30.53 ± 0.86 mg/100gm) followed by *Hippophae salicifolia* jam (28.80 ± 1.19 mg/100gm), *Diploknema butyraceae*jam (28.06 ± 0.50 mg/100gm), *Hippophae salicifolia* jelly (28.04 ± 0.89 mg/100gm), *Diploknema butyraceae*juice (26.34 ± 0.63 mg/100gm), *Diploknema butyraceae*candy (26.32 ± 0.57 mg/100gm) and least was noticed in *Elaeagnus latifolia* ketchup (7.54 ± 0.43 mg/100gm), *Elaeagnus latifolia* chutney (5.88 ± 0.67 mg/100gm), *Elaeagnus latifolia* jam (5.60 ± 0.35 mg/100gm), *Machilus edulis* puree (3.47 ± 0.55 mg/100gm), *Machilus edulis* mayonnaise (3.01 ± 0.07 mg/100gm), *Machilus edulis* powder (2.83 ± 0.81 mg/100gm), *Docynia indica* pickle (1.02 ± 0.00 mg/100gm), *Docynia indica* (0.89 ± 0.06 mg/100gm), *Docynia indica* jam (0.23 ± 0.00 mg/100gm).

4.4. Impact of processing on Ionome profiling of value added foods

4.4.1. Potassium (K)

The Potassium content of value added products revealed that it varied between (0.460 to 68.816 µg/100gm). Potassium content for *Diploknema butyraceae* juice (68.816 µg/100gm) was highest among value added productsprepared from underutilized fruit species followed by *Diploknema butyraceae* jam (45.594 µg/100gm, *Machilus edulis* powder (37.767 µg/100gm), *Machilus edulis* mayonnaise (33.067 µg/100gm), *Hippophae salicifolia* juice (25.176 µg/100gm), *Diploknema butyraceae* candy (23.882 µg/100gm), *Hippophae salicifolia* jam (22.410 µg/100gm), *Docynia indica* pickle (21.850 µg/100gm), *Elaeagnus latifolia* chutney (20.747µg/100gm), *Docynia indica* powder (20.288 µg/100gm) and *Machilus edulis*puree (19.969 µg/100gm), *Docynia indica* jam (19.309 µg/100gm) was at par. *Elaeagnus latifolia* jam (0.460µg/100gm) had the lowest potassium content.

4.4.2. Magnesium (Mg)

The magnesium content of different value added products have been recorded where the range for content was (0.212 to 4.114 µg/100gm). The product of *Machilus edulis* puree (4.114 µg/100gm) contained maximum amount followed by *Diploknema butyraceae* jam (1.532 µg/100gm), *Machilus edulis* powder (1.516 µg/100gm), *Hippophae salicifolia* jam (1.435 µg/100gm), *Machilus edulis* mayonnaise (1.329 µg/100gm), *Diploknema butyraceae* juice (1.320 µg/100gm), *Elaeagnus latifolia* chutney (1.301 µg/100gm), *Diploknema butyraceae* candy (1.121 µg/100gm), *Elaeagnus latifolia* ketchup (0.916 µg/100gm), *Docynia indica* pickle (0.911 µg/100gm), *Hippophae salicifolia* jelly (0.764 µg/100gm), *Hippophae salicifolia* juice (0.639 µg/100gm) while, the magnesium content in the product *Docynia indica* jam (0.611 µg/100gm) and *Docynia indica* powder (0.603 µg/100gm) was recorded lowest.

4.4.3. Calcium (Ca)

The calcium content of different value added products prepared from underutilized fruits have revealed the data which recorded calcium content in the value added products ranged from (0.001 to 1.148 µg/100gm). Maximum calcium content was observed in the product of *Hippophae salicifolia* juice (1.148 µg/100gm) among the value added products evaluated followed by *Hippophae salicifolia* jam (1.141 µg/100gm), *Hippophae salicifolia* jelly (1.139 µg/100gm), *Elaeagnus latifolia* ketchup (1.138 µg/100gm), *Elaeagnus latifolia* jam (1.138 µg/100gm), *Diploknema butyraceae* jam (0.016 µg/100gm), *Diploknema butyraceae* juice (0.014 µg/100gm), *Diploknema butyraceae* candy (0.011 µg/100gm), while the least content of calcium was recorded in the product *Docynia indica* pickle, *Docynia indica* jam and *Docynia indica* powder with the value (0.002 µg/100gm) and (0.001 µg/100gm).

4.4.4. Sodium (Na)

The sodium content of underutilized fruit value added products studied are presented in the table no.8. The sodium content in value added products was found within a range between (0.379 to 8.767µg/100gm). The sodium content was recorded in the product of *Machilus edulis* mayonnaise was found maximum (8.767 µg/100gm) followed by *Machilus edulis* powder, *Machilus edulis* puree, *Docynia indica* powder, *Docynia indica* jam, *Elaeagnus latifolia* chutney, *Hippophae salicifolia* jam, *Hippophae salicifolia* jelly, *Diploknema butyraceae* candy, *Elaeagnus latifolia* jam, *Hippophae salicifolia* juice, *Elaeagnus latifolia* ketchup, *Diploknema butyraceae* jam with the value (8.647 µg/100gm), (8.040 µg/100gm), (4.498 µg/100gm), (4.366 µg/100gm), (3.258 µg/100gm), (2.751 µg/100gm), (1.902 µg/100gm), (1.856 µg/100gm), (1.755 µg/100gm), (1.703 µg/100gm), (1.240 µg/100gm), (1.081 µg/100gm) whereas, least amount of sodium content was recorded from the product of *Docynia indica* pickle and *Diploknema butyraceae* juice (0.719µg/100gm) and (0.379µg/100gm)**.**

4.4.5. Iron (Fe)

The iron content for all the value added products is presented in table no. 8. It is noticed that the product of *Docynia indica* pickle (2.454 µg/100gm) obtain highest iron followed by *Hippophae salicifolia* jam (2.404 µg/100gm), *Elaeagnus latifolia* chutney (2.252 µg/100gm), *Hippophae salicifolia* juice (1.955 µg/100gm), *Diploknema butyraceae* candy (1.796 µg/100gm), *Elaeagnus latifolia* jam (1.744 µg/100gm), *Diploknema butyraceae* jam (1.601 µg/100gm), *Docynia indica* jam (1.440 µg/100gm), *Hippophae salicifolia* jelly (1.298 µg/100gm), *Elaeagnus latifolia* ketchup (1.029 µg/100gm) *Diploknema butyraceae* juice (1.020 µg/100gm). The lowest iron content was observed in the products of *Docynia indica* powder (0.828 µg/100gm) whereas in the products of *Machilus edulis* iron content was not detectable.

Table no. 8. Impact of processing on Ionome profiling of value added food

Value added products	Potassium (K)	Magnesium (Mg)	Calcium (Ca)	Sodium (Na)	Iron (Fe)	Zinc (Zn)	Manganese (Mn)
Diploknema butyraceae candy	23.882	1.121	0.011	1.856	1.796	0.102	0.032
Diploknema butyraceae juice	68.816	1.320	0.014	0.379	1.020	0.010	0.031
Diploknema butyraceae jam	45.594	1.532	0.016	1.081	1.601	0.102	0.036
Docynia indica pickle	21.850	0.911	0.002	0.719	2.454	0.214	0.002
Docynia indica Jam	19.309	0.611	0.001	4.366	1.440	0.212	0.001
Docynia indica Powder	20.288	0.603	0.001	4.498	0.828	0.165	Nd
Machilus edulis Puree	19.969	0.212	Nd	8.040	Nd	0.037	0.002
Machilus edulis mayonnaise	33.067	1.329	Nd	8.767	Nd	0.042	0.001
Machilus edulis powder	37.767	1.516	Nd	8.647	Nd	0.049	0.001
Hippophae salicifolia juice	25.176	0.639	0.148	1.703	1.955	0.206	0.003
Hippophae salicifolia jam	22.410	1.435	0.141	2.751	2.404	0.224	0.005
Hippophae salicifolia jelly	13.839	0.764	0.139	1.902	1.298	0.265	0.006
Elaeagnus latifolia ketchup	20.127	0.916	0.138	1.240	1.029	0.233	0.001
Elaeagnus latifolia chutney	20.747	1.301	0.131	3.258	2.252	0.189	0.004
Elaeagnus latifolia jam	0.460	4.114	0.136	1.755	1.744	0.243	0.004

Value added products	**Boron (B)**	**Lead (Pb)**	**Chromium (Cr)**	**Nickel (Ni)**	**Aluminium (Al)**
Diploknema butyraceae candy	0.006	0.018	0.027	0.002	Nd
Diploknema butyraceae juice	0.005	0.039	0.020	0.004	Nd
Diploknema butyraceae jam	0.002	0.019	0.028	0.002	Nd
Docynia indica pickle	0.012	Nd	0.005	Nd	Nd
Docynia indica jam	0.006	Nd	0.004	Nd	Nd
Docynia indica Powder	0.014	Nd	0.004	Nd	Nd
Machilus edulis Puree	0.013	0.008	0.014	Nd	Nd
Machilus edulis mayonnaise	0.011	0.014	0.011	Nd	Nd
Machilus edulis powder	0.011	0.017	0.011	Nd	Nd
Hippophae salicifolia juice	0.014	Nd	0.114	Nd	0.017
Hippophae salicifolia jam	0.012	Nd	0.103	Nd	0.011
Hippophae salicifolia jelly	0.017	Nd	0.137	Nd	0.012
Elaeagnus latifolia ketchup	0.150	0.004	Nd	0.002	0.003
Elaeagnus latifolia chutney	0.138	0.003	Nd	0.003	0.014
Elaeagnus latifolia jam	0.137	0.004	Nd	0.002	0.008

4.4.6. Zinc (Zn)

The zinc content of the studied value added products are illustrated in table no. 8. in a trace amount and significantly was not varied. *Hippophae salicifolia* jelly(0.265 µg/100gm) exhibited the maximum zinc content among the valued added products followed by *Elaeagnus latifolia* jam (0.243 µg/100gm), *Elaeagnus latifolia* ketchup (0.233 µg/100gm), *Hippophae salicifolia* jam (0.224 µg/100gm), *Docynia indica* pickle (0.214 µg/100gm), *Docynia indica* jam (0.212 µg/100gm), *Hippophae salicifolia* juice (0.206 µg/100gm), *Elaeagnus latifolia* chutney (0.189 µg/100gm), *Docynia indica* powder (0.165 µg/100gm). Zinc content in *Diploknema butyraceae* jam and *Diploknema butyraceae* powder was at par with the value (0.102 µg/100gm) while minimum amount of zinc content was observed in the products of *Machilus edulis* powder (0.049 µg/100gm), *Machilus edulis* mayonnaise (0.042 µg/100gm), *Machilus edulis* puree (0.037 µg/100gm) and *Diploknema butyraceae* (0.010 µg/100gm).

4.4.7. Manganese (Mn)

The manganese content was observed in a trace amount where the maximum was recorded in the product of *Diploknema butyraceae* jam (0.036 µg/100gm) followed by *Diploknema butyraceae* candy (0.032 µg/100gm), *Diploknema butyraceae* juice(0.031 µg/100gm) whereas least or smaller quantity of manganese was recorded in the products of *Hippophae salicifolia* jelly (0.006 µg/100gm), *Hippophae salicifolia* jam (0.005 µg/100gm), *Elaeagnus latifolia* chutney (0.004 µg/100gm), *Elaeagnus latifolia* jam (0.003 µg/100gm), *Machilus edulis* puree (0.002 µg/100gm) and (0.001 µg/100gm) in *Machilus edulis* mayonnaise, *Machilus edulis* powder, *Elaeagnus latifolia* ketchup and *Docynia indica* jam it was least and at par respectively. The manganese content in the product of *Docynia indica* powder was not detectable.

4.4.8. Boron (B)

Table.no.8. depicts the boron content in different value added productsprepared from underutilized fruits in appreciable amount. Highest boron content was recorded in the product of *Elaeagnus latifolia* ketchup (0.150 µg/100gm), *Elaeagnus latifolia* chutney (0.138 µg/100gm) and *Elaeagnus latifolia* jam (0.137 µg/100gm). *Hippophae salicifolia* jelly, *Hippophae salicifolia* juice, *Docynia indica* powder, *Machilus edulis* puree, *Hippophae salicifolia* jam, *Docynia indica* pickle, *Machilus edulis* mayonnaise, *Machilus edulis* powder, *Docynia indica* jam, *Diploknema butyraceae*candy and *Diploknema butyraceae* juice with the value (0.017 µg/100gm), (0.014 µg/100gm), (0.014 µg/100gm), (0.013 µg/100gm), (0.012 µg/100gm), (0.012 µg/100gm), (0.011 µg/100gm), (0.011 µg/100gm), (0.006 µg/100gm), (0.006 µg/100gm) and (0.005 µg/100gm) while, *Diploknema butyraceae* jam (0.002 µg/100gm), has least content of boron.

4.4.9. Lead (Pb)

The lead content of all the value added products taken for study are presented in table no.7.*Diploknema butyraceae*juice (0.039 µg/100gm) recorded highest amount followed by *Diploknema butyraceae* jam (0.019 µg/100gm), *Diploknema butyraceae* candy (0.018 µg/100gm), *Machilus edulis* powder(0.017 µg/100gm), *Machilus edulis* mayonnaise(0.014 µg/100gm) and *Machilus edulis* puree, (0.080 µg/100gm). The lead content was found lowest in *Elaeagnus latifolia* ketchup and jam (0.004 µg/100gm) and *Elaeagnus latifolia* chutney (0.003 µg/100gm) whereas in the products of *Docynia indica* and *Hippophae salicifolia* the lead content was not detectable.

4.4.10. Chromium (Cr)

From the table no.8. it was shown that chromium content was recorded highest in *Hippophae salicifolia* jelly(0.137 µg/100gm) followed by *Hippophae salicifolia* juice(0.114 µg/100gm) *Hippophae salicifolia* jam (0.103 µg/100gm), *Diploknema butyraceae* jam(0.028 µg/100gm), *Diploknema butyraceae* candy(0.027 µg/100gm), *Diploknema butyraceae* juice(0.020 µg/100gm), *Machilus edulis* puree (0.014 µg/100gm), *Machilus edulis* mayonnaise and powder (0.011 µg/100gm). While it was observed lowest in the underutilized fruit products of *Machilus edulis* (0.015µg/100gm), pickle of *Docynia indica* (0.005 µg/100gm) followed by *Docynia indica* powder and jam (0.004 µg/100gm). The chromium content was not detectable in the value added products of *Elaeagnus latifolia*.

4.4.11. Nickel (Ni)

The nickel content in all the value added products was recorded to be very low in content and presented in table.no.8. Nickel content in *Diploknema butyraceae* juice, *Elaeagnus latifolia* chutney was (0.004 µg/100gm) and (0.003 µg/100gm) while the products candy and jam prepared from *Diploknema butyraceae*, *Elaeagnus latifolia* ketchup, *Elaeagnus latifolia* jam, it was at par with the same value (0.002 µg/100gm). In the case of *Docynia indica, Machilus edulis* and *Hippophae salicifolia* products chromium was not detectable.

4.4.12. Aluminium (Al)

The aluminium content of all the value added products taken for study are represented in table.no.8. The content of aluminium tested was present in smaller quantity with the value (0.017 µg/100gm) in *Hippophae salicifolia* juice followed by *Elaeagnus latifolia* chutney(0.014 µg/100gm), *Hippophae salicifolia* juice (0.012 µg/100gm), *Hippophae salicifolia* jam (0.011 µg/100gm), *Elaeagnus latifolia* jam (0.008 µg/100gm) and *Elaeagnus latifolia* jam (0.003 µg/100gm) while in the products of *Diploknema butyraceae*, *Docynia indica* and *Machilus edulis* the aluminium content was not detectable.

4.5. Evaluation of value added products from a sensory standpoint

The products prepared are evaluated for sensory evaluation was juice, powder and candy from *Diploknema butyraceae* jam, jelly and juice from *Hippophae salicifolia* jam, jelly and pickle from *Docynia indica* ketchup, chutney and jam from *Elaeagnus latifolia* and powder, puree and mayonnaise from *Machilus edulis.* The products made from different underutilized fruits was judged according to its flavour, colour, aroma and appearance and an overall acceptance was measured. The scoring was given according to the preference of all the individuals in the panellist. The scoring ranged from 1-9 in general. The highest overall acceptance was obtained in product of *Elaeagnus latifolia* jam with mean overall acceptability as (7.33$\pm$1.29) followed by *Hippophae salicifolia* juice having (7.0$\pm$1.43), *Hippophae salicifolia* jelly (6.60$\pm$1.00), *Elaeagnus latifolia* chutney (6.60 $\pm$1.13), *Diploknema butyraceae* candy (6.50$\pm$1.10), *Docynia indica* jelly (6.23$\pm$1.45), *Elaeagnus latifolia* ketchup (6.20 $\pm$ 1.35), *Diploknema butyraceae* juice (5.87 $\pm$1.19), *Docynia indica* jam (5.87$\pm$1.04), *Docynia indica* powder (5.53 $\pm$1.41), *Diploknema butyraceae* jam

(5.40 ± 1.00) and the least was recorded in *Machilus edulis* puree (3.90 ± 0.96), *Machilus edulis* mayonnaise (3.77±1.38) and *Machilus edulis* powder (3.77 ±1.38) respectively.

Table no. 9. Evaluation of value added products from a sensory standpoint according to Flavour, Colour, Aroma and Appearance).

Value added products	**Overall Acceptance**
Diploknema butyraceae jam	5.40±1.00
Diploknema butyraceae juice	5.87±1.19
Diploknema butyraceae candy	6.50±1.10
Hippophae salicifolia jelly	6.60±1.00
Hippophae salicifolia juice	7.00±1.43
Hippophae salicifolia jam	6.40±1.65
Elaeagnus latifolia jam	7.33±1.29
Elaeagnus latifolia chutney	6.60±1.13
Elaeagnus latifolia ketchup	6.20±1.35
Docynia indica jelly	6.23±1.45
Docynia indica powder	5.53±1.41
Docynia indica jam	5.87±1.04
Machilus edulis puree	3.90±0.96
Machilus edulis mayonnaise	3.77±1.38
Machilus edulis powder	3.77±1.38

(Values are expressed as mean ±SD)

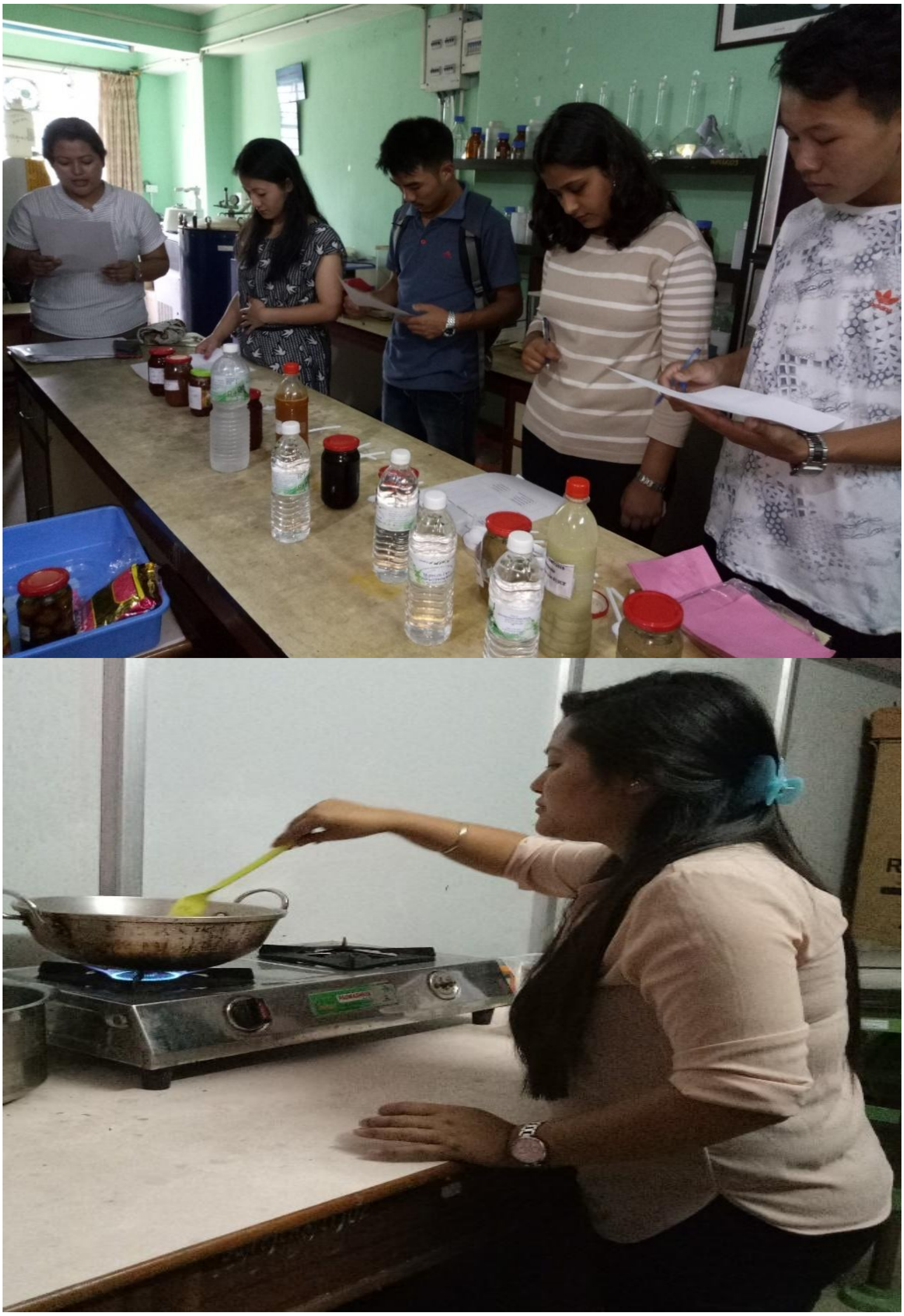

Fig.no.11. Glimpse of product preparations

4.6. Nutritional assessment of fortified *Hippophae salicifolia* juice and *Elaeagnus latifolia* jamwith Calcium citrate malate and Ascorbyl palmitate.

4.6.1. Total Soluble Solids

The total soluble solids of fortified products are presented in table no. 10. The content in the *Elaeagnus latifolia* jam with Calcium and Vitamin C was estimated maximum (45.87 ± 0.60 ^{0} Brix) and (45.52± 0.48^{0} Brix) while incase of *Hippophae salicifolia* juice fortification with Calcium and Vitamin C fortified products of was recorded minimum (34.87±0.60^{0} Brix) and (32.52± 0.48^{0} Brix) respectively.

4.6.2. Titratable Acidity

The titratable acidity content was found significantly different of the fortified products. The fortified products of *Hippophae salicifolia* juice with Calcium and Vitamin C was depicted maximum (1.27 ± 0.41%) and (1.39 ± 0.76%) whereas in *Elaeagnus latifolia* jam fortified with Calcium and *Elaeagnus latifolia* jam fortification with Vitamin C was minimum (0.10 ± 0.01%) and (0.08 ± 0.01%) respectively.

4.6.3. Total, Reducing and Nonreducing sugars

The total, reducing and non-reducing sugars evaluated was not varied significantly among fortified products. Total sugar in the product *Hippophae salicifolia* juice fortified with Calcium and Vitamin C exhibited the highest (3.28 ±0.44%) and (3.29 ± 0.54%) whereas lowest in *Elaeagnus latifolia* jam fortified with Calcium and *Elaeagnus latifolia* jam fortified with Vitamin C with the value (3.15 ± 0.03%) and (2.82 ± 0.20%). Similarly reducing sugar was observed maximum in

Hippophae salicifolia juice fortified with Vitamin C (2.55 ± 0.37%) whereas in the product *Hippophae salicifolia* juice fortified with Calcium followed by *Elaeagnus latifolia* jam fortified with Calcium (2.47 ± 0.61%), (2.47 ± 0.31) was at par and *Elaeagnus latifolia* jam fortified with Vitamin C with the value (2.16 ± 0.33%) was recorded least. Non reducing sugar in *Hippophae salicifolia* juice fortified with Calcium and Vitamin C (0.35 ± 0.11%), (1.14 ± 0.86%) was observed highest and *Elaeagnus latifolia* jam fortified with Calcium and *Elaeagnus latifolia* jam fortified with Vitamin C showed least with the value (0.07 ± 0.03%) and (0.20 ± 0.04%).

4.6.4. Total Anthocyanin

The result of the fortified products was illustrate in table no.10. The content of total anthocyanin in *Elaeagnus latifolia* jam fortified with Calcium and *Elaeagnus latifolia* jam fortified with Vitamin C (0.17 ± 0.02 mg/100g) and (0.48 ± 0.56 mg/100g) exhibited maximum whereas in *Elaeagnus latifolia* jam fortified with Calcium and *Elaeagnus latifolia* jam fortified with Vitamin C it was recorded minimum with the value (0.07 ± 0.05mg/100g) and (0.04 ± 0.01mg/100g).

4.6.5. Total Antioxidant

The amount of total antioxidant in the product varied significantly. The content of total antioxidant of *Hippophae salicifolia* juice fortified with Calcium and Vitamin C was evaluated highest with the value (80.84 ± 0.50µg/ml) and (81.12 ± 0.70 µg/ml) whereas in *Elaeagnus latifolia* jam fortified with Calcium and *Elaeagnus latifolia* jam fortified with Vitamin C it was evaluated least with the value (4.87 ± 0.47 µg/ml) and (5.54 ± 0.48 µg/ml).

Table no. 10. Nutritional assessment of fortified *Hippophae salicifolia* juice and *Elaeagnus latifolia* jam with Calcium citrate malate and Ascorbyl palmitate.

TREATMENTS	***Hippophae salicifolia* juice fortified with Ca**	***Hippophae salicifolia* juice fortified with Vit C**	***Elaeagnus latifolia* jam fortified with Ca**	***Elaeagnus latiofolia* jam fortified with Vit C**
TSS^0 Brix	34.87±0.60	32.52± 0.48	40.57±0.65	41.63±0.43
Titratable acidity %	1.27±0.41	1.39 ± 0.76	0.10±0.01	0.08±0.01
Total Sugar %	3.28±0.44	3.29 ± 0.54	3.15±0.03	2.82±0.20
Reducing sugar %	2.47±0.61	2.55 ± 0.37	2.16±0.33	2.47±0.31
Non Reducing sugar %	0.35±0.11	1.14 ± 0.86	0.07±0.03	0.20±0.04
Total Anthocyanin mg/100g	0.07±0.05	0.04 ± 0.01	0.17±0.02	0.48±0.56
Total Antioxidant µg/ml	80.84±0.50	81.12 ± 0.70	4.87±0.47	5.54±0.48
Total Carotenoids mg/100gm	2.80±0.13	2.66 ± 0.31	2.02±0.07	1.84±0.17
Ascorbic Acid mg/100gm	13.15±0.64	39.43 ± 0.62	5.68±0.06	36.45±0.05
Total Phenolmg/g/GAE	65.77±0.40	64.38 ± 0.89	20.87±0.75	21.56±0.45
Total Flavonoids mg/ g/QE	30.82±0.24	27.63 ± 0.10	9.88±0.32	8.91±0.29
SE(m)	0.248	0.359	0.210	0.192
CD (P<0.05)	0.733	1.061	0.620	0.567

4.6.6. Total Carotenoids

Total Carotenoids in the product of *Hippophae salicifolia* juice fortitified with Calcium and Vitamin C was noticed maximum (2.80 ± 0.13mg/100g) and (2.66 ± 0.31mg/100g) followed by (2.02±0.07mg/100g) and (1.84±0.17mg/100g) in *Elaeagnus latifolia* jam fortified with Calcium and *Elaeagnus latifolia* jam fortified with Vitamin C with least content.

4.6.7. Ascorbic Acid

The result varied significantly among fortified products. The content of ascorbic acid in *Hippophae salicifolia* juice fortified with Calcium and Vitamin C was depicted maximum (30.15 ± 0.64 mg/100g)and (39.43 ± 0.62 mg/100g)whereas in *Elaeagnus latifolia* jam fortified with Calcium and *Elaeagnus latifolia* jam fortified with Vitamin C it was evaluated least with the value (4.68 ± 0.06 mg/100g) and (6.45 ± 0.05 mg/100g)**.**

4.6.8. Total Phenol mg/g/GAE

The data pertaining in the table no. 8 showed the maximum content of total phenol in the *Hippophae salicifolia* juice fortified with Calcium and Vitamin C (65.77 ± 0.40mg/g/GAE) and (64.38 ± 0.89mg/g/GAE)whereas minimum content was depicted in *Elaeagnus latifolia* jam fortified with Calcium and *Elaeagnus latifolia* jam fortified with Vitamin C (20.87 ± 0.75 mg/g/GAE) and (21.56 ± 0.45 mg/g/GAE).

4.6.9. Total Flavonoids mg/ g/QE

The total flavonoids content in the *Hippophae salicifolia* juice fortified with Calcium and Vitamin C product recorded highest value (30.82 ± 0.24mg/ g/QE) and (27.63 ± 0.10 mg/ g/QE) while in the *Elaeagnus latifolia* jam fortified with Calcium and *Elaeagnus latifolia* jam fortified with Vitamin C noted least with the value (9.88±0.32 mg/ g/QE) and (8.91±0.29 mg/ g/QE) respectively.

4.7. Ionome profiling of fortified *Hippophae salicifolia* juice and *Elaeagnus latifolia* jam with Calcium citrate malate and Ascorbyl palmitate.

4.7.1. Potassium (K)

The Potassium content of fortified products revealed in table no. 11. Potassium content for *Hippophae salicifolia* juice fortified with Vit C (92.967 µg/100gm) was observed the highest whereas lowest potassium content was noticed in the fortified products of *Hippophae salicifolia* juice fortified with Ca (21.733 µg/100gm), *Elaeagnuslatiofolia*jam fortified with Vit C (21.198 µg/100gm) and*Elaeagnuslatiofolia*jam fortified with Ca (21.026 µg/100gm).

4.7.2. Magnesium (Mg)

The magnesium content of fortified products have been represented in the table no. 11. The amount of magnesium range recorded was (0.892 to 4.187 µg/100gm). The magnesium content in *Elaeagnus latifolia* jam fortified with Ca (4.187 µg/100gm) exhibited highest followed by *Hippophae salicifolia* juice fortified with Vit C (1.166 µg/100gm), *Hippophae salicifolia* juice fortified with Ca (1.082

µg/100gm) whereas lowest was observed in the *Elaeagnuslatiofolia*jam fortified with Vit C (0.892 µg/100gm).

4.7.3. Calcium (Ca)

The calcium content of different fortified products have been shown in the Table no. 11 where the maximum calcium content was noticed in *Hippophae salicifolia* fortified with Ca (89.113 µg/100gm) followed by *Elaeagnus latifolia*fortified with Ca (65.229 µg/100gm) was evaluated while the least content of calcium was recorded in *Hippophae salicifolia* juice fortified with Vit C and *Elaeagnus latiofolia* jam fortified with Vit C with the value (0.225 µg/100gm) and (0.112 µg/100gm).

4.7.4. Sodium (Na)

The sodium content of fortified products taken for study are presented in the Table no.9. The sodium content in the fortified products was found within a range between (0.930 to 1.260 µg/100gm). The highest amount of sodium content was recorded in *Elaeagnus latiofolia* jam fortified with Vit Cfollowed by *Hippophae salicifolia* juicefortified with Vit C with the value (1.260 µg/100gm) and (1.027 µg/100gm) whereas, least amount of sodium content was recorded from the fortified product of *Elaeagnus latifolia* jam fortified with Ca and *Hippophae salicifolia* juice fortified with Ca(0.985 µg/100gm) and (0.930µg/100gm)**.**

Table no. 11. Ionome profiling (µg/ 100g) of *Hippophae salicifolia* juice and *Elaeagnus latifolia* jam fortified with Calcium citrate malate and Ascorbyl palmitate.

FORTIFIED PRODUCTS	Potassium (K)	Magnesium (Mg)	Calcium (Ca)	Sodium (Na)	Iron (Fe)
Hippophae salicifolia juice fortified with Ca	21.733	1.082	89.113	0.930	2.439
Hippophae salicifolia juice fortified with Vit C	92.967	1.166	0.225	1.027	2.538
Elaeagnus latifolia jam fortified with Ca	21.026	4.987	65.229	0.985	0.029
*Elaeagnus latiofolia*jam fortified with Vit C	21.198	0.892	0.112	1.260	0.041

Zinc (Zn)	Manganese (Mn)	Lead (Pb)	Chromium (Cr)	Nickel (Ni)	Aluminium (Al)
0.551	0.014	0.013	0.014	0.026	0.016
0.658	0.015	0.082	0.013	0.025	0.013
0.349	0.002	Nd	Nd	0.010	0.002
0.406	0.002	Nd	Nd	Nd	0.009

4.7.5. Iron (Fe)

The iron content for all the fortified products is presented in table no. 11. It is noticed that *Hippophae salicifolia* juice fortified with Vit Ccontain highest iron content (2.538 µg/100gm) followed by *Hippophae salicifolia* juice fortified with Ca (2.439 µg/100gm). The lowest iron content was observed in *Elaeagnus latifolia* jam fortified with Vit C (0.041 µg/100gm) followed by *Elaeagnus latifolia* jam fortified with Ca (0.029 µg/100gm).

4.7.6. Zinc (Zn)

The zinc content of fortified products studied are illustrated in table no. 11.The maximum zinc was noticed in *Hippophae salicifolia* juice fortified with Vit Cand Ca (0.658 µg/100gm), (0.551 µg/100gm) followed by *Elaeagnus latifolia* jam fortified with Vit C(0.406 µg/100gm) while the minimum amount of zinc content was observed in the fortified products of *Elaeagnus latifolia* jam fortified with Ca (0.349 µg/100gm).

4.7.7. Manganese (Mn)

The manganese content was recorded in smaller quantity, *Hippophae salicifolia* juicefortified with Vit C (0.015 µg/100gm) followed by *Hippophae salicifolia* juice fortified with Ca (0.014µg/100gm), *Elaeagnus latifolia* jam fortified with Vit C and *Elaeagnus latifolia* jam fortified with Ca with same value (0.002µg/100gm).

4.7.8. Lead (Pb)

The lead content of all the studied fortified products are presented in table no.11.The maximum was noticed in fortified *Hippophae salicifolia* juice with Vit C(0.082 µg/100gm) and lowest was found in *Hippophae salicifolia* juice fortified with Ca(0.013 µg/100gm), whereas in of *Elaeagnus latifolia* jam fortified with Ca and Vit Cthe lead content was not detectable.

4.7.9. Chromium (Cr)

The chromium content in the studied fortified products are depicted in table.no.9. From the table it was shown that chromium content was recorded in a very low concentration in *Hippophae salicifolia* juice fortified with Ca (0.014 µg/100gm) followed by *Hippophae salicifolia* juice fortified with Vit C (0.013 µg/100gm). The chromium content in *Elaeagnus latifolia* jam fortified with Ca and Vit Cwas not detectable.

4.7.10. Nickel (Ni)

The nickel content in all the fortified was presented in table.no.9. Nickel in fortified *Hippophae salicifolia* juice with Ca (0.026 µg/100gm) was recorded highest followed by *Hippophae salicifolia* juice fortified with Vit C (0.025 µg/100gm) whereas least in *Elaeagnus latifolia* jam fortified with Ca (0.010 µg/100gm). It was not detectable in the fortified product of *Elaeagnus latifolia* jam fortified with Vit C.

4.7.11. Aluminium (Al)

The aluminium content of fortified products studied are represented in table.no.3. The aluminium content was recorded was very low in content with the value (0.016 µg/100gm) in *Hippophae salicifolia* juice fortified with Ca followed by *Hippophae salicifolia* juice fortified with Vit C (0.013 µg/100gm), *Elaeagnus latifolia* jam fortified with Vit C (0.009 µg/100gm) and *Elaeagnus latifolia* jam fortified with Ca (0.002 µg/100gm) respectively.

4.8. Nutritional assessment of Commercial product

4.8.1. TSS (total soluble solids) and Titratable acidity

The total soluble solids was observed maximum (12.00 ± 0.05^0 Brix) in commercial product of mosambi juice and minimum in (11.24 ± 0.28^0 Brix) in mixed fruit jam. The content of titratable acidity was evaluated as highest (1.02 ± 0.07%) in mosambi juice while least (0.46 ± 0.02%) in mixed fruit jam respectively.

4.8.2. Sugars (Total, Reducing and Non- reducing)

Total, reducing, and non-reducing sugars were assessed in the selected commercial products. Total sugar was found to be highest (7.12 ± 0.22 percent) in mosambi juice and lowest (6.31 ± 0.12 percent) in mixed fruit jam. Similarly, reducing sugar was found in the maximum concentration (6.13 ± 0.16 percent) was observed in the product mosambi juice, and the lowest concentration (4.43 ± 0.41 percent) in mixed fruit jam. The highest concentration of non-reducing sugar was found in mixed fruit jam (0.86 ± 0.07 percent), while the lowest concentration was found in mosambi juice (1.71 ± 0.05 percent).

Table no. 12. Nutritional evaluation of Commercial product

TREATMENTS	Mosambi juice	Mixed fruit jam
TSS^0 Brix	12.00 ± 0.05	11.24 ± 0.28
Titratable acidity %	1.02 ± 0.07	0.46 ± 0.02
Total Sugar %	7.12 ± 0.22	6.31 ± 0.12
Reducing sugar %	6.13 ± 0.16	4.43 ± 0.41
Non Reducing Sugar %	0.86 ± 0.07	1.71 ± 0.05
Total Anthocyanin mg/100g	1.38 ± 0.20	0.32 ± 0.01
Total Antioxidant µg/ml	14.86 ± 0.27	12.37 ± 0.40
Total Carotenoids mg/100gm	1.64 ± 0.11	1.50 ± 0.07
Ascorbic Acid mg/100gm	20.25 ± 0.49	9.41 ± 0.61
Total Phenol mg/g/GAE	6.50 ± 0.59	4.83 ± 0.16
Total Flavonoids mg/ g/QE	2.02 ± 0.07	3.18 ± 0.28
SE(m)	0.158	0.167
CD (P<0.05)	0.466	0.493

4.8.3. Total Anthocyanin and Total Antioxidant

The content of total anthocyanin in mosambi juice was depicted maximum (1.38 ± 0.20 mg/100g) while minimum in mixed fruit jam (0.32 ± 0.01 mg/100g) whereas the total antioxidant was observed highest in mosambi juice (14.86 ± 0.27µg/ml) and incase of mixed fruit jam it was recorded the lowest (12.37 ± 0.40 µg/ml) respectively.

4.8.4. Total Carotenoids and Ascorbic Acid

Total Carotenoids content in the product of mosambijuice was evaluated highest (1.64 ± 0.11mg/100gm) and mixed fruit jam was estimated least (1.50 ± 0.07 mg/100gm). The content of ascorbic acid evaluated in the mosambijuice recorded maximum (20.25 ± 0.49 mg/100gm) and minimum in mixed fruit jam (9.41 ± 0.61 mg/100gm).

4.8.5. Total Phenol and Total Flavonoids

The data pertaining in the table.no. 12. showed the content of total phenol in mosambijuice was noticed highest (6.50 ± 0.59 mg/g/GAE) and least was recorded in mixed fruit jam (4.83 ± 0.16 mg/g/GAE) followed by total flavonoids content depicting the maximum value (3.18 ± 0.28 mg/ g/QE) in mixed fruit jam while least in mosambi juice (2.02 ± 0.07 mg/ g/QE) and respectively.

4.9. Ionome profiling of Commercial products

4.9.1. Potassium (K)

The potassium content of commercial products revealed in table no. 13. Potassium content for Mixed fruit jam (23.393µg/100gm) was observed the highest whereas lowest potassium content was noticed in the commercial products of Mosambi juice(2.766 µg/100gm).

4.9.2. Magnesium (Mg)

The magnesium content of commercial products are depicted in the table no. 13. The maximum magnesium content was found in the product mixed fruit jam(1.196µg/100gm) whereas lowest was observed in mosambi juice (1.703 µg/100gm).

4.9.2. Calcium (Ca)

The calcium content of commercial products is presented in table no. 13, the result herein presents that the highest calcium content was found in mosambi juice (0.017 µg//100 gm) and the calcium content in mixed fruit jam was not detectable.

4.9.3. Sodium (Na)

The sodium content of commercial products taken for study are shown in the table no.13. The sodium content was recorded in mixed fruit jam with the highest value (7.193µg/100gm) whereas, least amount of sodium content was recorded from mosambi juice (2.013 µg/100gm).

Table no. 13.Ionome profiling (µg/ 100g) of Commercial product

COMMERCIAL PRODUCTS	Potassium (K)	Magnesium (Mg)	Calcium (Ca)	Sodium (Na)	Iron (Fe)	Zinc (Zn)	Manganese (Mn)	Lead (Pb)	Chromium (Cr)	Nickel (Ni)	Aluminium (Al)
Mosambi juice	2.766	1.703	0.017	2.013	0.005	Nd	Nd	Nd	Nd	Nd	0.097
Mixed fruit jam	23.393	1.196	Nd	7.193	1.127	Nd	0.004	Nd	0.007	Nd	0.179

4.9.4. Iron (Fe)

The iron content for the commercial products is presented in table no. 13. It is noticed that mixed fruit jam contained highest iron (1.127µg/100gm) whereas lowest iron content was observed in mosambi juice (0.005µg/100gm).

4.9.5. Lead (Pb), Nickel (Ni) and Zinc (Zn)

The zinc, lead and nickel content in the commercial products both in mixed fruit jam as well as mosambi juice was not detectable.

4.9.6. Manganese (Mn)

The manganese content was recorded in smaller quantity, in mixed fruit jam (0.004µg/100gm) while in mosambi juice it was not detectable during evaluation.

4.9.7. Chromium (Cr)

Table.no.13 shows the chromium content of the commercial products studied. According to the table, chromium content was recorded at a very low concentration in mixed fruit jam (0.007 µg/100gm), whereas it was not detectable during evaluation in mosambi juice.

4.9.8. Aluminium (Al)

The aluminium content of fortified products studied are represented in table.no.13. The aluminium content was recorded was very low in content with the value (0.179µg/100gm) in mixed fruit jam followed bymosambi juice (0.097 µg/100gm) respectively.

4.10. Sensory assessment of (fortified products) *Hippophae salicifolia* juice, *Elaeagnus latifolia* jam, Mosambi juice and mixed fruit jam

The overall acceptance of the fortified *Hippophae salicifolia* juice, fortified *Elaeagnus latifolia* jam, commercial mosambi juice and mixed fruit jam are presented in table.no. 14. The overall acceptability was evaluated based on flavour, colour, aroma, and appearance, with mixed fruit jam receiving the best overall acceptance (7.06 ± 0.32), followed by *Elaeagnus latiofolia* jam fortified with Vit C (6.92 ± 0.01). *Elaeagnus latifolia* jam fortified with Ca and commercial product mosambi juice were practically at par with the value (6.88 ± 0.02) and (6.86 ± 0.40), followed by *Hippophae salicifolia* juice fortified with Vit C (6.72 ± 0.02) whereas *Hippophae salicifolia* juice fortified with Ca (6.40 ± 0.15) yielded the lowest results.

Table no. 14. Sensory assessment offortified and commercial products

FRORTIFIED AND COMMERCIAL PRODUCTS	OVERALL ACCEPTANCE
Hippophae salicifolia juice fortified with Ca	6.40 ± 0.15
Hippophae salicifolia juice fortified with Vit C	6.72 ± 0.02
Elaeagnus latifolia jam fortified with Ca	6.88 ± 0.02
Elaeagnus latiofolia jam fortified with Vit C	6.92 ± 0.01
Mosambi juice	6.86 ± 0.40
Mixed fruit jam	7.06 ± 0.32

(Values are expressed as mean ±SD)

4.11. Microbial assessment of fortified products

The study's microbiological assessment revealed microbial contamination in all samples as the storage period and age of the product increased. The results on yeast and mould count of different treatments and controls at zero days of storage showed that they were both 100% negative (free from microbes). The samples was found to harbour the total bacterial count range from (10×10^{4} to 41×10^{4}) for *Hippophae salicifolia* sample and (9×10^{4} to 38×10^{4}) for *Elaeagnus latifolia* sample. The total fungal count for *Hippophae salicifolia* sample ranged from (2×10^{3} to 5×10^{3}) and (2×10^{3} to 6×10^{3}) for *Elaeagnus latifolia* jam. The microbial activity has increased in each 30 days period of storage, as can be seen in table no.15.

Table no. 15. Microbial assessment of fortified products

Microbial analysis of fortified products	***Hippophae salicifolia* juice fortified with Ca**	***Hippophae salicifolia* juice fortified with Vit C**	***Elaeagnus latifolia* jam fortified with Ca**	***Elaeagnus latifolia* jam fortified with Vit C**
TREATMENTS	Average TBC	Average TFC	Average TBC	Average TFC
0 DAYS	0×10^{4}	0×10^{3}	0×10^{4}	0×10^{3}
30	10×10^{4}	2×10^{3}	9×10^{4}	2×10^{3}
60	26×10^{4}	4×10^{3}	20×10^{4}	3×10^{3}
90	41×10^{4}	5×10^{3}	38×10^{4}	6×10^{3}

TBC= total bacterial count, (Cfu/ml), TFC= total fungal count, (spore/ml)

CHAPTER-5 DISCUSSION

The findings of the current study on "**Processing effect on nutritional qualities of value added products from select underutilized fruits of Sikkim**"are addressed and supported with plausible scientific causes using the literature available in this field of study, which is listed below:

5.1. Nutritional assessment of underutilized fruits

The estimated nutritional composition indicates that these underutilized Sikkim Himalayan fruits are a rich source of various constituents and compounds that should be explored further, particularly at the commercial level. Despite the fact that these fruits have yet to be studied in a clinical setting, many people believe they have therapeutic properties (Rai *et al.*, 2005). These underutilized fruits, which are high in antioxidants, will aid in the prevention of many diseases such as a weakened immune system, inflammatory diseases, and so on. It serves as a supplement and enrichment in the daily diet of local community people, and it will also help them to become economically stable because these fruits will be freely available in the forest during their season, making them easily accessible. It can also be comparable to commercial fruits due to the presence of these nutritional compounds as mentioned in the research studies, and it will improve the nutritional and medicinal value.Underutilized edible fruit rich in ascorbic acid will help to mitigate people to fight against cardiovascular disease, stroke, cancer (Willett, 2002). *Hippophae salicifolia* had the greatest total antioxidant, total phenol, and ascorbic acid levels among the five underutilized fruits studied.

The word "Brix degrees" (°Brix) refers to the percentage of soluble solids contained in the mass-to-volume ratio. Total soluble solids of different underutilized fruits ranged from (3.46 ^{0} B ± 0.05 to 16.75± 0.44 ^{0} B). The result obtained in this investigation was almost identical to those published by with only a little deviation (Bhutia, 2013; Sundriyal&Sundriyal, 2001 and Sundriyal*et al.*, 1998). It's possible that the variation is attributable to climate and varietal conditions. The results of this study also suggest that the TSS level of these neglected fruits is equivalent to commercial fruits such as mango and litchi. These underutilized fruits are economically significant. The titratable acidity of fruits is an important factor for their organoleptic quality. The current study's findings reveal a wide range of acidity content concentrations, ranging from (0.64 ± 0.02 percent to 2.49 ± 0.07 percent).

Sugar is a composition of carbohydrates contributing to our daily dietary energy. The sugar (total, reducing and non-reducing) evaluated varied significantly among underutilized fruits ranging from (4.21 ± 0.13% - 9.45 ± 0.36%, 2.50% ± 0.59 – 6.26 ± 0.10% and 1.006 ± 0.00% – 3.86± 0.05%) considerately. The highest total sugar was recorded in fruits of *Docynia indica* (9.45 ± 0.36%) whereas *Machilus edulis*had the least total sugar (4.21 ± 0.13%). The highest amount of reducing sugar was also evaluated for *Diploknema butyraceae* (6.26 ± 0.10 %) whereas the minimum was recorded for *Machilus edulis* (2.50 ± 0.05%). Usually, the sugar content of fresh fruits ranges between 2 and 30 % (Norman, 1976). Non-reducing sugars pertained to be higher in *Docynia indica* (3.86 ± 0.05 %) while the minimum was recorded for *Elaeagnus latifolia.* Numerous literature exists on many underutilized fruits from different 136 regions of India and abroad reported the content of sugar to be the notable insufficient amount (Misra&Misra, 2016; Kumar *et al.*, 2015; Nayak & Basak, 2015 and Valvi*et al.*, 2014). The observation from the above findings recommends that these select underutilized fruits can serve as nutrition-rich foods as it does have the potential to fulfil the needed content of sugars in our daily diet, especially for the local community people as it is available in locals.

Anthocyanin belongs to a group of flavonoids known for water-soluble pigment available in many fruits and vegetables which is also responsible for the pigment red, blue and purple (Rommel *et al.,* 1992). The total anthocyanin content was measured highest in *Elaeagnus latifolia* (1.26 ± 0.16 mg/100gm) while least was observed in *Machilus edulis* with (0.05 ± 0.005 mg/100gm). Similar observations were in close conformity with the results reported by (Bhutia, 2013 and Sundriyal and Sundriyal, 2001) with slight differences among species. The difference in the content of total anthocyanin content among these underutilized fruits may be due to climatic and biotic, abiotic stress. Previous studies also illustrate the presence of total anthocyanin in these underutilized fruit species (Kumar *et al.,* 2015; Singh *et al.,* 2014; Hassan *et al.,* 2013; Goyal *et al.,* 2013; Olayiwola*et al.,* 2013; Purgar*et al.,* 2012; Karuppusamy*et al.,* 2011; Sood*et al.,* 2010 and Rimpapa*et al.,* 2007). The present study suggested that there is a presence of total anthocyanin in these underutilized fruits and also believe that these will promote health as the total anthocyanin prevent many diseases like anti-inflammatory, antiviral and anticancer diseases also high blood pressure, colds, heart diseases etc.

Antioxidants are the compounds, which delay or inhibit oxidation significantly of that substrate which is harmful even if it is at low concentration and protects from health diseases (Liu and Finly, 2005). The DPPH assay method is the most preferred method to evaluate the radical scavenging effect of antioxidants because it is easy, fast and reliable. The highest content of total antioxidant was observed in the fruit *Hippophae* *salicifolia* (92.69 ± 0.55 µg/ml) and appreciable content was also noticed in *Diploknema butyraceae* (7.60 ± 0.00 µg/ml). Several studies have also suggested that the antioxidants rich indigenous plant sources have the potential in preventing the damaging effects of oxidative stress (Zahin*et al.,* 2009). The epidemiological investigation has been carried out in underutilized fruit species in India and across the world which does have a potential for scavenging free radicals which leads to suppress the spread of oxidation (Khomdram*et al.,* 2014; Hassan *et al.,* 2013; Goyal *et al.,* 2013; Pal *et al.,* 2013; Murillo *et al.,* 2012; Haripyaree and Guneshwor, 2012; Seal, 2011; Karuppusamy*et al.,* 2011). It can be estimated from the current study that these underutilized are rich in antioxidants which can be beneficial for the local people who cannot afford expensive fruit in seasons and used as an alternate source of supplements.

Flavonoids are hydroxylated phenolic substances, accountable for therapeutic use such as anti-oxidative, anti-allergic, antibiotic, hypoglycaemic and anti-carcinogenic (Borneo *et al.,* 2008) most commonly and widely distributed groups. Epidemiological studies reported that the risk of cancer disease could be reduced with flavonoids rich foods are consumed (Manach*et al.,* 2004). Results showed that the maximum content was noticed in *Docynia indica* (49.05 ± 0.75 mg/g/QE) and least with value (17.62 ± 0.38 mg/g/QE) in *Machilus edulis* respectively. Previous studies in underutilized fruits had indicated the presence of flavonoids from different parts of India and abroad (Islary*et al.,* 2017; Mann *et al.,* 2016; Hazali*et al.,* 2015; Bhardwaj *et al.,* 2014; Hassan *et al.,* 2013; Swapana *et al.,* 2012; Ashraf *et al.,* 2011 and Charoensiddhi & Anprung, 2008). Flavonoids are known to have properties or compounds that perceive anti-allergic, anti-viral, anti-carcinogenic properties and anti-proliferative (Middleton and Kandaswami, 1993) and their inflammatory properties reduce toxin-mediated stress along with chronic disease prevention (AlDrak*et al.,* 2017). (Sharma *et al.,* 2015) reported (0.504±0.074 QE mg/g) in *Docynia indica* which was in smaller quantity as compared to our findings might be due to growing condition. Phenolics are secondary metabolism in plants that have properties to protect against pathogens, parasites, and predators besides helping in the reproduction and growth of plants and are gaining interest among researchers (Liu and Felice, 2007). Results revealed the content of total phenol was estimated highest in the *Hippophae salicifolia* (71.15 ± 0.54 mg/g/GAE) while least was noticed in *Machilus edulis* (17.04 ± 0.35 mg/ 100g). From the above findings, we can estimate that the content in these underutilized fruits can be the source of medicine and nutrition for the local community. Epidemiological studies reported the relation between reduced risk of a cancerous cell and polyphenols (Potter, 2005).

Carotenoids are bioactive compounds in food products including antioxidant properties. It has a role in the improvement of the immune response and the risk of degenerative diseases such as cancer, macular degeneration and cardiovascular diseases (Haque *et al.*,2015). *Machilus edulis* with value (61.65 ± 0.68 mg/100gm) was estimated highest in total carotenoid content whereas the minimum was evaluated in *Diploknema butyraceae* (2.56 ± 0.50 mg/100gm). The carotenoid content was found similar by the study reported by (Bhutia, 2013). The current investigation report that there is an appreciable amount of carotenoids that could be harnessed by the locals as it does have the properties of antioxidants.

Ascorbic acid is a natural antioxidant also most widely used in the food industries in form of ascorbic acid with varied chemistry. It has complex multi-functional effects depending on state ascorbic acid can act as an antioxidant, a metal chelator, a prooxidant, an oxygen scavenger or a reducing agent. Ascorbic acid and its esters function as antioxidants by securing double bonds and scavenging oxygen (Jayathilakan*et al.,* 2007). The content of Ascorbic acid was noticed high in *Hippophae salicifolia* (37.44 ± 0.52 mg/100g) and appreciable content was observed in *Docynia indica* (1.14 ± 0.03 mg/100gm). (Bhutia, 2013) suggested the concentration of ascorbic acid in different underutilized edible fruits and the range varied from (0.7 – 32. 0 mg 100 g^{-1}) of Sikkim which coincide closely with the present findings. Evaluation of ascorbic acid content in many underutilized fruit species was estimated to identify the species with high ascorbic acid content and earlier reported that these species obtained appreciable amount of ascorbic acid (Korekar*et al.,* 2014; Singh *et al.,* 2014; Sarma*et al.,* 2014; Pal *et al.,* 2013; Purgar*et al.,* 2012; Karuppusamy*et al.,* 2011 and Sood*et al.,* 2010). The present and previous findings on the content of ascorbic acid present in these underutilized fruits could lead to the recognition and promotion of these fruits as ascorbic acid is known to prevent many ailments cardiovascular disease, stroke, cancer (Willett, 2002) also act as an antioxidant against oxidative stress (Padayatty*et al.,* 2003).

The above findings observed the role of select underutilized fruits in the rural community if guided through proper source also add income generation, its nutritional values and food security, bioactive compounds and helps to mitigate food security in food scarcity may find a place in the global markets. Nutritional compounds for select underutilized

fruits are significantly varied in a range of works which might be due to methods carried out, genetic and climatic factors, cultivars, variety, processing, soil condition, cultivation place, post-harvest changes resulting from physiological activity and maturity (Yu *et al.,* 2002: Chitarra & Chitarra, 2005).

5.2. Ionome profiling of underutilized fruits

Minerals possess an essential part of physiological processes. The concentration of minerals in fruits can differ in terms of plants, maturity, soil conditions, climate, and agricultural practices (Brack*et al.,* 2007; Kinnup& Barros, 2008). Humans require these essential nutrients for the proper function and maintenance of life. Minerals help in the metabolism of numerous enzymes, maintaining their acid-base balance and the osmotic pressure which facilitate the transfer of essential compounds through the membranes and also are important constituents of body tissues in some instances (Aberoumand & Deokule, 2009). From the above study, we can observe that these underutilized edible fruits have the ability to fulfil the criteria in the diet of the local people. Besides the importance of these elements, there are deficiencies and health issues if consumed in excess.

Many research studies have reported the concentration of those mineral elements of underutilized fruits. Epidemiological studies in plants reported that they can be a major source of multielement improving its nutritional, medicinal and therapeutic values (Rajurkar and Damame, 1998; Choudhary and Rehman, 2002 and Al-Kharusi *et al.,* 2009; Higdon, 2003; Lieberman and Brunning, 2003). The present study revealed that the potassium range from (71.832 to 119.583 µg/100gm) where the maximum content was observed in the fruit of *Machilus edulis* (119.583 µg/100gm). (Rai *et al.,* 2005) evaluated the mineral content from different indigenous fruits of Sikkim. They reported potassium content in a range of (160.5 to 911.6 mg 100 g^{-1}). The variation in the concentration of minerals among the same species may be due to various biotic and abiotic factors. Various studies reported that underutilized edible fruits are a major source of potassium (Islary*et al.*, 2017; Mann *et al.*, 2016; Sudhakaran& Nair 2016; Nayak &Basak, 2015; Rajalakshmi *et al.*, 2017). Magnesium content range between (1.528 to 4.132 µg/100gm) where the highest magnesium content was found in the fruit of *Elaeagnus latifolia* (4.132 µg/100gm). Magnesium deficiencies include coronary artery disease, high blood pressure, cardiac arrhythmias, musculoskeletal disorders panic disorders, anxiety, epilepsy and asthma (Nayak and Basak, 2015). The data recorded calcium content in those underutilized fruit species was ranged from (0.002 to 1.501 µg/100gm) and maximum calcium content was observed in the fruit of *Hippophae salicifolia* (1.501 µg/100gm). (Seal, 2012) evaluated the mineral composition of five underutilized edible plants, traditionally used by local tribes of Meghalaya and reported the suitable concentration of calcium (5860 ±40 and 6260 ±100 mg Kg^{-1}) from the fruit of *Elaeagnus latifolia* which was on the contrary i.e. less than our finding. The observed variation may be due to climatic differences. The presence or potential of calcium in local indigenous available seasonal fruits is reported therefore it is advisable to consume it as calcium has a primary role in regulating and maintaining body function. Considering the different calcium excess/ deficient issues, WHO/ FAO recommends the daily intake of 400- 500 mg of calcium for adults and 1200 mg/ day until the age of 24 years (WHO/FAO, 1973). In this context, the fruits which are found to be a significant source of calcium, if intake (100-150 g/day) can satisfy the recommended daily allowance of calcium. The sodium content in underutilized fruit species was found with a wide range between (1.813 to 50.728 µg/100gm). The highest amount of sodium content was recorded in the fruit of *Hippophae salicifolia* with the value (50.728 µg/100gm). Sodium content is 2% of total mineral and count as one of the essential macronutrients for the human body (Christian and Ukhun, 2006). The Highest RDA (Food and Nutrition Board, Institute of Medicine, National Academies) is 1.5g. (Sundriyal*et al.,* 1998) reported Na content in *Diploknema butyracea* (0.065%), *Machilus edulis* (0.024%) which is not similar to the present findings might be due to agroclimatic condition.

The iron content in underutilized fruit species was found with a wide range between (0.031 to 2.565 µg/100gm). It is noticed that the samples of *Diploknema butyraceae* contain the highest iron (2.565 µg/100gm). It is stated in many pieces of literature that iron is required for haemoglobin synthesis in red blood cells which is needed for oxygen transportation to all parts of the body. Deficiency of iron leads to the most prevalent disease i.e.anaemia and immune system dysfunction (Islary*et al.,* 2016), reduced work efficiency, impaired body temperature and regulation, impairment in behaviour and intellectual performance and susceptibility to infections. (Islary*et al.,* 2017) also reported (8.279 mg and 7.579 mg per 100 g) from the two underutilized fruit *E. operculata* and *A. bunius,* respectively. (Sundriyal*et al.,* 1998) also reported Na content in *Diploknema butyracea* (0.178%), *Elaeagnus latifolia* (0.180%) and *Machilus edulis* (0.253%) which was higher than our findings might be due to growing conditions, climate change and maturity. Zinc content ranged from (0.064 to 0.289 µg/100gm) where *Hippophae salicifolia* (0.289 µg/100gm) exhibited the maximum zinc content among selected underutilized fruits. Zinc is an essential micro-element vital for human growth and development as well as immune functions. It is estimated that 20 per cent population of around the world are reported to be at risk of zinc deficiency. Present results are in close agreement with (Rai *et al.,* 2005) and the observed variation might have resulted from geograpHic, climatic and seasonal variation. The manganese, copper, boron, lead, chromium, nickel and aluminium content was recorded to be in a very low or trace amount in the studied underutilized fruits ranging from (0.002 to 0.244µg/100gm) overall. Many works of literature had reported the significant amount of zinc from the various underutilized fruits from India and abroad (Sundriyal and Sundriyal 2001; Rai *et al.,* 2005; Adepoju 2009; Valvi and Rathod, 2011; Ersoy*et al.,* 2013; Seal *et al.*, 2014; Kalita*et al.,* 2014; Sudhakaran and Nair, 2016; Mann et al. 2016; Islary*et al.,* 2016; Islary*et al.,* 2017; Rajalakshmi *et al.,* 2017; Khashti Dasila and Mithilesh Singh, 2021), it was slightly different from the present findings due to climatic factors. The lead content in the selected underutilized fruits was observed within the range of (0.004 to 3.679 µg/100gm) which was under permissible range as presented in table no.4. However, the above findings suggested that these underutilized fruits possess an appreciable amount of mineral elements, recommended for the processing could be further analysed as these fruits, in turn, will provide the local community profitable returns along with nutritional, medicinal and employment generation could be achieved and also we can perceive that these underutilized fruits can be compared to commercial fruits like mango, litchi etc.

5.3. The impact of processing on nutritional andionome profiling of value added foods

5.3.1. Nutritional assessment

Processing of food and a loss of nutrients during processing is inevitable. The nutrient loss also might be intentional and accidental. It is essential to attain sensory characteristics and healthy attributes which add value to the fruits. In recent years, the food habits of consumershave switched towards consumption of processed foods and ready-to-eat fruit-based products, which leads to marketing of such processed products (Antunes *et al.,* 2010, Elez-Martínez*et al.,* 2006, Osorio *et al.,* 2008). The two most important aspect associated with food processing is food safety and food quality where the major safety issue related to thermal processes includes inactivating pathogenic microorganisms for longer shelf life as well as a public health concern. Quality issues involve minimizing the chemical reactions and loss of nutrients during processing and ensuring the consumer acceptability referring to sensory characteristics (appearance, colour, flavour and texture). Although enzyme activity can change the quality of foods, must also examine. Conflicts between safety and quality matter exist. For example, more the severe heat applied to the food microbial inactivation and food safety is increased whereas the product quality is generally deteriorating. Processing has two forms of methods: thermal processing methods which include freezing, pasteurization, cooling, baking etc and non-thermal methods including filtration, high pressure, pulsed electric fields etc. Processing of food, such as thermal treatment, affects a range of characteristics such as structural rearrangement, colour, texture, which also alter its nutrient compositions (Rechkemmer, 2007). An absence of ample literature or scarce and limited data are available for the effect of nutritional and multielement evaluation of processed fruit products of underutilized fruits. In the present investigation comparing the nutritional and multielement content of underutilized edible fruit in raw and its processed product we can observe that there has been a significant loss in the content of nutritional and multielement content accept TSS, however, the loss in nutritional content was in the range of (0.1 to 10.68%).

Evaluation of TSS is not only essential for organoleptic characteristics but also reflects the commercial and economic importance of processed fruit products. The higher the TSS more the products are acceptable. The maximum content of TSS was noticed in the *Elaeagnus latifolia* jam (47.40 ± 0.56^0 Brix) and the minimum was noticed in *Machilus edulis* puree (2.10 ± 0.10^0 B) while in fruits, the value of TSS content was (7.12± 0.27^0 Brix) in Elaeagnus latifolia and (3.46 ± 0.05^0 Brix) in *Machilus edulis*. In the case of TSS, it has been shown an increasing trend in processed products as compared to raw. The study carried out by (Mehta and Bajaj, 1983) also documented an increased amount of TSS of lemon juice and sweet orange. Similar reports were decipHered by (Dar *et al.*, 1992) for apple juice, (Pareek *et al.*, 2011) for Nagpur mandarin juice. The soluble sugar compound is formed due to a long chain of carbohydrate breakdown which ultimately increase the total soluble solids content (Pantastico*et al.*, 1986).

This is in line with the increase in temperature and heating time, the higher the temperature causes the breaking of long chains of carbohydrate compounds into the dissolved sugar compound becomes faster so that the sugar content present in the solution (juice) also increases. The titratable acidity content was found highest in *Docynia indica* pickle (2.17 ± 0.01 %) and the minimum was observed in *Elaeagnus latifolia* ketchup (0.13 ± 0.02 %) but in the case of fruit *Docynia indica* it obtained (2.49 ± 0.07%) and *Elaeagnus latifolia* (1.06 ± 0.01%). (Garcia *et al.*, 2015) reported that reduction in the acidity value in the thermally processed samples could be attributed to the degradation of labile acid compounds like ascorbic or nicotinic acid. The highest total sugar was recorded in *Docynia indica* pickle (9.37 ± 0.13 %) while minimum in *Machilus edulis* powder (1.32 ± 0.20 %) in case of fruits it was (9.45 ± 0.36 %) in *Docynia indica* and (4.21 ± 0.13 %) in *Machilus edulis*. Similarly, the maximum content of reducing sugar was also estimated highest for *Docynia indica* pickle (5.11 ± 0.09 %) while the minimum was recorded for *Machilus edulis* powder (0.75 ± 0.19 %) in the case of fruit it perceives (5.59 ± 1.11%) in *Docynia indica* and

(4.30 ± 0.05%) in *Machilus edulis*. Non-reducing sugars possessed maximum in *Docynia indica* jam (5.28 ± 0.09%) and least in *Elaeagnus latifolia* ketchup (0.14 ± 0.03 %) on the other hand, in *Elaeagnus latifolia* fruit it was (1.006 ± 0.00%) and (3.86 ± 0.05%) in *Docynia indica* fruit. The decrease in sugar content may occur because of the formation of Millard reaction products which are formed by the reaction between sugars, amino acids and proteins (Martins *et al.,* 2000). It is known that thermal processing leads to the release of water-soluble carbohydrates (Escamilla-Trevino, 2012; Mancilla-Margalli & Lopez, 2002). The maximum content of β-carotene was depicted in *Elaeagnus latifolia* jam (6.32 ± 0.32mg/100g) whereas the least was observed in *Docynia indica* pickle (0.64 ± 0.40 mg/100g). (Lu *et al.,* 2018) recorded a decrease in β-carotene content after thermal processing in Cara Cara juice which is similar to our findings.

The highest content of total anthocyanin was observed in *Elaeagnus latifolia* ketchup (1.13 ± 0.03 %) and minimum in *Machilus edulis* mayonnaise (0.03 ± 0.01 mg/100gm) while in fruits it perceives (1.26 ± 0.16 mg/100gm) in *Elaeagnus latifolia* and (0.05 ± 0.005 mg/100gm) in *Machilus edulis*. The decrease of anthocyanins content is possibly due to as described by (Clifford 2000) who investigated that the hydrolysis of the glycoside linkage leads to the first step of anthocyanins degradation. He also reported that the elevated temperatures during jam processing shifted the anthocyanin equilibrium toward the colourless chalcones, which are unstable mostly when lacking the sugars. The chalcones may be exposed to degradation via oxidation reactions during the processing of foods. (Sadilova*et al.*, 2007) reported that opening of the pyrylium ring and chalcone glycoside formation occurs first rather than deglycosylation during the thermal degradation at pH 3.5 for the same anthocyanins. The decreasing rates of anthocyanin availability increased with increasing solid content during heating. This could be possibly due to molecules reacting closely in juice with higher soluble solid content (Nielsen*et al.,* 1993). A loss of 30% to 40% loss of total anthocyanin content was recorded in the final product of juice and puree (Hartmann *et al.,* 2008). (Brownmiller*et al.,* 2008) also reported that high temperature in combination with pasteurization also affect the anthocyanin content resulted in 43% loss while processing blueberries into purees. Anthocyanin degradation was also reported in sour cherry (Cemeroglu*et al.*, 1994), strawberry (Garzon and Wrolstad, 2002), raspberry (Kim and Padilla-Zakour, 2004).

Hippophae salicifolia juice possess the highest concentration of total antioxidant (82.01 ± 0.42 µg/ml) whereas least was observed in *Diploknema butyraceae* jam (4.65 ± 0.42 µg/ml) while in the fruit it obtained (92.69 ± 0.55 µg/ml) in *Hippophae salicifolia* and (7.60 ± 0.00 µg/ml) *Diploknema butyraceae*. High temperatures cause major losses in the antioxidant concentration mainly due to the chemical oxidation of antioxidants. Antioxidant compounds depletion in thermally treated fruits and vegetables may also be attributed to consumption of ascorbic acid and polyphenols as reactants in the Millard reaction (Kannane*et al.,* 1988). The total flavonoids content in all the processed understudy did vary significantly and was recorded in the range of (12.26 ± 0.03 mg/g/QE to 41.58 ± 0.55 mg/g/QE) whereas in the fruit it range from (17.62 ± 0.38 mg/g/QE to 71.15 ± 0.54 mg/g/QE). Flavonoids are heat sensitive and when heat at 75°C could affect the activity of enzyme and synthesis pathway is blocked (Chaaban*et al.,* 2017).

The highest value of total phenol content was noted in *Hippophae salicifolia*juice (69.26 ± 0.06 mg/g/GAE) whereas the lowest value was evaluated in *Diploknema butyraceae* jam (11.98 ± 0.61 mg/g/GAE) while in fruit the content was (71.15 ± 0.54

mg/g/GAE) and (17.67 ± 0.38 mg/g/GAE). The phenolic compound on heating tends to some structural rearrangement which may enhance the decrease or increase in the phytochemical composition (De Corcuera*et al.,* 2004). Phenolic acids having both free and bound groups and exposure towards heat could break these bonds which cause their release due to cell disruption and rupture of the food matrix (Dewanto*et al.,* 2002). The decrease in nutrient content depends on the overall composition and types of individual compounds present in maximum in the concerned fruit juice. (Kanwal *et al.,* 2017) reported that the influence of different processing methods affects the content of total phenols of guava jam. The results obtained are per (Rababah*et al.,* 2011) who found that strawberry fruits had significantly the maximum quantity of total phenolics (1693.55 mg GAE/100 g) followed by strawberry jam after processing (848.86 mg GAE/100 g).

Processed underutilized edible fruit product *Machilus edulis* powder (56.80 ± 0.26 mg/100gm) possessed the maximum content of total carotenoids whereas in the fruit it possessed (61.65 ± 0.68 mg/100gm). During processing, carotenoids are susceptible to a reduction of provitamin A activity via the oxidation process. (Nguyen *et al.,* 2001) reported that the thermal stability of carotenoid content is affected by their crystalline state, hydrophobicity, molecular and chemical shape and structure, solubility etc. (Lu *et al.,* 2018) also suggested the decrease in carotenoid content in orange cv. Cara Cara juice after thermal processing. (Vijayanand*et al.,* 2015) also recorded that during pulp processing of Totapuri, Mallika and Sindhura mango variety had a decrease of carotenoids significantly. Among the products prepared the maximum content of ascorbic acid was depicted in *Hippophae salicifolia*juice (30.53 ± 0.86 mg/100gm) while lowest in *Docynia indica* jam (0.23 ± 0.00 mg/100gm) while in the fruit it was observed (37.44 ± 0.52 mg/100gm) in *Hippophae salicifolia* and

(1.14 ± 0.03 mg/100gm) in *Docynia indica*. Nutrient content has been affected during cooking significantly especially water-soluble vitamins such as ascorbic acid, Vitamin B1 and B2 (Davey *et al.,* 2000). Earlier studies on Ascorbic acid degradation during processing stated that it follows first-order kinetics in an aqueous solution. (Vikram *et al.,* 2005). (Poiana *et al.*, 2011) perceive the low sugar fruit jam where thermal processing leads to the degradation of vitamin C by 22-33%. (Talcott *et al.,* 2003) found that pasteurization (85° C for 30 min) of passion fruit juice resulted in a 25% loss of L-ascorbic acid.

Several studies have been reported that the chemical and physicochemical of processed fruit products characteristics are little or partially affected on the bioactive compound and composition of foods during processing due to heat exposure (Brownmiller*et al.*, 2008; Patras *et al.*, 2009; Rababah*et al.*, 2011; Fernandes *et al.*, 2011; Fengmei*et al.,* 2011; Bof*et al.,* 2012; Howard *et al.,* 2012; Levaj*et al.,*2012; S. Olanrewaju Arinola and Kunle Adesina 2014; Vijayanand*et al.*, 2015; Aadil *et al.*, 2017; Kanwal *et al.,* 2017; Gaikwad *et al.,* 2017; Koppel *et al.*, 2018; Iuga*et al.*, 2018; Wang *et al.*, 2018; Aaby*et al.,* 2018). The decrease of these phytochemical content could be the high solubility and susceptibility to heat and oxygen and make it a conservative indicator of nutrient retention. Moreover, the degradation of phytochemicals or nutrients is primarily caused by oxidation, cleavage of covalent bonds. Therefore, the method of heating, temperature and heat treatment time is also the key factors that impact the kinetics of food compositions during processing.

5.3.1. Ionome profiling

More than 100mg of major minerals (N, P, K, Ca, Mg, Na) and minor minerals (Co, Fe, Mn, Cu, Br, Zn) less than 100 mg is optimum required or necessary for human bodies (Aslam *et al.,* 2005; Rajangam *et al.*, 2001). Sodium (Na) largely determines its volume and osmotic pressure which is present in the intracellular fluid, contributing to the cell membrane potential and enzymatic reactions. Dietary sodium is especially consumed with table salt (NaCl) (William *et al.,* 2018). Potassium (K) is important for the regulation of membrane potential, maintaining the osmotic pressure, acid-base-balance and electrolyte homeostasis. Calcium (Ca) has been vital for bone maintenance and its structure for ages. It is involved in several intracellular signal transduction functions and is essential for muscle contraction, hormonal system regulation, blood coagulation nerve impulse transmission also involves in energy and fat metabolism (Vaskonen, 2003). Magnesium (Mg) is necessary for several enzymatic reactions, energy metabolism and protein/nucleic acid synthesis (Elin *et al.,* 2010). Unlike vitamins and amino acids minerals cannot be destroyed by exposure to heat, light, oxidation agents or other factors, however, it is removed from foods by leaching or physical separation (Miller D, 1996). There is poor data literature available regarding the effect of processing in mineral content in underutilized fruit processed products particularly. Potassium is probably the most sensitive mineral to this type of loss (Adams and Erdman, 1988). Potassium content in underutilized fruits ranges from (71.832 to 119.583 µg/100gm) whereas in value-added products of those underutilized fruits range from (0.460 to 68.816 µg/100gm). Calcium content in underutilized fruits ranges from (0.002 to 1.501 µg/100gm) whereas in value-added products of those underutilized fruits range from (0.001 to 0.148 µg/100gm). (Akinyele*et al.,* 1990) recorded a decrease in potassium and calcium content of pineapple juice during thermal processing by 50% which is different from our study might be due to the type of processing methods applied. The magnesium content in underutilized fruits ranges from (0.002 to 1.501 µg/100gm) whereas in value-added products of those underutilized fruits range from (0.001 to 0.148 µg/100gm). Sodium content in underutilized fruits ranges from (1.813 to 50.728 µg/100gm) whereas in value-added products of those underutilized fruits range from (0.379 to 8.767 µg/100gm). Iron content in underutilized fruits ranges from (0.031 to 2.565 µg/100gm) while from (0.828 to 2.454 µg/100gm) the range is shown in value-added products. Zinc content in underutilized fruits ranges from (0.064 to 0.289 µg/100gm) whereas in value-added products of those underutilized fruits range from (0.010 to 0.265 µg/100gm). Manganese, Boron, Chromium, Nickel and Aluminium content in underutilized fruits ranges from (0.002 to 0.153 µg/100gm) whereas in value-added products of those underutilized fruits range from (0.001 to 0.150 µg/100gm). Therefore, there is a minimum reduction in multielement analysis in value-added products as compared to raw fruits which might be removed from processed products by leaching or pHysical separation.

Micro, macro elements are beneficial for human bodies for maintenance and proper function whereas on the other hand, heavy elements are harmful even they are present in a small quantity in foods. The food regulatory bodies set up limits for all the nutritional and multielement concentrations in food items for safe consumption purposes. In India, it is maintained and implemented by FSSAI which regulates and set the limits. Although the studied underutilized fruits and their products contain those micro, macro and heavy elements, it is safe for human consumption. The potential presence of these heavy metals in the agriculture system is due to anthropogenic impact or depends on the bedrock that lies in a particular area or due to industries discharging such metals.

5.4. Evaluation of a value added products from a sensory standpoint

Descriptive Sensory Analysis is the most sophisticated sensory method. It is used to identify and quantify the sensory characteristics of products, usually in the order of their occurrence, through the objective descriptions of assessors who possess extraordinary sensory perception. Studies regarding the underutilized processed fruit products are recent, and no such scientific publications and sensory evaluation are found which restricts the comparisons between the present results and those of other studies. The sensory evaluation was carried out where the overall acceptance score of different value-added products ranged from (3.77±1.38 to 7.33±1.29). The highest overall acceptance was obtained in the product of *Elaeagnus latifolia* jam with mean overall acceptability as (7.33 ± 1.29) followed by *Hippophae salicifolia* juice (7.00±1.43) which was taken further for evaluation. On the other hand, the least acceptability was observed in the products prepared from *Machilus edulis* fruit having the mean overall acceptability as (3.90 ± 0.96, 3.77 ± 1.38 and 3.77 ± 1.38) for puree, mayonnaise and powder respectively. The reason for its less acceptability might be because *Machilus edulis* is barely sweet in taste due to which the panellist gave less scoring for its product. Moreover, puree and powder are liked by people when it is sweeter. (Ihediohanma*et al.*, 2014) reported that pineapple jam is most acceptable followed by an orange jam. (Vranac*et al.*, 2017) reported blending of single-cultivar juices from commercial cultivars with juices obtained from traditional apple cultivars results in their taste and aroma enrichment and overall improvement. (Gupta *et al.*, 2016) also observed that papaya gooseberry jam prepared with different variations especially (80:20) was considered best in sensory qualities and could be successfully incorporated in fruit jam. Sensory evaluation is a way to identify the market acceptability for different food products and helps to develop a product and improve also the most important factor for a particular market and improve further.

5.5. Methods of Improving nutritional status

Improvement of nutritional status through dietary method is possible either by balancing their diet or by educating population and by introducing value food products or are as follows:

1. The food group approach

The dietary planning based on recommended allowance for foods such as fruits, vegetables, diary products, cereals etc could be encouraged along with thepamplets, publications, trained worker for instruction and demonstration both in urban and rural areas. This method of food group approach however, will not improve the status of nutrient if the availability of the foods are marked increased.

2. Introduction of nutritional food products

Several food products has been introduced with high amount of vitamins, minerals for use in the developing countries. In recent years, to improve nutrient status more emphasis has been given on introducing those type of products. It has been an effective method as these products can be incorporated in our daily diets easily without changing our food patterns. It also effect on utilizing the nutrients in our food resources which might not otherwise, possible through lack of popularity of natural food, stuff, poor cooking methods and storage loss.

3. Fortification

Fortification of foods can play an essential part and strategy to improve the population nutrient status at a larger proportion. It will help preventing or correcting many deficiency providing benefit to the health of the community. It will increase the micronutrient(s) intakes among populations as they are more concerned about the nutrition rich diet. Fortification of foods will supply micronutrients in desirable amounts at a larger portion by providing with a well-balanced diet.

5.6. Comparison of Fortified products with Commercial products based on Nutritional, Ionomeprofiling with Sensory assessment.

5.6.1. Nutritional assessment:

Food is a subject of great concern and essential for one's survival (Goula*et al.,* 2011). Food fortification includes the addition of micronutrients to processed foods which is lost during processing adding nutritional and economic value. Adding nutrients (fortificants) to foods (vehicle) is not a new idea but the types of food choice and the nutrients content added will completely depend on the nutritional needs (SaraswatiBulusu and Annie S. Wesley, 2011). The selection of food and its fortificants is imperative. The fortificants should and must be stable, have a longer shelf life also should not be able to alter the colour, taste and appearance of food. The food matrix should not hamper the absorption of the micronutrient, hence affecting its bioavailability. The food selected should be available readily and adequate to the population and also sufficient to meet and match their dietary requirement daily (Das *et al.,* 2013). Recently there is an increasing awareness regarding the diet which plays an important role in human health. Nowadays people are more food concerned which is changing the concept of food and the way of eating food. Sensory analysis of processed or value-added products exhibited the *Elaeagnus latifolia* jam and *Hippophae salicifolia* juice observed the highest overall acceptance and was carried out for fortification further. There are no studies that exist on fortified *Hippophae salicifolia* juice and *Elaeagnus latifolia* jam with Ca and Vit C and also the literature on fortification of fruit products with vitamins and minerals are scarce and limited as far as we are aware.

There is an increase in both the micronutrient content after fortification. Vitamin C and Calcium have equal roles and importance in well being as well as their imbalances have a significant impact on human health. Calcium involves in metabolic processes, muscle contraction, hormone and neurotransmitter release, glycogen metabolism, and cell proliferation and differentiation and is also referred to as the most common deficiencies among the rural women of many regions also known for maintenance of bone health. Vitamin C is ascorbic acid and dehydroascorbic acid maintain collagen formation and also acts as an electron donor (Allen *et al.*, 2006). Additionally, it functions as an important antioxidant. Beta-carotene was not fortified as the content present in the products were in abundance to satisfy the daily dietary requirement. Based on the FAO/WHO recommended intake the Recommended Dietary Allowance of the Calcium and Vitamin C and Beta-carotene is 1000mg, 45mg and 600µg respectively.

Among fortified products, *Hippophae salicifolia* fortified products showed maximum nutrient content as compared to *Elaeagnus latifolia* fortified products. Although in processed products of *Hippophae salicifolia* juice and *Elaeagnus latifolia* jam. Vitamin C and Calcium was observed (35.30 ± 0.55 mg/100g, 47.40 ± 0.57 mg/100g) and after fortification it was observed increased by (39.43 ± 0.62 mg/100g, 36.45±0.05 mg/100g) of Vitamin C and Calcium. Comparing the fortified products (*Hippophae salicifolia* juice and *Elaeagnus latifolia* jam) with commercial products (mosambi juice and mixed fruit jam), the TSS in the fortified products range from (32.52±0.48° Brix to 41.63±0.43° Brix) whereas in commercial products it was (11.24 ± 0.28 ° Brix to 12.00 ± 0.05° Brix). The titratable acidity in the fortified products range between (0.08±0.01 % to 1.39 ± 0.76%) whereas in commercial products it was (0.46 ± 0.02% to 1.02 ± 0.07%). The total sugar in the fortified products was range from (2.82±0.20% to 3.29 ± 0.54%) while evaluating commercial products it was (6.31 ± 0.12% to 7.12 ± 0.22%). The reducing sugar in the fortified products range between (2.16±0.33% to 2.55 ± 0.37%) whereas in commercial products it was (4.43 ± 0.41% to 6.13 ± 0.16%). The Non- reducing sugar in the fortified products was range from (0.07±0.03 % to 0.20 ± 0.04%) while evaluating commercial products it was (0.86 ± 0.07% to 1.71 ± 0.05%). The total anthocyanin in the fortified products range between (0.04 ± 0.01mg/100g) to (0.48±0.56mg/100g) whereas in commercial products it was (0.32 ± 0.01mg/100g to 1.38 ± 0.20mg/100g). The total antioxidant in the fortified products ranges between (4.87±0.47 µg/ml to 81.12 ± 0.70 µg/ml) whereas in commercial products it was (12.37 ± 0.40 µg/ml) to (14.86 ±0.27µg/ml). The total carotenoids in the fortified products range between (1.84±0.17mg/100g to 2.80±0.13mg/100g) whereas in commercial products it was (1.50 ± 0.07mg/100g to 1.64 ± 0.11mg/100g). The ascorbic acid in the fortified products ranges between (5.68±0.06mg/100g to 39.43 ± 0.62mg/100g) on the other hand in commercial products it was (9.41 ± 0.61mg/100g to 20.25 ± 0.49mg/100g). The range for total phenol content in the products fortified was (20.87±0.75 mg/g/GAE to 65.77±0.40 mg/g/GAE) while evaluating commercial products it was (4.83 ± 0.16 mg/g/GAE to 6.50 ± 0.59 mg/g/GAE). The total flavonoids in the fortified products range between

(8.91±0.29 mg/ g/QE to 30.82±0.24 mg/ g/QE) whereas in commercial products it was (2.02 ± 0.07 mg/ g/QE to 3.18 ± 0.28 mg/ g/QE). The above comparison states that the fortified products are rich in nutritional properties except for sugars and anthocyanin content, all the nutritional aspects were observed high in fortified products as compared to commercial products.

Several reports regarding fortification of food products by blending with vitamins, mineral elements, fruits, and other foods had been reported and suggested that when food is fortified it was found highly acceptable, enhanced the value of products as well as promotes consumption which has a high impact on human health (Hamid Ziena and Sahar A Nasser 2019; Kennas*et al.,* 2018; Ullah *et al.,* 2017; Madhav Kumar and Er. Parimita 2016; VijayanandPasupuleti and ShyamraoGururao Kulkarni 2014; Altunkaya*et al.,* 2013; Catana *et al.,* 2013; Biancuzzo *et al.,* 2010). (Bhardwaj *et al.,* 2019) reported the apple and carrot jam blended, with flaxseed giving different treatments it was fortified where total sugar was increased by (62.85 - 64.40 %) whereas TSS (°brix) reduced significantly from (69.58 - 68.64), for acidity (0.35 - 0.31%) and ascorbic acid (15.74 - 11.82 mg) which was similar with the present findings. (ToyinOluyemisiAkinwale, 1999) recorded the juice of some tropical fruit fortified with cashew apple juice boosted the sensory qualities like taste, mouthfeel and colour though were different it improved the overall acceptability of the products. Likewise, (Parekha*et al.,* 2014) recorded the cultivar of mango (Mangifera indica L.) bar cv. Kesar fortified with desiccated coconut powder reported the increase in acidity and reducing sugar contents while total sugar, non-reducing sugar, TSS, and ascorbic acid decreased also sensory attributes were highly acceptable. Similarly (M. N Revathy and S Ponne, 2013) reported that the standard and calcium-fortified grapefruit squash was found to be highly acceptable as compared to other citrus fruit squashes. (Sonker*et al.,* 2018) investigated the research on the fortification adding Amla and Giloy with pineapple beverage ready-to-serve (RTS) where the products increased functional value with the health-protective properties. The study suggested on yellow passion fruit demonstrated that vitamin C fortification preserved more phytochemicals during processing compared to the nonfortified control (Talcott *et al.,* 2003). (Hallim*et al.,* 2019) also evaluated fortified yoghurt using fortificant cactus pear and pomegranate juices, suggested that at the end of 15 days, titratable acidity, protein content and total solids of stirred yoghurt fortified were significantly varied similarly the concentration of antioxidant capacity and phenolic compounds were increased. The present finding of our study indicates that fortified products will not only preserve the vitamins but will also add value by adding those vitamins and minerals lost without hampering or altering their original form also improve the quality, enhance, enrich the products.

5.6.2. Ionome profiling:

Multi elements had a vital role in human health as they serve nutrition, medicinal values, but they cannot be synthesized by the body, however, they must be acquired through the diet. The metal ions in the human body if found absent could affect health (Rajurkar and Damame, 1998; Choudhary and Rehman, 2002 and Al-Kharusi *et al.,* 2009; Higdon, 2003; Lieberman and Brunning, 2003). Hydrogen, oxygen, nitrogen and carbon are found in organic molecules apart from this, mineral nutrients or dietary minerals are required for living organisms (Herman *et al.,* 2011). It is a known fact that sixteen elements are essentially important as they provide functional, structural as well as electrolytes to regulate human biochemical processes (Dietary mineral). More than 2 billion people are vitamin and mineral deficient World

Health Organization (WHO). From a health perspective, it is observed that about 7.3 per cent of global diseases related to micronutrient deficiencies are caused (Alina *et al.,* 2018). Fortification of food could be one of the strategies to overcome minerals and nutrient deficiencies also has been used effectively and safely (Das *et al.,* 2013). 22 mineral elements are at least necessary for the well-being of people health (Samoraj*et al.,* 2018). These micronutrients can be provided through a proper diet. Although, deficiencies of copper (Cu), calcium (Ca) and magnesium (Mg), are commonly observed in many developing as well as and developed countries (Thacher*et al.,* 2006). One of the reasons could be the crops produced in areas where low mineral bioavailability and/or (sporadic) crops are present with inherent tissue mineral concentrations, (Samoraj*et al.,* 2018) or low-micronutrient crops (Shi *et al.,* 2010). Mineral malnutrition at present is a serious global challenge and active but it can be avoidable including proper strategy (Kumar *et al.,* 2018). Fortification of foods could be suggested to overcome many malnutrition problems. Comparing the multielement or Ionome content of fortified products (*Hippophae salicifolia* juice and *Elaeagnus latifolia* jam) with commercial products (mosambi juice and mixed fruit jam), the potassium content in the fortified products range from (21.026 to 92.967 µg/100gm) whereas in commercial products it was (2.766 to 23.393 µg/100gm). The magnesium in the fortified products ranged between (0.892 to 4.987 µg/100gm) whereas in commercial products it was (1.703 to 1.196 µg/100gm). The calcium in the fortified products was range from (0.112 to 9.113 µg/100gm) while evaluating commercial products it was (0.017 µg/100gm). The sodium in the fortified products ranged between (0.930 to 1.260 µg/100gm) whereas in commercial products it was (2.103 to 7.193 µg/100gm). The iron in the fortified products was range from (0.029 to 2.538 µg/100gm) while evaluating commercial products it was (0.005 to 1.127

µg/100gm). The zinc in the fortified products ranged between (0.349 to (0.656 µg/100gm) whereas in commercial products it was not detectable. The manganese in the fortified products ranged between (0.002 to 0.015 µg/100gm) whereas in commercial products it was (0.004 µg/100gm). The lead content in the fortified products ranges from (0.013 to 0.082 µg/100gm) whereas it was not detectable in commercial products. The concentration of chromium range with value (0.013 to 0.0014 µg/100gm) in fortified products whereas in commercial products it was (0.007 µg/100gm). The nickel content in the fortified products ranged between (0.010 to 0.026 µg/100gm) on the other hand in commercial products it was not detectable. The aluminium content in the fortified products was range from (0.002 to 0.016 µg/100gm) while evaluating in commercial products it was (0.097 to 0.179 µg/100gm). The present findings state that except for sodium all the mineral elements was observed higher in the fortified products as compared to commercial products also the elements like lead, chromium, nickel and aluminium which are harmful was under permissible limit. The fortified products can be an alternate or a substitute for various mineral elements and can be added to our daily diet.

5.7. Sensory assessment

Sensory assessment or evaluation is one of the variables that determines whether a product will succeed or fail in the market, and it is frequently disregarded as a prerequisite prior to its debut. The mixed fruit jam (7.06 ± 0.32) received the highest overall acceptance, whereas *Hippophae salicifolia* juice enriched with Vit C (6.40 ± 0.15) received the lowest. Although the mixed fruit jam received the highest score for sensory evaluation among the products, it did not differ substantially (*Hippophae salicifolia* juice, *Elaeagnus latifolia* jam) or between commercial items

(*Hippophae salicifolia* juice, *Elaeagnus latifolia* jam) (mosambi juice and mixed fruit jam). (Bhardwaj *et al.*, 2019) investigated the sensory evaluation of apple and carrot jam mixed with flaxseed in various treatments, finding that 90:10 was the most acceptable jam treatment with the highest score for all parameters. (Catana*et al.*, 2013) investigated the sensory properties of apricot and plum-based concentrated goods, finding that the smell, colour, taste, and appearance did not alter and were determined to be extremely acceptable for fortificant usage.

As a result, food fortification of these products can improve micronutrient status quickly and at a low cost if existing technology and local distribution networks are utilized. Food fortification can be a very cost-effective public health intervention if existing technology and local distribution networks are utilized. Food fortification is simple to implement, particularly in the near term. The usage of these enriched goods should be incorporated into nutrition programmes run by Food and Nutrition Research Centers and its affiliates around the country. Campaigns should be established for these items to promote them throughout the life of the fortified products so that the general public is aware of them and recognize them.

5.8. Microbial assessment of fortified products

Bacterial and fungal growth in fruit juice is influenced by pH, storage temperature, types of packaging material, humidity, water activity, preservative concentrations, use of UV treatments during production, sugar content, quality of juice water, quality of juice machines, raw materials, and fruit quality, among other factors. The main source of contaminating bacteria discovered in fruit juices is incorrect fruit washing along with poor quality water used in juice processing. The microorganism will have an impact on the quality of a product because they have the ability to destroy it by consuming components or altering the food composition's contents. Product preparation is one of the processes when some bacteria may be present, resulting in inactive or reduced nutritional activity, which is eventually detrimental to human ingestion.

The microbial contamination was recorded maximum in the *Hippophae salicifolia* sample as compared to the *Elaeagnus latifolia* sample. The low pH of fruits greatly affects the number and the type of bacteria surviving on or growing in (Prescott *et al.,* 2002). (Noah, A. Aduke 2020) investigated mixed fruit juice in ratios where the result decipHers the total viable count were range between (3.2×10^3 - 4.5×10^3cfu/ml). The total fungal count in all the samples was in a range of (1.5×10^3 - 2.6×10^3cfu/ml) and the coliform count was in a range of (1.0 - 2.8×10^3 cfu/ml) which was in close conformity to our findings. (Tasmina Rahman *et al.,* 2011) reported the total viable bacterial count in most of the fresh juice samples was found as (2.4×10^4cfu/ml and 3.2×10^3cfu/ml) in fresh and packed juice and the total fungal count varied from (2.2×10^3 to 9.0×10^6 cfu/ml)which was slightly different as shown in the result might be due to the environment and type of fruits. (Bello *et al.,* 2014) also reported the highest total viable count in papaya juice (6.5×10^4cfu/ml) and grape juice (4.0×10^4cfu/ml) it was noticed least while the highest yeast count in orange juice exhibited (3.5×10^4cfu/ml) and lowest in grape juice (2.0×10^4 cfu/ml) which is not so similar to my report because of the quality of water used in juice, raw materials etc. (Makanjuola *et al.,* 2019) evaluated the total plate count in a strawberry jam with value (10.33×10^4cfu/g), (80% Date, 10% Apple and 10% Orange) sample has (55.00×10^4cfu/g), (90% Date and 10% Orange) sample has (13.67×10^4cfu/g) in case of (90% Date and 10% Apple) sample it showed (17.67×10^4 cfu/g) which came to close conformity to the above result respectively. The current investigation was carried out to decipher that the contamination of microbial contamination was in the permissible limit or acceptable limit up to 90 days of storage as per (ICMSF) International Commission on Microbiological Specification for Foods (2002) as the total plate counts and fungi counts did not exceed the acceptable limit of ($x10^6$cfu/g).

CHAPTER-6 SUMMARY AND CONCLUSION

The current study, titled **"Processing effect on nutritional qualities of value added products from select underutilized fruits of Sikkim"** was conducted between 2017 and 2020 at the Department of Horticulture, Sikkim University, 6th mile Samdur, Gangtok, Sikkim. Nutritional evaluation, ionome profiling, value added products, sensory attributes, product fortification, and microbial analysis were all estimated observations. The following are a summary of the experimental findings of this study:

6.1. Nutritional assessment of underutilized fruits

- ✓ TSS was highest in *Diploknema butyraceae* fruits (16.75± 0.44 ° Brix) and lowest in *Machilus edulis* (3.46 ± 0.05° Brix), while titratable acidity was highest in *Docynia indica* (2.49 ± 0.07 percent) Brix) and lowest in *Elaeagnus latifolia* (1.06 ± 0.01 percent).
- ✓ Total, reducing, and non-reducing sugars were estimated in these underutilized fruits, with *Docynia indica* fruits having the highest content of total sugar (9.45± 0.36 percent), *Diploknema butyraceae* having the highest amount of reducing sugar (6.26 ± 0.10 percent), and *Docynia indica* having the highest amount of non-reducing sugar (3.86± 0.05 percent)
- ✓ *Elaeagnus latifolia* had the highest total anthocyanin concentration (1.26 ± 0.16 mg/100gm), while *Machilus edulis* had the lowest (0.05 ± 0.005 mg/100gm).
- ✓ Total antioxidant content was found to be highest in the fruit *Hippophae salicifolia* (92.69 ± 0.55 µg/ml) and lowest in *Diploknema butyraceae* (7.60 ± 0.00 µg/ml)

- ✓ Total flavonoids content analysis revealed that *Docynia indica* had the highest content (49.05± 0.75 mg/g/QE) and *Machilus edulis* had the lowest (17.62± 0.38 mg/g/QE).
- ✓ The total phenol content was significantly elevated in *Hippophae salicifolia* (71.15 ± 0.54 mg/g/GAE) and lowest in *Machilus edulis* (17.04 ± 0.35 mg/100g).
- ✓ In terms of total carotenoid content, *Machilus edulis* had the highest value (61.65± 0.68 mg/100gm), while *Diploknema butyraceae* had the lowest (2.56 ± 0.50 mg/100gm).
- ✓ Ascorbic acid content was highest in the fruit *Hippophae salicifolia* (37.44 ± 0.52 mg/100g), with appreciable content in *Elaeagnus latifolia* (9.93± 0.56 mg/100gm), *Machilus edulis* (4.17± 0.46 mg/100gm), and least in *Docynia indica* (1.14 ± 0.03 mg/100gm).

6.2. Ionome profiling of underutilized fruits

- ✓ The fruit of *Machilus edulis* (119.583 µg//100gm) had the highest potassium content among the underutilized fruit species, while *Diploknema butyraceae* (71.832 µg//100gm) had the lowest potassium content.
- ✓ The fruit of *Elaeagnus latifolia* had the highest magnesium content (4.132 µg/100gm), while *Docynia indica* had the lowest (1.528 µg/100gm).
- ✓ The highest calcium concentration was found in the fruit of *Hippophae salicifolia* (1.501 µg/100gm), while the lowest calcium content was found in the fruit of *Machilus edulis* (0.002 µg100gm).
- ✓ The highest amount of sodium content was recorded in the fruit of *Hippophae salicifolia* (50.728 µg/100gm) whereas, the least amount of sodium content was recorded in *Diploknema butyraceae* fruit (1.813 µg/100gm)**.**

- ✓ The maximum iron concentration was found in *Diploknema butyraceae* samples (2.565 µg/100gm), while the lowest iron content was obtained in fruits *Docynia indica* (0.031 µg/100gm), and no iron content was observed in the fruit of*Machilus edulis.*
- ✓ Among the five underutilized fruits investigated, *Hippophae salicifolia* had the maximum zinc concentration (0.289 µg/100gm), whereas *Machilus edulis* fruit had the least zinc level (0.064 µg/100gm).
- ✓ The present study revealed the manganese content in the underutilized fruit was present in smaller quantities and was recorded maximum in the fruit of *Diploknema butyraceae* (0.037 µg/100gm) whereas the least was recorded in the fruit of *Machilus edulis* and *Docynia indica* with the value (0.002µg/100gm).
- ✓ The copper content was observed highest in the fruit of *Diploknema butyraceae* (0.013 µg/100gm) and the least or trace amount was observed in the fruit of *Machilus edulis* (0.003 µg/100gm) incase of *Hippophae salicifolia, Elaeagnus latifolia* and *Docynia indica* fruits the copper content was not detectable.
- ✓ Highest boron content was recorded in the fruit of *Elaeagnus latifolia* (0.153 µg/100gm) while, *Diploknema butyraceae* (0.006 µg/100gm), has the least content of boron.
- ✓ The lead content of all the studied underutilized fruits, *Diploknema butyraceae* recorded highest amount (0.079 µg/100gm) while in *Elaeagnus latifolia* it was recorded least, (0.004 µg/100gm), whereas in the fruit *Hippophae salicifolia* and *Docynia indica* it was not detectable.
- ✓ The highest chromium content was found in *Hippophae salicifolia* (0.244 µg100gm) and the lowest in *Docynia indica* fruit (0.006 µg100gm). The fruit of *Elaeagnus latifolia* contained no chromium.

- ✓ Nickel concentrations in *Diploknema butyraceae* and *Elaeagnus latifolia* were (0.004 µg/100gm) and (0.003 µg/100gm), respectively. It was not detectable in *Hippophae salicifolia, Docynia indica*, or *Machilus edulis*.
- ✓ *Elaeagnus latifolia* had the highest content (0.025µg/100gm), while *Hippophae salicifolia* had the lowest (0.014µg/100gm), and the fruit of *Diploknema butyraceae, Docynia indica*, and *Machilus edulis* aluminium content was not detectable.

6.3. Nutritional assessment of value addedfoods

- ✓ The highest total soluble solid content was discovered in *Elaeagnus latifolia* jam (47.40 ± 0.57 0 Brix) and the lowest in *Machilus edulis* puree (2.10 ± 0.10 0 Brix).
- ✓ Estimates of the titratable acidity content of all value added products studied were found to be significantly different. The highest titratable acidity content was found in *Docynia indica* pickle (2.17 ± 0.01 percent), while the lowest was found in *Elaeagnus latifolia* ketchup (0.13 ± 0.02 percent).
- ✓ The product pickle made from *Docynia indica* had the highest total sugar (9.37 ± 0.13 percent), while the remaining value added products ranged from (1.32 ± 0.20 percent to 5.62 ± 0.19 percent).
- ✓ Similarly, the maximum content of reducing sugar was also estimated for *Docynia indica* pickle (5.11 ± 0.09 %) while the minimum was recorded for *Machilus edulis* powder (0.75 ± 0.19 %).
- ✓ *Docynia indica* jam possessed the maximum amount of non-reducing sugar (5.28 ± 0.09%) while minimum recorded for *Elaeagnus latifolia* ketchup (0.14 ± 0.03%).
- ✓ Maximum content of β-carotene was observed in *Elaeagnus latifolia* jam (6.32 ± 0.32mg/100g) whereas least was observed in the products of *Docynia indica* pickle (0.64 ± 0.40 mg/100g).

- ✓ The highest content of total anthocyanin was noticed in *Elaeagnus latifolia* ketchup (1.13 ± 0.03 mg/100gm) and the lowest (0.03± 0.01 mg/100gm) in *Machilus edulis* mayonnaise and *Machilus edulis* powder.
- ✓ As can be seen for total antioxidant content, *Hippophae salicifolia* juice had the highest total antioxidant content (82.01± 0.42 µg/ml), while *Diploknema butyraceae* jam had the lowest (4.65± 0.42 µg/ml).
- ✓ The total flavonoids content in all the processed under study did vary significantly and was recorded maximum (41.58 ± 0.55 mg/g/QE) in pickle prepared in *Docynia indica* while *Machilus edulis* mayonnaise was recorded least (12.26± 0.03 mg/g/QE).
- ✓ *Hippophae salicifolia* juice had the highest total phenol concentration (69.26 ± 0.06 mg/g/GAE), whereas *Diploknema butyraceae* jam had the lowest total phenol content (11.98 ± 0.61 mg/g/GAE).
- ✓ Among the value added products, powder made from *Machilus edulis* had the highest total carotenoid concentration (56.80 ± 0.26 mg/100gm), while *Diploknema butyraceae* juice had the lowest (1.08 ± 0.02 mg/100gm).
- ✓ The highest ascorbic concentration was found in *Hippophae salicifolia* juice (30.53 ± 0.86 mg/100gm) while the lowest was found in *Docynia indica* jam (0.23 ± 0.00 mg/100gm).

6.4. Ionome profiling of value addedfoods

- ✓ The Potassium content of value added products revealed *Diploknema butyraceae* juice (68.816 µg/100gm) was the highest among value added whereas the lowest potassium content was noticed in the product of *Elaeagnus latifolia* jam (0.460µg/100gm).
- ✓ The magnesium content highest were found in the product of *Machilus edulis* puree (4.114 µg/100gm) while, the magnesium content in the product *Docynia indica* powder (0.603 µg/100gm) was recorded lowest.

- ✓ The data recorded for calcium content of different value added products was observed in the product of *Hippophae salicifolia* juice with maximum value (1.148 µg/100gm) while the least content of calcium was recorded in the product *Docynia indica* powder with the value (0.001 µg/100gm).
- ✓ The highest amount of sodium content was recorded in the product of *Machilus edulis* mayonnaise (8.767 µg/100gm) whereas, the least amount of sodium content was recorded from the product of *Diploknema butyraceae* juice (0.379µg/100gm).
- ✓ It was noticed that the product of *Docynia indica* pickle (2.454 µg/100gm) obtained the highest iron content while the lowest iron content was observed in the products of *Docynia indica* powder (0.828 µg/100gm) whereas in the products of *Machilus edulis* iron content was not detectable.
- ✓ *Hippophae salicifolia* jelly (0.265 µg/100gm) exhibited the maximum zinc whereas the in the product of *Diploknema butyraceae* (0.010 µg/100gm) it was shown minimum.
- ✓ The manganese content was observed in a trace amount where the maximum was recorded in the product of *Diploknema butyraceae* jam (0.036 µg/100gm and (0.001 µg/100gm) in *Machilus edulis* mayonnaise, *Machilus edulis* powder, *Elaeagnus latifolia* ketchup and *Docynia indica* jam with the least content respectively. The manganese content in the product of *Docynia indica* powder was not detectable.
- ✓ Highest boron content was recorded in the product of *Elaeagnus latifolia* ketchup (0.150 µg/100gm), while, *Diploknema butyraceae* jam (0.002 µg/100gm), has the least content of boron.
- ✓ *Diploknema butyraceae* juice (0.039 µg/100gm) recorded maximum lead content whereas lowest in *Elaeagnus latifolia* chutney (0.003 µg/100gm) while in the

products of *Docynia indica* and *Hippophae salicifolia* the lead content was not detectable.

- ✓ The chromium content was recorded highest in *Hippophae salicifolia* jelly (0.137 µg/100gm) while it was observed lowest in the underutilized fruit products of *Docynia indica* powder and jam (0.004 µg/100gm). The chromium content was not detectable in the value added products of *Elaeagnus latifolia*.
- ✓ Nickel content was highest in *Diploknema butyraceae* juice (0.004 µg//100gm), while it was lowest in *Diploknema butyraceae* candy and jam, *Elaeagnus latifolia* ketchup, and *Elaeagnus latifolia* jam (0.002 µg//100gm). Nickel was not detected in products derived from *Docynia indica, Machilus edulis*, or *Hippophae salicifolia*.
- ✓ Aluminium content was found in smaller amounts in *Hippophae salicifolia* juice (0.017 µg/100gm) and *Elaeagnus latifolia* jam (0.003 µg/100gm), but it was not detected in *Diploknema butyraceae*, *Docynia indica*, or *Machilus edulis* products.

6.5. Evaluation ofvalue added products from a sensory standpoint

- ✓ The sensory attributes of different underutilized fruits was recorded where the highest overall acceptance was obtained in the product of *Elaeagnus latifolia* jam with mean overall acceptability as (7.33 ± 1.29) and the least was recorded in *Machilus edulis* puree (3.90 ± 0.96), *Machilus edulis* mayonnaise (3.77 ± 1.38) and *Machilus edulis* powder (3.77 ± 1.38) respectively.

6.6. Nutritional assessment of *Hippophae salicifolia* juice and *Elaeagnus latifolia* jam fortified products

- ✓ The perusal of total soluble solids in *Hippophae salicifolia* juice fortification with Calcium was estimated maximum (45.87 ± 0.60 0 Brix) while incase of fortified products of *Elaeagnus latifolia* jam with Calcium was recorded minimum (40.57±0.650 Brix) and respectively.

- ✓ Investigation on the titratable acidity content was recorded and found maximum in *Hippophae salicifolia* juice with Vitamin C (1.39 ± 0.76%) whereas in *Elaeagnus latifolia* jam fortification with Vitamin C was minimum ((0.08 ± 0.01%) respectively.
- ✓ Total sugar in *Hippophae salicifolia* juice fortified with Vitamin C exhibited the highest (3.29 ± 0.54%) whereas lowest in *Elaeagnus latifolia* jam fortified with Vitamin C with the value (2.82 ± 0.20%).
- ✓ Similarly reducing sugar was observed maximum in *Hippophae salicifolia* juice fortified with Vitamin C (2.55 ± 0.37%) whereas in *Elaeagnus latifolia* jam fortified with Vitamin C with the value (2.16 ± 0.33%) was recorded least.
- ✓ Non reducing sugar in *Hippophae salicifolia* juice fortified with Vitamin C was observed highest (1.14 ± 0.86%) and *Elaeagnus latifolia* jam fortified with Calcium showed least with the value (0.07 ± 0.03%).
- ✓ Estimation in *Elaeagnus latifolia* jam fortified with Vitamin C (0.48 ± 0.56 mg/100g) exhibited maximum total anthocyanin whereas in *Hippophae salicifolia* juice fortified with Vitamin C it was recorded minimum with the value (0.04 ± 0.01mg/100g).
- ✓ The amount of total antioxidant in *Hippophae salicifolia* juice fortified with Vitamin C was evaluated highest with the value (81.12 ± 0.70 µg/ml) whereas in *Elaeagnus latifolia* jam fortified with Calcium it was evaluated least with the value (4.87 ± 0.47 µg/ml).
- ✓ Total Carotenoids in the product of *Hippophae salicifolia* juice fortified with Calcium was recorded maximum (2.80 ± 0.13mg/100g) while in *Elaeagnus latifolia* jam fortified with Vitamin C (1.84±0.17mg/100g) with least content.

- ✓ The highest concentration of ascorbic acid was found in *Hippophae salicifolia* juice fortified with Vitamin C (39.43 ± 0.62 mg/100g), while the lowest concentration was found in *Elaeagnus latifolia* jam fortified with Calcium (4.68± 0.06 mg/100g).
- ✓ Total phenol content was found to be highest in *Hippophae salicifolia*juice fortified with Calcium (65.77± 0.40 mg/g/GAE), and lowest in *Elaeagnus latifolia* jam treated with Calcium (20.87 ± 0.75 mg/g/GAE).
- ✓ The maximum total flavonoids concentration was found in *Hippophae salicifolia* juice fortified with Calcium (30.82 ± 0.24 mg/ g/QE), while the lowest was found in *Elaeagnus latifolia* jam fortified with Vitamin C (8.91± 0.29 mg/ g/QE).

6.7. Ionome profiling of fortified *Hippophae salicifolia* juice and *Elaeagnus latifolia* jam

- ✓ Potassium content for *Hippophae salicifolia* juice fortified with Vit C (92.967 µg/100gm) was observed the highest whereas the lowest potassium content was noticed in the fortified products of *Elaeagnus latiofolia* jam fortified with Ca (21.026 µg/100gm).
- ✓ *Elaeagnus latifolia* jam fortified with Ca (4.187 µg/100gm) exhibited highest magnesium content whereas lowest were observed in the *Elaeagnus latiofolia* jam fortified with Vit C (0.892 µg/100gm).
- ✓ The maximum calcium content was noticed in *Hippophae salicifolia* fortified with Ca (89.113 µg/100gm) while the least content of calcium was recorded in *Elaeagnus latiofolia* jam fortified with Vit C with the value (0.112 µg/100gm).
- ✓ Among fortified products the highest amount of sodium content was observed in *Elaeagnus latiofolia* jam fortified with Vit C (1.260 µg/100gm) whereas, the least

amount of sodium content was recorded from the fortified product of *Hippophaesalicifolia* juice fortified with Ca (0.930µg/100gm)**.**

- ✓ It was observed that *Hippophae salicifolia* juice fortified with Vit C had the highest iron level(2.538 µg//100gm), while *Elaeagnus latifolia* jam fortified with Ca had the lowest iron content (0.029 µg//100gm)
- ✓ Among fortified items, the highest zinc level was found in *Hippophae salicifolia*juice fortified with Vit C (0.658 µg/100gm), while the lowest zinc concentration was found in *Elaeagnus latifolia* jam fortified with Ca (0.349 µg/100gm).
- ✓ *Hippophae salicifolia* juice fortified with Vit C (0.015 µg/100gm) had the highest manganese concentration, whereas Elaeagnus latifolia jam fortified with Ca had the lowest manganese amount (0.002 µg//100gm).
- ✓ The manganese content was recorded maximum in *Hippophae salicifolia* juice fortified with Vit C (0.015 µg/100gm) while *Elaeagnus latifolia* jam fortified with Ca observed least with the same value (0.002µg/100gm).
- ✓ The maximum lead was noticed in fortified *Hippophae salicifolia* juice with Vit C (0.082 µg/100gm) and in *Hippophae salicifolia* juice fortified with Ca (0.013 µg/100gm) with the minimum, whereas in *Elaeagnus latifolia* jam fortified with Ca and Vit C the lead content was not detectable.
- ✓ From the present research it was shown that chromium content was recorded in a very low concentration in *Hippophae salicifolia* juice fortified with Ca (0.014 µg/100gm) and in *Elaeagnus latifolia* jam fortified with Ca and Vit C was not detectable.
- ✓ Nickel content in fortified *Hippophae salicifolia* juice with Ca (0.026 µg/100gm) was recorded highest whereas least in *Elaeagnus latifolia* jam fortified with Ca (0.010

µg/100gm). It was not detectable in the fortified product of *Elaeagnus latifolia* jam fortified with Vit C.

- ✓ The aluminium content in *Hippophae salicifolia* juice fortified with Ca was recorded maximum with the value (0.016 µg/100gm) and minimum in *Elaeagnus latifolia* jam fortified with Ca (0.002 µg/100gm) respectively.

6.8. Nutritional eassessment of Commercial product

- ✓ The total soluble solids were observed maximum (12.00 ± 0.050 Brix) in a commercial product of Mosambi juice and minimum in (11.24 ± 0.280 Brix) in mixed fruit jam. The content of titratable acidity was evaluated as highest (1.02 ± 0.07%) in mosambi juice while least (0.46 ± 0.02%) in mixed fruit jam respectively.
- ✓ Total sugar in the product mosambi juice was depicted maximum (7.12 ± 0.22%) whereas least (6.31 ± 0.12%) in mixed fruit jam. Similarly reducing sugar was observed highest (6.13 ± 0.16%) and (4.43 ± 0.41%) lowest in the product mosambi juice followed by mixed fruit jam. Non reducing sugar in mixed fruit jam was estimated maximum (0.86 ± 0.07%) and in mosambi juice with the least value (1.71 ± 0.05%).
- ✓ The content of total anthocyanin in mosambi juice was depicted maximum (1.38 ± 0.20 mg/100g) while minimum in mixed fruit jam (0.32 ± 0.01 mg/100g) whereas the total antioxidant was observed highest in mosambi juice (14.86 ± 0.27 µg/ml) whereas incase of mixed fruit jam it was recorded least (12.37 ± 0.40 µg/ml) respectively.
- ✓ Evaluation of total carotenoids content in the product of mosambi juice was evaluated highest (1.64 ± 0.11 mg/100gm) and mixed fruit jam was estimated least (1.50 ± 0.07 mg/100gm). The content of ascorbic acid evaluated in the mosambi juice recorded

maximum (20.25 ± 0.49 mg/100gm) and minimum in mixed fruit jam (9.41 ± 0.61 mg/100gm).

- ✓ The data pertaining to total phenol in mosambi juice was noticed highest (6.50 ± 0.59 mg/g/GAE) and least was recorded in mixed fruit jam (4.83 ± 0.16 mg/g/GAE) followed by total flavonoids content depicting the maximum value (3.18 ± 0.28 mg/ g/QE) in mixed fruit jam while least in mosambi juice (2.02 ± 0.07 mg/ g/QE) and respectively.

6.9. Ionome profiling of Commercial products

- ✓ Potassium content for mixed fruit jam (23.393µg/100gm) was observed the highest whereas the lowest potassium content was noticed in the commercial products of mosambi juice (2.766 µg/100gm).
- ✓ The magnesium content highest was found in the product mixed fruit jam (1.196µg/100gm) whereas the lowest were observed in mosambi juice (1.703 µg/100gm).
- ✓ The calcium was observed in a very low content, mosambi juice (0.017 µg/100gm) while in mixed fruit jam the calcium content was not detectable.
- ✓ Thesodium content of the commercial products studied. The highest sodium content was found in mixed fruit jam (7.193µg/100gm), while mosambi juice had the lowest (2.013 µg/100gm).
- ✓ The iron content of commercial products was estimated where the highest iron concentration was found in mixed fruit jam (1.127µg/100gm), while the lowest iron content was observed in mosambi juice (0.005µg/100gm).

- ✓ The zinc, lead, and nickel content in commercial products, both mixed fruit jam and mosambi juice, were undetectable.
- ✓ Manganese content was measured in smaller amounts in mixed fruit jam (0.004µg/100gm), but not in mosambi juice during evaluation.
- ✓ Thechromium content of the commercial products studied. According to the table, chromium content was recorded at a very low concentration in mixed fruit jam (0.007µg/100gm), whereas it was not detectable during evaluation in mosambi juice.
- ✓ The aluminium content of the fortified products studied. The aluminium content was very low, with a value of (0.179µg/100gm) in mixed fruit jam and (0.097 µg/100gm) in mosambi juice, respectively.

6.10. Sensory assessment of fortified *Hippophae salicifolia* juice, *Elaeagnus latifolia* jam, Mosambi juice, and mixed fruit jam.

- ✓ Mixed fruit jam received the highest overall acceptance (7.06± 0.32), followed by *Elaeagnus latiofolia* jam fortified with Vit C (6.92 ± 0.01), while *Hippophae salicifolia* juice fortified with Vit C (6.72 ± 0.02) and *Hippophae salicifolia* juice fortified with Calcium (6.40 ± 0.15) receiving the lowest overall acceptance.

6.11. Microbial assessment of fortified products

- ✓ The total bacterial count in the samples ranged from (10 x 10^4 to 41 x $10^{4)}$ for the *Hippophae salicifolia* sample to (9 x 10^4 to 38 x 10^4) for the *Elaeagnus latifolia* sample. The total fungal count ranged from (2 x 10^3 to 5 x 10^3) for *Hippophae salicifolia* samples and from (2 x 10^3 to 6 x 10^3) for *Elaeagnus latifolia* jam. The microbial activity has grown with each 30-day storage interval. It was under permissible limit.

CONCLUSION

Based on the current finding of the study suggest that these underutilized fruits its value added products, as well as fortified products are attributed with phytochemical and ionome content. Although there was a minimum loss after processing the losses can be used as an indicator for the severity of processing technique, therefore, impair good quality of the products. These underutilized fruits, processed and fortified products showed a great potential in ensuring food and nutritional security at times of food scarcity, to make seasonal horticultural produce available throughout the year, to put them into a convenient form for the user, to safely put the food away for emergencies to increase the value of the product and also better return to the farmers. These value added products can add to daily diet as health enhancing aid also it will fulfill the demand for new nutritious products as there is a constant effort to prepare these products. Nutrition rich food its availability is the area growing concern worldwide these underutilized fruits can play a vital role as these will not only provide better value recognition but also benefit the local inhabitant and the State overall. It could lead to maintenance, domestication, conservation and utilization of these underutilized fruits. It had the potential to fulfil the nutritional criteria for a large population especially when fortified as fortification of these products can be considered as a cost-effective strategy to bridge the nutrient gap in public health and for food-based approach, it can acheive an important part where the nutritive food also existing food supplies are confined which does not allow the adequate levels of the nutrients needed for the daily diet. It can be made affordable if existing technology with local distributor are approached properly. It will help to reach those susceptible or vulnerable groups of people who cannot afford those costly commercial products. Derived knowledge will be helpful to optimize processing technology which further improves the quality, consumer acceptability, marketability of these products in a bigger scale with the future prospect. Microbial analysis was also found acceptable up to 90 days of storage as per (ICMSF) International Commission on Microbiological Specification for Foods (2002). It will thus have a huge contribution towards the subsistence economy and livelihood of the local community. The genetic resource can be studied further in order to access and improve the physiological state, adaptability, nutritional value so as to develop these underutilized fruits, value added products and fortified products as future food and supply.

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ABSTRACT

Sikkim has a biodiversity comprising of varied agro climatic zones with a wide range of flora and fauna having traditional values, medicinal properties and nutritional properties to the indigenous population especially local community. The current study represents the nutritional aspect, value added products, and fortified products of *Diploknema butyraceae*, *Docynia indica*, *Hippophae salicifolia*, *Machilus edulis* and *Elaeagnus latifolia* found in Sikkim with TSS ranging from (3.46 ± 0.05° Brix to 48.59 ± 0.19° Brix), titratable acidity (0.08±0.01% to 2.49 ± 0.07%), Sugars (0.07±0.03% to 9.45 ± 0.36%), total anthocyanin (0.03 ± 0.01 mg/100gm to 1.26 ± 0.16 mg/100gm), total antioxidant (4.65 ± 0.42 µg/ml to 92.69 ± 0.55 µg/ml), total carotenoids (1.08± 0.02 mg/100gm to 61.65 ± 0.68 mg/100gm), total flavonoids (8.91±0.29 mg/ g/QE to 49.05 ± 0.75 mg/ g/QE), total phenol (11.98± 0.61 mg/g/GAE to 57.24 ± 0.11 mg/g/GAE) ascorbic acid (0.23 ± 0.01 mg/100gm to 39.43 ± 0.62 mg/100gm) and ionome content such as potassium, magnesium, calcium, sodium, iron, zinc, manganese, with an appreciable amount whereas lead, chromium, nickel and aluminium with a trace amount.Sensory examinations of value-added and fortified foods were also found to be satisfactory, with results comparable to those of more expensive commercial brands. Up to 90 days of storage, microbial analysis was also confirmed to be acceptable. According to research, these underutilized fruits, as well as their value added consumables and fortified products, are high in nutritional and ionome content, providing locals with economic benefits as well as nutritious additions to their diet. It has a wide application since nutrition-rich meals are becoming more popular as consumers become more conscious. It will also help to give healthy, appealing, and delicious new foods in the market that are unfamiliar to the rest of the country.