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Comparative Study of Development and Formulation of Syrups Based on Non-Nutritive Non- Glycogenic Sweetener

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ABSTRACT

Background: Syrups represent a type of liquid medication; these liquid pharmaceuticals are typically preferred for their convenience in administering to individuals such as children and the elderly who may struggle with swallowing solid medications. This research work was conducted to: First Prepare, develop and design stable, non-medicated simple syrups based on non-nutritive and non-glycogenesis sweeteners such as Stevia and Monk Fruit sugars. Second compare these syrups in terms of physical and microbiological properties with sucrose and fructose based syrups. The sweeteners used in this study were Stevia, Monk Fruit, Sucrose, Fructose, Cane sugar and Honey in order to prepare stable simple syrups. The syrups were prepared by simple solution method with the aid of heat. The sweetener was dissolved in purified water with a continuous agitation. The prepared syrups were evaluated for the following parameters Physical appearance (color, odor, and taste), pH, Refractive index, Conductivity, Optic rotation, Specific gravity, Viscosity and Microbiological studies. The study showed that syrups based on non-nutritive sweeteners such as Stevia 1% w/w and Monk Fruit 5% w/w, 10%w/w are stable in terms of the parameters of evaluation and tests that were carried out during the 6 months of the study at room temperature and 50 oC, in addition to that, no color changes, no sedimentation, no recrystallization nor growth of any type of microscopic organism were detected. Stevia 1% w/w and Monk fruit 5% and 10 % w/w can be used to prepare stable simple syrup as well as sucrose 66.7 % w/w based syrup

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1- INTRODUCTION

Syrups are liquid dosage forms; these liquid pharmaceuticals have generally been justified on the basis of ease of administration to children and elderly who have difficulties in swallowing solid dosage forms. The major components of syrups are purified water and a sweetening agent such as sugar. Sucrose is commonly used in syrups, but under certain conditions, it can be fully or partially substituted with other sugars or substances like sorbitol, glycerin, and propylene glycol. Sometimes, all glycogenetic substances, which convert to glucose in the body, including the aforementioned agents, are replaced with nonglycogenetic substances like methylcellulose or hydroxyethylcellulose. These substances are not broken down and absorbed into the bloodstream, making them suitable for creating syrup-like vehicles for medications aimed at diabetic patients or those needing to avoid glycogenetic substances. The viscosity provided by these cellulose derivatives is comparable to that of a sucrose syrup, and incorporating one or more artificial sweeteners can effectively mimic the taste and texture of traditional syrup. The incorporation of artificial sweeteners in various formulations is on the rise, with saccharin sodium being commonly used in many of these formulations, sucralose and aspartame are utilized either alone or in conjunction with sugars or sorbitol to decrease the overall sugar content in the formulation.

Syrups may or may not contain medication or added flavoring agents. Syrups without a medication, but with a flavoring agent, are called non-medicated or flavored syrups.

Sweetening agents are employed in liquid formulations, such as syrups and elixirs, formulated for oral administration with the specific purpose of enhancing the palatability of the therapeutic agent.

Stevia sugar is naturally occurring compound found in the leaves of a small shrub, Stevia rebaudiana Bertoni, native to Brazil and Paraguay, also called yerba dulce. It is 150-300 times sweeter than sucrose.

Stevia is calorie-free, non–cariogenic sweetener, heat stable, resistant to acid hydrolysis, non-fermentable that makes them advantageous over the non-caloric sweeteners [1].

Stevia sugar Stevioside is an intense sweetener particularly well-suited for liquid oral dosage forms like syrups, dry syrups, and suspensions. Syrups were prepared using stevioside at concentrations of 0.5% and 1% w/v, with salbutamol sulfate and bromhexine hydrochloride as model drugs. Stevioside offers several benefits for patients with diabetes, phenylketonuria, and those who are calorie-conscious, making it suitable for all age groups from pediatrics to geriatrics. When the sweetener is soluble in the solvent, a concentration as low as 0.5% w/v is sufficient. The formulated liquid oral dosage forms were stable at room temperature, demonstrated good sweetness and palatability, and were assessed for drug content, viscosity, pH, and compatibility. A panel of trained volunteers evaluated the sweetness and palatability, confirming that a 0.5% w/v concentration of stevioside provided a pleasant taste [2].

Stevia rebaudiana (Bertoni), a perennial shrub in the Asteraceae family, is renowned for being the sweetest plant. Its leaves are rich in diterpene glycosides such as stevioside, rebaudioside A-F, dulcoside, and steviolbioside, which contribute to its sweetness. These compounds have been commercially used as sugar substitutes in various foods, beverages, and medicinal products [3]. In 1995, the The FDA has authorized the import and use of Stevia as a dietary supplement, though it has not approved it as a sweetener. Steviol glycoside has undergone extensive testing to confirm its safety for human use [4]. Samsher and Goyal reported that Stevia offers several health benefits, including anti-bacterial, anti-fungal, anti-inflammatory, anti-microbial, anti-viral, anti-yeast, cardio-tonic, diuretic, hypoglycemic, hypotensive, and vasodilatory properties. It has an edge over artificial sweeteners due to its stability at high temperatures and its effectiveness across a pH range of 3-9. It was reported that Stevia extract is used as a sweetener or flavour enhancer in many countries such as China, Japan, Korea, Brazil and Paraguay. It is also used in soft drinks, ice creams, cookies, pickles, chewing gum, tea and skincare products. Stevia plant and its extract both are used in weight-loss programmes because of their ability to reduce the craving for sweet and fatty foods [5]. A recent study found that the Stevia rebaudiana extract was more effective in inhibiting Streptococcus mutans compared to chlorhexidine [6]. Monk fruit sugar or Mogroside is our second non-nutritive sweetener Siraitia grosvenorii, commonly referred to as monk fruit or luohan guo, is a perennial vine from the gourd family (Cucurbitaceae). Native to southern China and northern Thailand, this plant is grown for its fruit extract, known as mogrosides, which provides a sweetness approximately 250 times greater than that of sucrose. The sweetness of the fruit primarily derives from mogrosides, which are a type of triterpene glycosides comprising approximately 1% of the fresh fruit's flesh. By using solvent extraction, it is possible to produce a powder that contains 80% mogrosides [7&8]. Mogroside extract is utilized as a low-calorie sweetener for beverages and is also employed in traditional Chinese medicine. Monk fruit is particularly known for its intense sweetness, which can be extracted and concentrated from its juice. The plant is highly valued for its sweet fruits, which serve both medicinal purposes and as a sweetener. In traditional Chinese medicine, the fruits are used to treat coughs and sore throats, and in southern China, they are thought to promote longevity. Typically sold dried, these fruits are traditionally used in herbal teas or soups.

In Europe, it is identified as an unapproved Novel Food (not utilized in the food system prior to May 1997), it can only be marketed as a food or food ingredient following a safety evaluation and authorization by the European Commission; as of 2017[9].

Aims: The aim of this work was to formulate non sucrose based simple syrup, Natural sugar substitutes, and

- To prepare, develop and design a stable, non-medicated simple syrups based on nonnutritive and non glycogenetic sweeteners such as Stevia and Monk fruit.
- To compare these syrups in terms of physical and microbiological properties with sucrose and fructose based syrups.

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2- MATERIAL AND METHODS

Natural mineral water, Sucrose, Fructose, Honey, Cane sugar, Monk fruit and Stevia.
All materials were purchased from the local markets in Pinang, Malaysia.
pH meter , Oswald Viscometer, ME SNB 2 (1 – 6 000 000 cp) Mesu lab Digital Viscometer Refractometer, Polarimeter (WXG-4 Polarimet Misu Lab), Pycnometer.
The preparation of non-medicated syrups (Simple Syrup) screening different concentrations of Sucrose, Fructose, Cane Sugar, Honey, Monk Fruit and Stevia as sweetening agents. As shown in table 1.

Table 1: concentration w/w of sweeteners used in the study

Sucrose	Cane Sugar	Fructose	Honey	Stevia	Monk Fruit
10 % w/w	10 % w/w	10 % w/w	10 % w/w	1 % w/w	5 % w/w
30 % w/w	30 % w/w	30 % w/w	30 % w/w	2 % w/ w	10 % w/w
50 % w/w	50 % w/w	50 % w/w	50 % w/w	3 % w/w	20 % w/w
66.7 % w/w	66.7 % w/w		66.7 % w/w	5 % w/w	

Preparation of Syrups
Numerous official syrups lack a formally specified preparation method.
All the syrups were prepared by simple solution method with the aid of heat. The sweetener was dissolved in purified water with a continuous agitation till a homogeneous solution achieved.

Quality control assessment of the syrups
The prepared syrups were evaluated for the following parameters
1. Visual inspection including Physical appearance (color, odor, and taste)
2. pH
3. Refractive index
4. Conductivity
5. Optic rotation
6. Specific gravity
7. Viscosity.
8. Microbiological studies will be considered.

3- RESULTS AND DISCUSSION

Stability studies conducted on the six kinds of sweeteners over a period of 180 days, with evaluations at 0, 30, 90, and 180 days, and storage conditions at both room temperature (25°C) and in a stability chamber (50°C), the following summary can be provided:

1. Stevia Sugar
Based on the information regarding the stability studies of stevia preparations over a one-year period, the following summary can be drawn.
Stevia 1% w/w:

Microbiological and Physical Stability: Table 2 shows that stevia syrup at 1% w/w is microbiologically and physically stable for one year without any preservatives. There was no fermentation observed during the storage period at room temperature.

Table 2: Results of Stability Testing of Liquid Oral (Stevia)

Stevia	15 days	30 days	90 days	180 days	1 year
1%	Clear solution	Clear solution	Clear	Clear	Clear
2 %	Clear solution	Clear solution	Recrystallization		
3 %	Clear solution	Recrystallization	Recrystallization		
5 %	Recrystallization	Recrystallization	Recrystallization		

Physical Parameters: According to Table 3, there were no significant changes in physical values such as refractive index, specific gravity, pH, and viscosity. Stevia solutions are not optically active, so polarity values remained zero.

No Sedimentation: Unlike higher concentrations, there was no sedimentation or precipitation observed in the 1% w/w stevia solution, indicating its stability.

Table 3: Stability studies through physicochemical parameters of developed Syrup (Stevia 1 % w/w)

Stevia	1 day	1 month	3 months	1 month	3 months
1 %	**25 ºC**	**25 ºC**	**25 ºC**	**50 ºC**	**50 ºC**
Brix	1 %	0.9 %	0.9 %	0.9 %	0.9 %
Sp gr	1.004	1.003	1.004	1.003	1.003
Sp gr pycnometer	1.003	1.003	1.003	1.002	1.003
pH	8.50	7.62	7.27	8.32	8.17
PPM	145	136	117	143	158
Conductivity	294	274	236	286	316
Viscosity cp	0.32	0.32	0.35	0.33	0.33
Viscosity sec	4.23	4.21	4.59	4.53	4.30
Polarization	Zero	Zero	Zero	Zero	Zero

Stevia 2% w/w and 5% w/w:

Physical Stability: Tables 4 and 5 indicate that while there were no significant changes in physical parameters such as refractive index, specific gravity, pH, and viscosity, both 2% w/w and 5% w/w stevia solutions showed precipitation or recrystallization of stevia 15 days after preparation.

Supersaturation Issue: The precipitation or recrystallization in these solutions is likely due to supersaturation, making them less stable compared to the 1% w/w solution.

Table 4: Stability studies through physicochemical parameters of developed Syrup (Stevia 2 % w/w)

Stevia	1 day	1 month	3 months	1 month	3 months
2 %	**25 ºC**	**25 ºC**	**25 ºC**	**50 ºC**	**50 ºC**
Brix	1.9 %	2 %	2 %	2 %	2 %
Sp gr	1.008	1.007	1.007	1.008	1.008
Sp gr pycnometer	1.005	1.006	1.006	1.007	1.007
pH	8.39	8.09	7.20	8.50	8.81
PPM	170	141	184	131	98
Conductivity	340	282	368	262	196
Viscosity cp	0.35	0.36	0.35	0.34	0.35
Viscosity sec	5.36	4.46	4.25	4.41	4.35
Polarization	Zero	Zero	Zero	Zero	Zero

Table 5: Stability studies through physicochemical parameters of developed Syrup (Stevia 5 % w/w)

Stevia	1 day	1 month	3 months	1 month	3 months
5 %	**25 ºC**	**25 ºC**	**25 ºC**	**50 ºC**	**50 ºC**
Brix	4.8 %	4 %	4 %	4.5 %	4.5 %
Sp gr	1.018	1.015	1.016	1.018	1.017
Sp gr pycnometer	1.014	1.014	1.015	1.014	1.014
pH	7.35	7.29	7.12	7.82	8.10
PPM	99	94	95	99	94
Conductivity	198	188	190	198	188
Viscosity cp	0.34	0.33	0.36	0.32	0.35
Viscosity sec	4.83	5.19	4.59	4.37	4.70
Polarization	Zero	Zero	Zero	Zero	Zero

2. Monk Fruit Syrup at 5% and 10% w/w:

Color Stability: According to Table 6, syrups with 5% and 10% w/w Monk fruit sugar maintained their color throughout the study period, indicating good stability.

Microbiological Stability: No microbial growth or fermentation was observed in these syrups, suggesting that Monk fruit sugar does not promote microbial contamination.

Table 6: Results of Stability Testing of Liquid Oral (Monk Fruit)

Monk Fruit	15 days	30 days	90 days	180 days
5 %	Clear solution	Clear	Clear	Clear
10 %	Clear solution	Clear	Clear	Clear
20 %	Clear solution	Recrystallization	Recrystallization	
30 %	Recrystallization	Recrystallization	Recrystallization	

Physical Stability: Tables 7 and 8 show no significant changes in physical properties such as viscosity, pH, and turbidity over time. This indicates that syrups at these concentrations are stable.

Table 7: Stability studies through physicochemical parameters of developed Syrup (Monk Fruit 5 % w/w)

Monk Fruit	1 day	1 month	3 months	1 month	3 months
5 %	25 ºC	25 ºC	25 ºC	50 ºC	50 ºC
Brix	4.5 %	4.1 %	4.5 %	4.4 %	4.4 %
Sp gr	1.018	1.017	1.018	1.018	1.017
Sp gr pycnometer	1.014	1.014	1.014	1.014	1.013
pH	7.66	6.76	6.80	7.03	7.12
PPM	129	157	121	133	134
Conductivity	258	314	242	266	268
Viscosity cp	0.34	0.39	0.35	0.35	0.34
Viscosity sec	4.59	4.41	4.70	4.67	4.74
Polarization	Zero	Zero	Zero	Zero	Zero

Table 8: Stability studies through physicochemical parameters of developed Syrup (Monk Fruit 10 % w/w)

Monk Fruit	1 day	1month	3 months	1 month	3 months
10 %	25 ºC	25 ºC	25 ºC	50 ºC	50 ºC
Brix	11.8 %	11.7 %	8.9 %	11.5 %	11.5 %
Sp gr	1.045	1.044	1.033	1.045	1.045
Sp gr pycnometer	1.040	1.039	1.036	1.038	1.038
pH	7.4	6.78	6.70	6.42	7.20
PPM	86	134	110	109	94
Conductivity	172	266	220	218	188
Viscosity cp	0.34	0.34	0.41	0.34	0.37
Viscosity sec	5.46	5.30	4.94	5.22	5.63
Polarization	Zero	Zero	Zero	Zero	Zero

Monk Fruit Syrup at Higher Concentrations (20% and 30% w/w):

Supersaturation and Precipitation: When the concentration of Monk fruit sugar exceeds 10% w/w, issues with precipitation or recrystallization arise. This instability indicates that higher concentrations lead to the syrup becoming supersaturated, causing the sugar to precipitate out of the solution.

Initial Physical Stability: Tables 9 show that although physical parameters such as viscosity, pH, and turbidity for 20% and 30% w/w Monk fruit syrups did not change significantly initially, precipitation or recrystallization was observed 15 days post-preparation.

Optical Activity:
Optically Inactive: Monk fruit sugar is optically inactive, meaning it does not rotate plane-polarized light. This property is consistent across all concentrations, with polarization readings remaining at zero.

Table 9: Stability studies through physicochemical parameters of developed Syrup (Monk Fruit 20 % w/w)

Monk Fruit	1 day	1 month	3 months	1 month	3 months
20 %	25 ºC	25 ºC	25 ºC	50 ºC	50 ºC
Brix	16.9 %	16.5 %	17.6 %	17.7 %	17.5 %
Sp gr	1.069	1.067	1.068	1.068	1.068
Sp gr pycnometer	1.061	1.060	1.060	1.060	1.059
pH	7.33	6.65	6.83	7.29	6.68
PPM	69	88	89	77	78
Conductivity	138	176	178	154	156

Viscosity cp	4.40	4.67	4.50	3.48	3.88
Viscosity sec	6.62	6.76	6.64	6.35	6.29
Polarization	Zero	Zero	Zero	Zero	Zero

3. Sucrose

Stability and Physical Properties of Sucrose Syrup:

1. Sucrose Syrup at 66.7% w/w:
Microbiological Stability: Table 10 indicates that sucrose syrup at 66.7% w/w was microbiologically stable. There was no fermentation or bacterial growth observed throughout the study period.

Table 10: Results of Stability Testing of Liquid Oral (Sucrose)

Sucrose	**15 days**	**30 days**	**90 days**	**180 days**
10 %	**Impurity**	**Impurity**	**Impurity**	
30 %	**Impurity**	**Impurity**	**Impurity**	
50 %	**Clear transparent**	**Impurity**	**Impurity**	
66,5 %	**Clear transparent**	**Clear transparent**	**Clear transparent**	**Clear transparent**

Physical Stability: According to Table 11, physical properties such as pH, polarization, specific gravity, viscosity, and Brix did not show any significant changes throughout the study period, indicating physical stability.

Table 11: Stability studies through physicochemical parameters of developed Syrup (Sucrose 66.7% w/w)

Sucrose 66.7 %	**1 day 25 ºC**	**1month 25 ºC**	**3 months 25 ºC**	**1 month 50 ºC**	**3 months 50 ºC**
Brix	67%	67 %	66.5	67 %	66.5 %
Sp gr pycnometer	1.328	1.328	1.329	1.237	1.237
pH	7.44	7.38	6.71	7.50	6.60
PPM	6	6	5	5	4
Conductivity	12	12	10	10	8
Viscosity cp	57.22	142.543	105.64	57.28	44.81
Polarization	+58.5^{o}	+58.5^{o}	+ 58 ^{o}	+58.5 ^{o}	+ 57.5 ^{o}

2. Sucrose Syrup at Lower Concentrations (10%, 30%, and 50% w/w):
Chemical and Microbiological Instability:

pH and Optic Rotation: Over time and at varying temperatures, the pH and optic rotation values of sucrose syrups at 10% w/w (Table 12), 30% w/w (Table 13), and 50% w/w (Table 14) showed significant changes, becoming more acidic. This suggests chemical reactions like hydrolysis or microbial activity.

Microbial Growth: At these concentrations, impurities and microbial growth were observed within 15 days of preparation, indicating microbiological instability.

Table 12: Stability studies through physicochemical parameters of developed Syrup (Sucrose 10% w/w)

Sucrose 10 %	**1 day 25 ºC**	**1 month 25 ºC**	**3 months 25 ºC**	**1 month 50 ºC**	**3 months 50 ºC**
Brix	9.8	9.9 %	9.8 %	9.7 %	10%
Sp gr	1.038	1.038	1.038	1.037	1.038
Sp gr	1.038	1.039	1.038	1.037	1.039
pH	8.03	6.27	4.60	7.0	5.25
PPM	92	95	97	151	141
Conductivity	184	190	194	302	282
Viscosity	0.41	0.41	3.54	0.33	L
Viscosity	4.94	5.60	5.58	4.97	4.96
Polarization	+ 6.6^{o}	+6.6 ^{o}	+ 6.3 ^{o}	+6.6 ^{o}	1.2 ^{o}

Table 13: Stability studies through physicochemical parameters of developed Syrup (Sucrose 30% w/w)

Sucrose 30%	1 day 25 ºC	1 month 25 ºC	3 months 25 ºC	1 month 50 ºC	3 months 50 ºC
Brix	29.4	29.8	29.9 %	29.6 %	30 %
Sp gr	1.114	1.115	1.115	1.115	1.118
Sp gr	1.127	1.129	1.126	1.127	1.113
pH	7.55	4.28	4.29	6.15	3.91
PPM	62	45	52	51	55
Conductivity	126	90	104	102	110
Viscosity	3.8	3.8	4.88	3.8	0.55
Viscosity	8.33	10.73	10.04	8.79	9.60
Polarization	+22º	+22º	+20 º	+ 21.7 º	_- 2 º

Table 14: Stability studies through physicochemical parameters of developed Syrup (Sucrose 50% w/w)

Sucrose 50%	1 day 25 ºC	1 month 25 ºC	3 months 25 ºC	1 month 50 ºC	3 months 50 ºC
Brix	50%	50%	51 %	50 %	51 %
Sp gr pycnometer	1.234	1.235	1.239	1.236	1.237
pH	7.54	6.34	4.80	6.34	4.51
PPM	14	11	9	13	11
Conductivity	28	22	18	26	22
Viscosity cp	9.29	10.95	12.19	8.43	8.40
Viscosity sec	55.60	50.20	48.60	42	43.1
Polarization	+41.6º	+41.2º	+31 º	+40.5 º	+ 24 º

3. Cane Sugar Syrup Stability

Cane Sugar Syrup at 66.7% w/w:

Microbiological Stability: Table 15 confirms that cane sugar syrup at 66.7% w/w was microbiologically stable with no microbial contamination observed.

Table 15: Results of Stability Testing of Liquid Oral (Cane Sugar)

Cane Sugar	15 days	30 days	90 days	180 days
10 %	**Turbid**	**Cloudy Turbid Fermented**	**Fermented bad odor Gas**	
30 %	**Turbid**	**Turbid Impurities**	**Turbid bad odorGas**	
50 %	**Clear Solution**	**Impurities**	**Impurities gas**	
66.5 %	**Clear Solution**	**Clear Solution**	**Clear Solution**	**Clear Solution**

Physical Stability: There were no significant changes in physical parameters such as pH, polarization, specific gravity, and viscosity throughout the study Table 16.

Table 16: Stability studies through physicochemical parameters of developed Syrup (Cane Sugar 66.7% w/w)

Cane sugar 66.7 %	1 day 25 ºC	1month 25 ºC	3 months 25 ºC	1 month 50 ºC	3 months 50 ºC
Brix	66 %	66.5 %	66.5 %	66.5 %	66.5 %
Sp gr pycnometer	1.328	1.329	1.331	1.329	1.328
pH	6.34	6.20	5.95	5.90	5.73
PPM	14	16	13	17	14
Conductivity	28	32	26	34	28
Viscosity cp	139.89	114.60	82.73	117.82	45.61
Polarization	+57 º	+58º	+ 57 º	+57.7º	+ 57º

Cane Sugar Syrup at Lower Concentrations (10%, 30%, and 50% w/w):

- **Instability:** Tables 17, 18, and 19 show that cane sugar syrups at these concentrations underwent fermentation and became cloudy.
- **Contributing Factors**: The presence of impurities and a lower degree of saturation compared to pure sucrose syrups likely contributed to this instability.
- **Conclusion**: Cane sugar syrups at concentrations of 10%, 30%, and 50% w/w are microbiologically unstable and physically unstable, as indicated by fermentation and

Table 17: Stability studies through physicochemical parameters of developed Syrup (Cane Sugar 10% w/w)

Cane sugar 10 %	1 day 25 ºC	1month 25 ºC	3 months 25 ºC	1 month 50 ºC	3 months 50 ºC
Brix	9.9%	10 %	10 %	10 %	10 %
Sp gr	1.038	1.038	1.039	1.038	1.038
Sp gr pycnometer	1.04	1.039	1.039	1.039	1.039
pH	7.10	4.06	4.02	5.54	5.70
PPM	193	200	193	186	181
Conductivity	386	402	386	372	362
Viscosity cp	0.35	0.46	0.36	0.34	0.35
Viscosity sec	5.34	5.59	5.82	5,52	5.32
Polarization	+ 7.9º	7.4º	-1.2º	+7.6 º	+ 4.8 º

Table 18: Stability studies through physicochemical parameters of developed Syrup (Cane Sugar 30% w/w)

Cane sugar 30 %	1 day 25 ºC	1month 25 ºC	3 months 25 ºC	1 month 50 ºC	3 months 50 ºC
Brix	30 %	29.8 %	30 %	29.9%	30.6 %
Sp gr	1.116	1.116	1.116	1.115	1.119
Sp gr pycnometer	1.129	1.127	1.128	1.132	1.132
pH	6.96	4.17	4.59	4.33	4.51
PPM	158	184	151	176	176
Conductivity	323	366	304	352	352
Viscosity cp	3.62	3.86	7.27	3.89	0.42
Viscosity sec	10.20	10.19	10.20	10.72	9.83
Polarization	+22.6 º	+11.6 º	+11.4º	+11.5º	-2.5 º

Table 19: Stability studies through physicochemical parameters of developed Syrup (Cane Sugar 50% w/w)

Cane sugar 50 %	1 day 25 ºC	1month 25 ºC	3 months 25 ºC	1 month 50 ºC	3 months 50 ºC
Brix	51%	51 %	51.5 %	51 %	52.5%
Sp gr pycnometer	1.239	1.238	1.241	1.240	1.243
pH	6.18	5.14	5.25	5.38	5.35
PPM	85	77	63	66	62
Conductivity	170	154	126	132	124
Viscosity cp	10.42	13.08	14.17	13.18	5.74
Viscosity sec	45.64	43.67	50.88	40	42.51
Polarization	+ 44º	+37.3º	+ 12.5 º	+ 35 º	NA

4. Fructose Syrup Stability

Fructose Syrup at 50% w/w: Table 20 indicates that fructose syrup at 50% w/w was microbiologically stable, with no signs of fermentation or bacterial growth.

Table 20: Results of Stability Testing of Liquid Oral (Fructose)

Fructose	15 days	30 days	90 days	180 days
10 %	**Clear Solution**	**Impurity**	**Impurity**	
30 %	**Clear Solution**	**Impurity**	**Impurity**	
50 %	**Clear Solution**	**Clear Solution**	**Clear Solution**	**Clear Solution**

Table 21 shows that the physical properties of fructose syrup at 50% w/w, including pH, polarization, specific gravity, and Brix, remained unchanged throughout the study period.

Table 21: studies through physicochemical parameters of developed Syrup (Fructose 50% w/w)

Fructose 50 %	**1 day 25 ºC**	**1month 25 ºC**	**3 months 25 ºC**	**1 month 50 ºC**	**3 months 50 ºC**
Brix	48.5 %	49.5 %	49 %	49 %	49.5 %
Sp gr pycnometer	1.229	1.230	1.233	1.229	1.229
pH	6.85	5.86	4.74	4.26	3.86
PPM	10	9	8	12	16
Conductivity	20	18	16	24	32
Viscosity cp	7.72	9.10	8.58	8.90	5.32
Viscosity sec	33.74	33.10	25.68	29.82	30.47
Polarization	-60º	-61º	-60º	-60.1º	- 59.5 º

Fructose Syrups at Lower Concentrations (10% and 30%w/w)

Instability: Tables 22, and 23 show that fructose syrups at these concentrations show that these syrup are unstable and underwent fermentation.

Table 22: Stability studies through physicochemical parameters of developed Syrup (Fructose 10% w/w)

Fructose 10 %	**1 day 25 ºC**	**1month 25 ºC**	**3 months 25 ºC**	**1 month 50 ºC**	**3 months 50 ºC**
Brix	9.9 %	9.9 %	9.9 %	9,9 %	9.9 %
Sp gr	1.038	1.038	1.038	1.038	1.038
Sp gr pycnometer	1.038	1.040	1.040	1.039	1.040
pH	7.68	6.01	5.87	4.25	4.02
PPM	81	89	97	95	134
Conductivity	162	178	194	190	286
Viscosity cp	0.36	0.38	0.42	0.33	0.39
Viscosity sec	6.50	5.55	4.90	5.05	5.77
Polarization	-11º	-10º	-10º	-10º	- 10 º

Table 23: Stability studies through physicochemical parameters of developed Syrup (Fructose 30% w/w)

Fructose 30 %	**1 day 25 ºC**	**1month 25 ºC**	**3 months 25 ºC**	**1 month 50 ºC**	**3 months 50 ºC**
Brix	29.6 %	27 %	25 %	29 %	29.4 %
Sp gr	1.114	1.114	1.113	1.113	1.113
Sp gr pycnometer	1.130	1.129	1.128	1.128	1.128
pH	5.50	5.61	5.15	4.45	3.85
PPM	47	41	45	44	74
Conductivity	97	82	90	88	148
Viscosity cp	3.6	4.12	4.40	4.63	0.48
Viscosity sec	8.7	9.91	8.70	8.86	9.04
Polarization	-32.7º	-32º	-22º	-22º	- 22 º

5. Honey syrup

Tables 24 show that honey syrups did not maintain their stability, exhibiting rapid degradation and fermentation.

Table 24: Results of Stability Testing of Liquid Oral (Honey)

Honey	**15 days**	**30 days**	**90 days**
10 %	**Turbid**	**Bad odor Gas**	**Bad odor Gas**
30 %	**Turbid**	**Bad odor Gas**	**Bad odor Gas**
50 %	**Turbid**	**Bad odor Gas**	**Bad odor Gas**
66.5 %	**Clear Solution**	**Clear Solution**	**Bad odor Gas**

4- CONCLUSION:

From the analysis of the above results of various syrups, the following conclusion were drawn:

1% w/w stevia Concentration is the most stable preparation, both microbiologically and physically, without any preservatives, making it suitable for long-term storage at room temperature. The absence of sedimentation or precipitation further supports its stability.

Higher Concentrations (2% and 5% w/w): Although the physical parameters did not show significant changes, the occurrence of precipitation or recrystallization within 15 days indicates that these concentrations are less stable. The supersaturation leads to instability in the form of sedimentation.
In summary, stevia syrup at a concentration of 1% w/w is recommended for stable long-term storage, as it maintains its physical and microbiological integrity without preservatives. Higher concentrations (2% and 5% w/w) face stability issues due to supersaturation, resulting in precipitation or recrystallization shortly after preparation.
Monk Fruit Syrup at 5% and 10% w/w: Syrups with 5% and 10% w/w Monk fruit sugar are stable both microbiologically and physically over the study period, making them suitable for long-term storage. These concentrations did not show significant changes in viscosity, pH, and turbidity, indicating their suitability for various applications without stability concerns.

Monk Fruit Syrup at Higher Concentrations (20% and 30% w/w):

Stability Issues: Concentrations above 10% w/w lead to supersaturation, resulting in precipitation or recrystallization within 15 days. This makes higher concentrations less suitable for applications requiring stable syrup solutions.

For Stable Sucrose syrup 66.7 % w/w, Cane sugar syrup 66.7 % w/w and fructose Syrup 50% w/w Preparations are all microbiological and physical stability over time. These concentrations effectively prevents microbial growth and maintains the syrup's physical properties.

Sucrose and cane sugar syrups at 10%, 30%, and 50% w/w and fructose syrup at 10 % and 30 % are not recommended for long-term stability due to their susceptibility to microbial contamination and significant physical and chemical changes.

All honey syrups prepared at concentrations of 10%, 30%, 50%, and 66.7% w/w degraded and fermented quickly. This indicates that honey syrups at these concentrations were microbiologically unstable.

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دراسة مقارنة حول تصميم وتطوير وصياغة المشروبات باستخدام المحليات غير الغذائية وغير السكرية

الخلاصة

الهدف من هذا البحث هو تحضير وتطوير وتصميم شراب بسيط مستقر وغير علاجي يعتمد على المحليات غير الغذائية وغير الجليكوجينية (الغير سكرية) مثل سكر الستيفيا وسكر فاكهة المونك و مقارنة هذا الشراب مع شراب السكروز و الفركتوز.

بالاضافة الى سكر الستيفيا ، و سكر فاكهة المونك فقد استخدم السكروز ، والفركتوز ، وسكر القصب ، والعسل لتحضير الشراب البسيطة المستقرة لغرض المقارنة.

تم تحضير الشراب بطريقة المحلول البسيط بمساعدة الحرارة. باذابة المادة المحلية في ماء نقي مع تقليب مستمر.

ثم تم تقييم الشراب المحضر وفق المعايير التالية: الصفات الفيزياوية (اللون ، الرائحة ، والطعم) ، درجة الحموضة معامل الانكسار، التوصيلية ، الاستقطاب ، الوزن النوعي ، اللزوجة ، والدراسات الميكروبيولوجية.

أظهرت الدراسة أن الشراب المحضر من المحليات غير الغذائية مثل الستيفيا 1٪ وزن / وزن وفاكهة مونك 5٪ وزن / وزن و 10٪ وزن / وزن مستقرة من حيث معايير التقييم والاختبارات التي تم إجراؤها. خلال 6 أشهر من الدراسة في درجة حرارة الغرفة و درجة 50 مؤية ، حيث لم يطرا أي تغير في اللون أوترسب المواد المحلية أو إعادة بلورة أو نمو لأي نوع من الكائنات الحية الدقيقة.

يمكن استخدام الستيفيا 1٪ وزن / وزن وسكر فاكهة المونك 5٪ و 10٪ وزن / وزن لإعداد شراب بسيط ثابت كما هو عند استخدام السكروز 66.7٪ وزن / وزن الشراب الثابت بيولوجيا و فيزيائيا.