PROCESSING AND CHARACTERIZATION OF FERMENTED FOODS FROM LOCALLY AVAILABLE GREENGAGE PLUM

Ei Thu Zar Naing[1], Mon Mon Maung[2]

Abstract

Fermented foods have been produced from all manner of plant materials and not only from fruits. The conversion of raw food materials into finished fermented products is considered to be one of the best examples of "value added" processing. This research focused on the preparation of fermented food from locally available greengage plums and on the effects of sugar, yeast, fermentation and storage time on the properties of fermented food over a 1-year fermentation period. Firstly, characteristics of greengage plum were studied and greengage plum wine was processed with variations in sugar, yeast and fermentation period; the properties of the prepared wines were also analysed. The effects of these on the product's characteristics were investigated. Secondly, greengage plum syrup was prepared by fermenting greengage plums with varying sugar levels and storage times. The color of fermented foods was determined by UV Spectrophotometer, and the acceptability of experimental fermented foods was perceived by sensory evaluation using 9-Point Hedonic Scale Rating Test. The most suitable greengage plum syrup was obtained at the ratio of greengage plum to sugar (1:1). The highest alcohol content 10 % (v/v) in prepared greengage plum wine was formed with 1: 0.75 greengage plums to sugar ratio after seven weeks of fermentation period.

Keywords: greengage plum, fermented food, fermentation

Introduction

Fermented foods and alcoholic beverages have long been an important part of the human diet in nearly every culture on every continent. These foods are often well-preserved and serve as stable, significant sources of protein, vitamins, minerals, and other nutrients. Despite these standard features, there are many differences in substrates and products, and the types of microbes involved in the manufacture of fermented foods and beverages produced worldwide. Fermented foods and beverages depend on dietary comsumers' habits, as well as regional agricultural conditions and resources availability (Kamboj, Gupta, Bandral and Gandotra & Anjum, 2020).

The greengage plum is an important and widely cultivated temperate fruit crop with attractive colour and flavour. It is a highly perishable fruit with a shelf life of 3-4 days at ambient temperature and 1-2 weeks in cold storage. Production of alcoholic beverages from this fruit is a profitable alternative. It has demonstrated its potential for the preparation of alcoholic beverages, including wine and vermouth (Rastogi & Shukla, 2013).

Fruit syrups or fruit molasses are concentrated fruit juices used as sweeteners. Some foods are made using fruit syrups or molasses. In modern industrial food production, they are often made from less expensive fruits (such as apples, pears, or pineapples) and used to sweeten more expensive fruits or products and to extend their quantity. Wine may be defined as the usually fermented juice of a plant product (as a fruit) used as a beverage. To make a wine of acceptable quality, several approaches have been used, including yeast, dilution with water, and blending with low-acid juices. Besides, the sugar used to improve the must for fermentation to produce wine with a desirable alcoholic content profoundly influences on wine quality (Vyas & Joshi, 1982).

The term *fermentation* refers to microbial cell growth and the production of products under aerobic, microaerobic, or anaerobic conditions. The secretion of metabolites from the inside of microbial cells to the surrounding medium, and their accumulation in the medium,

[1] Department of Industrial Chemistry, University of Mandalay
[2] Department of Industrial Chemistry, University of Mandalay

occur as a consequence of the oxidation of monosaccharides, particularly glucose, under both aerobic and anaerobic conditions (Bisson, Butzke, and Ebeler, 1995). The main objective of this research was to prepare the fermented foods from greengage plum and to enrich food substrates with protein, essential amino acids, and vitamins. The specific objectives of this study were to study the characteristics of the greengage plum to prepare the fermented food from the greengage plum, and to analyse the properties of processed greengage plum syrup and wine.

Materials and Methods

Materials

Raw materials for the processing of fermented foods (syrup and wine) and greengage plums were collected from Wundwin Township, Mandalay Region. Sugar was purchased from Ocean Supermarket, Chan Mya Thar Si Township, Mandalay Region. The needed chemicals for processing were purchased from Wine Making Supplies & Equipment, Kywal Sal Kan 10th, between 78th and 79th, Mandalay.

Methods

Processing of Greengage Plum Syrup

Greengage plums were washed, drained and thoroughly dried. Any stems including the stubs near the stem, were removed. Alternating layers of sugar and plums were placed in a glass bottle. The glass bottle was covered and left in a cool place for 90 days. After 90 days, the plums with seeds were removed, and the syrup was stored at room temperature.

Processing of Greengage Plum Wine

Greengage plums were pitted, cut into pieces, and frozen overnight in a glass fermenter. After defrosting, three quarts of boiling water were poured over the plums. Once cooled, pectic enzyme, yeast nutrient, lemon juice, and wine yeast were added. The fermenter was loosely covered, and the mixture was fermented for five days. To prepare the sugar syrup, sugar was dissolved in boiling water to achieve 30 °Brix, then cooled and filtered to obtain a clear syrup. This syrup was added to the fermenting mixture, and additional water was added as needed. The must was stirred twice daily during fermentation. When fermentation ceased and no bubbles appeared in the airlock for at least five minutes, the fruit mash was strained through cheesecloth. The resulting wine was racked three times for clarification, then stored in sterilized wine bottles.

Characterization

The physicochemical characteristics of greengage plum, syrup, and wine were determined. Moisture content, ash content, fibre content, protein content, fat content, and carbohydrate content were analyzed using AOAC methods. pH and soluble solids (°Brix) were measured using a pH meter and a refractometer, respectively. To determine the alcohol content, the specific gravity of each sample was first measured and then converted to the corresponding alcohol percentage (% v/v) using the Standard Alcohol Density Table. Colour (absorbance) was measured using a UV spectrophotometer (UV-1800 Shimadzu). Reducing sugar was determined by the Lane-Eynon method. A sensory evaluation (organoleptic properties) of greengage plum syrup and wine was also conducted, based on colour, taste, odour, and overall acceptability, using a panel of 15 semi-trained panelists. The scoring was based on a 9-point Hedonic Scale, where: 9 = like remarkably, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, and 1 = dislike immensely. Overall acceptability was calculated as the average score of all these organoleptic attributes.

Results and Discussion

Fermented food preparation serves not only as an example of value-added processing, but also as an ancient technology. Fermentation is highly effective method for preserving foodstuffs at industrial level. This paper provides a general overview of the production of greengage plum syrup and wine, with a particular emphasis on the quality of fruit used for food processing.

The physicochemical characteristics of the greengage plum were determined for pH, acidity, soluble solids, moisture content, ash content, fibre content, protein content, fat content, carbohydrate content, and compared with the literature values. Moisture content, ash content, fibre content, protein content, fat content, carbohydrate content of greengage plum were 4.89, 0.33, 1.25, 0.65, 0.25, and 10.8 respectively, which were higher than the literature values. The soluble solids (°Brix), pH, acidity, reducing sugar content of greengage plum were 9.77, 2.61, 2.47, and 7.19 respectively, and were nearly similar to the literature values. The quality of fruit could also be affected by the cultivation method, e.g., organic or conventional.

Table 1: Effect of Volume of Sugar Syrup on the Characteristics of Prepared Greengage Plum Wine

Weight of Greengage Plum - 2000 g

Weight of Yeast - 3 g

Fermentation Period - Seven Weeks

Sr. No.	Sugar Syrup (mL)	Characteristics of Prepared Greengage Plum Wine				
		pH	Acidity	Soluble Solids (°Brix)	Specific Gravity	Alcohol Content % (v/v)
1.	0	3.55	0.69	12	1.0731	6
2.	500	3.68	0.65	13	1.0653	7
3.	1000	3.71	0.54	16	1.0534	9
4.	1500*	3.85	0.53	18	1.0458	10
5.	2000	3.91	0.49	15	1.0613	8

* The most suitable condition

Effects of volume of sugar syrup and weight of yeast on the characteristics of prepared greengage plum wine were analysed and are shown in Tables 1 and 2, respectively. Acidity is an important factor, as it contributes directly and indirectly to wines quality (Clarke & Baker, 2004). The pH of the prepared wine increased gradually as the acidity decreased with increasing volume of sugar syrup. Soluble solids (°Brix) and alcohol content of prepared wine were also increased but the specific gravity of prepared wine was decreased. The alcohol content of wines depended on the amount of sugar used in wine making. Soluble solids (°Brix) of prepared wine were also an important quality parameter and an indicator of the stability and completeness of fermentation. After 7 weeks of fermentation, the highest alcohol content of 10 % (v/v) was obtained using 3 g of yeast in wine making. If there was too much yeast during wine fermentation, it caused off-flavours and a shortened wine shelf life. Yeast affected not only the alcohol content of prepared wine, but also its aroma, character, mouthfeel, and flavor.

Table 2: Effect of Weight of Yeast on the Characteristics of Prepared Greengage Plum Wine

Weight of Greengage Plum - 2000 g
Volume of Sugar Syrup - 1500 mL
Fermentation Period - Seven Weeks

Sr. No.	Yeast (g)	Characteristics of Prepared Greengage Plum Wine				
		pH	Acidity	Soluble Solids (°Brix)	Specific Gravity	Alcohol Content % (v/v)
1.	1	3.53	0.69	11	1.0623	6
2.	2	3.65	0.65	12	1.0552	7
3.	3*	3.83	0.54	18	1.0458	10
4.	4	3.84	0.51	15	1.0523	9
5.	5	3.89	0.48	14	1.0535	8

* The most suitable condition

Table 3: Effect of Fermentation Period on the Characteristics of Prepared Greengage Plum Wine

Weight of Greengage Plum - 2000 g
Volume of Sugar Syrup - 1500 mL
Weight of Yeast - 3 g

Sr. No.	Fermentation Period (Weeks)	Characteristics of Prepared Greengage Plum Wine				
		pH	Acidity	Soluble Solids (°Brix)	Specific Gravity	Alcohol Content % (v/v)
1.	1	3.87	0.51	11	1.0675	6
2.	3	3.85	0.52	13	1.0573	8
3.	5	3.84	0.55	15	1.0465	9
4.	7*	3.83	0.54	18	1.0451	10
5.	9	3.63	0. 69	17	1.0451	10

* The most suitable condition

Table 4: Effect of Fermentation Period on the Yield of Alcohol Content in Greengage Plum Wines

Fermentation Period (Weeks)	Yield of Alcohol, % (v/v)				
	Greengage Plum:Sugar Syrup (1:0)	Greengage Plum:Sugar Syrup (1:0.25)	Greengage Plum:Sugar Syrup (1:0.5)	Greengage Plum:Sugar Syrup (1:0.75)	Greengage Plum:Sugar Syrup (1:1)
1	0	1	3	4	2
2	1	2	4	5	3
3	2	3	5	7	5
4	3	4	7	8	6
5	5	6	8	9	7
6	6	7	9	10	8
7*	6	7	9	10	8

FP = Fermentation Period

* The most suitable condition

The effect of the fermentation period on the characteristics of prepared greengage plum wine was studied, as shown in Table 3. The pH, acidity, soluble solids (°Brix), specific gravity, and alcohol content of the prepared wines were measured every two weeks. The pH values of the wines decreased slightly over time, ranging from 3.87 to 3.63. Acidity increased from 0.51 % to 0.69 %. The primary non-volatile acids—tartaric, citric, and malic acids—are crucial components in wine, as they influence both taste and color. As the soluble solids (°Brix) of the wine increased, the alcohol content also increased. The alcohol content remained relatively stable during the final weeks of fermentation. These results are presented in Table 4.

All greengage plum wine samples exhibited pH values of 3.0-4.0 and acidity values of 0.3-0.7 throughout the study. Soluble solids (˚Brix), specific gravity, and alcohol content were 10-20 (˚Brix), 1.01-1.09, and 5–10 % (v/v), respectively. All these results are shown in Table 5. The acidity of the prepared wines increased as fermentation progressed, due to the formation of organic acids by-products. The increase in acidity may be due to the increased alcohol production from the high initial sugar concentration (Attri, 2009). The fermentation period affects wine pH; as fermentation proceeds, pH decreases which is desirable because it inhibits their growth of microorganisms. Low pH and high acidity give good fermentation in natural environments. The decrease in soluble solids (°Brix) content of wine indicates the utilization of the sugar present in the must during fermentation. Alcohol was the most abundant volatile compound in wines and helped improve their sensory properties and acceptability. Ethanol was the most important alcohol in wine and an indicator of wine quality. Increasing fermentation time increases the alcohol concentration but decreases the wine's specific gravity. The decrease in the specific gravity of prepared wine during storage with varying amounts of yeast and sugar, may be due to the type of yeast used in wine production.

Table 5: Effect of Fermentation Period on the Properties of Prepared Greengage Plum Wine

Sr. No.	Properties	Fermentation Period (Week)						
		1	**2**	**3**	**4**	**5**	**6**	**7***
1.	pH	3.98	3.95	3.92	3.87	3.85	3.83	3.83
2.	Acidity, % (w/v)	0.35	0.39	0.46	0.49	0.52	0.54	0.54
3.	Specific Gravity	1.0653	1.0613	1.0534	1.0514	1.0438	1.0451	1.0451
4.	Alcohol Content, % (v/v)	4	6	7	8	9	10	10
5.	Soluble Solids, °Brix	25	23	22	20	19	18	18
6.	Reducing Sugar, %	0.25	0.28	0.29	0.31	0.32	0.33	0.33
7.	Colour (Absorbance)	0.04	0.05	0.09	0.17	0.11	0.15	0.15

* The most suitable condition

Table 6: Comparison between the Properties of Prepared Greengage Plum Wine and Commercial Wine

Sr. No.	Properties	Prepared Greengage PlumWine	Commercial Plum Wine
1.	pH	3.85	3.78
2.	Acidity, % (w/v)	0.52	0.49
3.	Specific Gravity	1.0731	0.994
4.	Alcohol Content, % (v/v)	10	10.0
5.	Soluble Solids, °Brix	18	6.5
6.	Reducing Sugar, %	0.33	0.67
7.	Colour (Absorbance)	0.15	0.19

The properties of the prepared greengage plum wine were compared with those of commercial plum wine, and the results are shown in Table 6. Although the pH, acidity, specific gravity, and alcohol content of the prepared wine were nearly similar, other properties were significantly different. Color is an essential physical factor that affects consumers' acceptability of a product. The colour of prepared wine and commercial wine had 0.15 and 0.19 colour (absorbance) in the visible region (wavelength 520 nm) and were clear and transparent, without sediments or cloudiness.

Sensory evaluation (organoleptic properties) of greengage plum wine included appearance, colour, taste, and aroma, and these results are shown in Table 7. In this table, panelists gave the highest preference to all sensory attributes of sample (3), followed by sample (4), sample (2), sample (1), and sample (5). Sample (3) was recorded as having the highest overall acceptance in the sensory evaluation (7.18) and the highest mean scores for appearance (7.15), colour (6.98), taste (7.26), and aroma (7.32). The sample with the least preference for all sensory attributes recorded the lowest overall acceptance in the sensory evaluation (5.15). The colour of the prepared wine changed from pale yellow to red during storage. As the wine appropriately aged, the harsh taste and yeasty odour diminished, and a smooth, mellow flavor and clean odour emerged.

Table 7: Sensory Evaluation of Prepared Greengage Plum Wine

Organoleptic Properties	**Panelist Hedonic Rating**				
	Sample (1)	**Sample (2)**	**Sample (3)***	**Sample (4)**	**Sample (5)**
Appearance	5.43	6.20	7.15	6.91	5.00
Colour	5.74	6.33	6.98	6.75	5.25
Taste	5.82	7.12	7.26	6.67	5.33
Aroma	5.87	6.67	7.32	7.11	5.00
Overall Acceptance	5.72	6.58	7.18	6.86	5.15

* The most suitable condition

Table 8: Effect of Ratio of Greengage Plum to Sugar on the Characteristics of Prepared Greengage Plum Syrup

Weight of Greengage Plum - 1200 g

Weight of Sugar - 400 g, 800 g, 1200 g, 1600 g, 2000 g

Storage Period - Three Months

Sr. No.	**Greengage Plum:Sugar**	**Characteristics of Prepared Greengage Plum Wine**				
		Soluble Solids (°Brix)	**Acidity % (w/v)**	**Reducing Sugar (%)**	**Non-Reducing Sugar (%)**	**Total Sugar (%)**
1.	1 : 033	52	1.49	1.65	68.31	69.96
2.	1 : 0.67	54	1.32	1.98	67.75	69.73

Sr. No.	Greengage Plum:Sugar	Characteristics of Prepared Greengage Plum Wine				
		Soluble Solids (°Brix)	Acidity % (w/v)	Reducing Sugar (%)	Non-Reducing Sugar (%)	Total Sugar (%)
3.	1 : 1*	56	1.36	2.48	67.69	70.17
4.	1 : 1.33	58	1.38	2.82	66.54	69.36
5.	1 : 1.67	60	1.42	2.95	66.47	69.42

* The most suitable condition

The ratio of plums to sugar was important for preparing good plum syrup. The basic ratio was 1:1, but it was increased 1:2 depending on the plums' size and juiciness of the plums. More sugar was added to achieve a good plum syrup, and less sugar resulted in mold or sourness rather than sweetness. The type of sugar also has an effect on the quality of the syrup. White sugar intensified the plum fragrance in the syrup. Brown sugar which contained a molasses-like substance in addition to sugar, diminished the flavor and fragrance of the greengage plums. Prepared greengage plum syrup with the ratio of plum to sugar (1:1), containing soluble solids 56 (°Brix), 1.36 (%w/w) acidity was found to be the best according to organoleptic evaluation, as shown in Table 8.

Table 9: Effect of Storage Period on the Characteristics of Prepared Greengage Plum Syrup

Weight of Greengage Plum - 1200 g

Weight of Sugar - 1200 g

Sr. No.	Storage Period (Months)	Characteristics of Prepared Greengage Plum Wine				
		Soluble Solids (°Brix)	Acidity % (w/v)	Reducing Sugar (%)	Non-Reducing Sugar (%)	Total Sugar (%)
1.	1	53	1.26	1.78	68.36	70.14
2.	2	55	1.29	1.96	67.39	69.35
3.	3*	56	1.36	2.48	67.69	70.17
4.	4	58	1.38	2.96	67.88	70.84
5.	5	59	1.4	3.2	67.98	71.18

* The most suitable condition

The soluble solids, acidity, reducing sugars, and total sugars increased, whereas non-reducing sugars decreased during storage in bottles. The syrup stored up to 3 months at ambient storage temperature in bottles is of acceptable quality. During storage, changes in soluble solids,

acidity, reducing sugar, non-reducing sugar, and total sugar were recorded monthly and are described in Table 9.

Comparative studies were conducted on the properties of prepared greengage plum syrup and commercial syrup, and the results are shown in Table 10. Properties of prepared syrup, like pH, reducing sugar, non-reducing sugar, and total sugar, were almost identical to those of commercial plum syrup. It was found that other properties of the prepared syrup and the commercial syrup were totally different.

Table 11 shows that sample 3 has the highest overall acceptance in the sensory evaluation (7.68) and the highest mean scores for appearance (7.45), colour (7.58), taste (8.00), and aroma (7.67). The least preference sample was recorded as having the lowest overall acceptance in the sensory evaluation (5.24). The overall acceptability of greengage plum syrup depended on its organoleptic properties.

Table 10: Comparison of the Properties of Prepared Greengage Plum Syrup and Commercial Syrup

Sr. No.	Properties	Prepared Greengage Plum Syrup	Commercial Plum Syrup (Royal Kalaw, Myanmar)
1.	pH	3.5	3.36
2.	Acidity (%w/v)	1.36	0.98
3.	Soluble solids (°Brix)	56	69
4 .	Reducing sugar (%)	2.48	2.36
5.	Non-reducing sugar (%)	67.69	65.48
6.	Total Sugar (%)	70.17	67.48
7.	Colour (Absorbance)	0.19	0.21

Table 11: Sensory Evaluation of Prepared Greengage Plum Syrup

Organoleptic Properties	Panelist Hedonic Rating				
	Sample (1)	Sample (2)	Sample (3)*	Sample (4)	Sample (5)
Appearance	6.54	6.53	7.45	6.24	5.49
Colour	6.42	5.64	7.58	6.35	5.36
Taste	6.55	6.92	8.00	7.00	5.00
Aroma	6.17	4.87	7.67	6.67	5.12
Overall Acceptance	6.42	5.99	7.68	6.57	5.24

* The most suitable condition

Conclusion

In this research, value-added fermented foods were prepared from locally available greengage plums. All prepared fruit syrups are free of pathogenic and aerobic bacteria, and only yeast contributes to the fermentation process. The use of unripe fruits for the preparation of fruit syrups, along with longer fermentation times, and whole-fruit sources, increases the functional properties and contributes to the unique flavor and taste of fruit syrups. Fruits, both in fresh and in processed forms, not only improve the quality of our diet but also provide essential ingredients like vitamins, minerals, carbohydrates, etc. The nutritive value of wine is increased due to the release of amino acids and other nutrients from yeast during fermentation.

Acknowledgements

I am grateful to Dr Tin Tun, Rector, University of Mandalay, and Dr Thu Nandar and Dr Ye Ye Cho, Pro-Rectors, University of Mandalay, for their permission to submit this article. I would like to express my deepest appreciation to Dr Khin Mar Hlaing, Professor and Head, Department of Industrial Chemistry, University of Mandalay, for her permission to submit this research paper, for reviewing the manuscript, and for her suggestions.

References

Attri, B. L. (2009) Effect of initial concentration on the physicochemical characteristics and sensory qualities of cashew apple wine. Indian Journal of Natural Products and Resources, 8: 374- 379.

Bisson L F, Butzke C E and Ebeler S E, (1995), The role of moderate ethanol consumption in health and human nutrition, Amer J Enol Vitic, 48(4), 449-460.

Clarke, R. J. and Bakker, J. (2004) Volatile components. In: Wine flavour chemistry. Blackwell Publishing Limited, Oxford, UK, pp. 120- 188.

Kamboj, S., Gupta, N., Bandral, J., Gandotra, G., & Anjum, N. (2020). Food safety and hygiene: A review. International Journal of Chemical Studies, *8*, 358– 368.

https://doi.org/10.22271/chemi.2020.v8.i2f.8794

Rastogi, D. A., & Shukla, S. (2013). Amaranth: A New Millennium Crop of Nutraceutical Values. Critical Reviews in Food Science and Nutrition, *53*,109–125.

https://doi.org/10.1080/10408398.2010.517876

Vyas K K and Joshi V K, (1982), Plum wine making: Standardization of a methodology, Indian Food Packer, 36, 80-86.