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Review Paper

Production technology and quality characteristics of mead and fruit-honey wines : A review

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Abstract

Mead is perhaps the oldest fermented drink in the world, yet it is difficult to find it commercially. A brief review of the history of mead, its value as a health tonic and technology of mead production has been given in the present paper. Fermentation of honey can be used to produce different varieties of mead, sherry, sparkling wine and fruit-honey wines and it may have different flavours depending upon floral source of honey, additives and type of yeast used in the fermentation. Honey which is the raw material to produce mead shows lot of variations in colour and composition which are likely to affect the end product (mead) produced. Composition of honey from different floral sources has also been described. One of the unique characters of honey is that it contains many minor constituents which are responsible for antioxidant activity of mead. Information on physical, chemical, microbiological and sensory evaluation of mead and honey wines prepared by using fruit juices has also been summarised.

Keywords: Mead, Honey fermentation, Fruit-honey wine, Sensory evaluation, Yeasts, Additives

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Introduction

Mead is an alcoholic beverage made from honey. It is the oldest and easily made fermented drink in the world. It is nutritious, containing many elements required by an organism and has an excellent effect on digestion and metabolism[1]. It has also been found good for those suffering from anaemia and chronic diseases of gastro-intestinal tract. Honey the raw material for preparation of mead is converted enzymatically to reducing sugars and removing excess moisture. Honey contains about 80 different substances but 95 to 99% of the total solids are sugars. The colour, flavour and aroma are important quality characteristics of honey from consumer's point of view. Moreover, the quality of honey varies with the source of nectar. The composition of honey even from the same floral source varies from year to year and region to region due to climatic and geographical factors[2].

Available archaeological evidence for production of mead dates back to 7000 BC. Pottery vessels containing mixture of mead, rice and other fruits with organic compounds of fermentation have been found in northern China. First known description of mead is found in the Rigveda dating back to 1700-1100 BC[3]. In Celtic mythology, mead was considered a drink of nobles and gods providing immortality, knowledge and gift of poetry[4].

Plate 1: Different types of honey (a. Completely granulated honey; b-c. Liquid honey of different colours; d. Partly granulated and liquid honey)

Though mead is the oldest fermented product being used by man yet it is difficult to find it commercially. Considerable information is available on methods of producing mead[1, 3, 5-12] and attempt has been made to give an overview of the same.

Technology of mead preparation

Preparation of an alcoholic beverage is dependent on several factors such as raw materials, microorganisms, additives, vinification practices, maturation procedure, etc. The alcoholic content of mead can vary between 7-22 per cent. By varying proportion of honey and water and point where fermentation is stopped, different types of meads can be prepared. The mead can be dry and light similar to traditional wine from grape or sweet and heavy-bodied desert wine and if fermentation is left to

continue while bottled, sparkling mead resembling sparkling white wine can also be produced[7].

Raw materials used in preparation of mead

***Honey*:** Depending on the floral source, honey can be mono-floral i.e. honey produced from nectar of one predominant plant species or multi- floral (made from nectar of different plant species). The honey quality is judged from its colour, aroma and flavour. Colour is one of the most important characteristics that contribute to appearance of honey. It has been classified under seven colours which can be determined by colorimetric method[13]. These colours are, water white, extra white, white, extra light amber, light amber, amber and dark amber (optical density at 560nm varying between 0.0945 to over 3.008).

On the basis of colour, light honey of creamy fawn colour is generally preferred to make mead as dark honey having strong flavour yields unpleasant mead[6]. Colour and some other characteristics of honey are also affected by the heat treatments given to it and its storage conditions[14-18]. Honey consists mainly of sugars and second major component is moisture (17.2 %). Third main component of honey which influences its properties is protein but its concentration is very low[19, 20]. Composition of honey from different floral sources[21, 22] is summarized in Table 1. Honey is a supersaturated solution with respect to dextrose and returns to stable condition by crystallizing excessive glucose at low temperature resulting in honey granulation or crystallization (Plate1). Granulation can be complete (Plate 1a) or partial (Plate 1d). Granulated honey needs to be liquefied by heating at 60°C, before making must for mead.

Differences have also been observed when honeys from different sources were used in preparation of mead. Mixed floral honey produced mead of higher final alcohol content than from ***Eucalyptus ochrophloia* F. Muell.** particularly when fermented by mead yeast[23]. Light honey from clover was, however, more difficult to ferment and required more additives in the form of vitamins, minerals and nitrogen as compared to dark honey from buckwheat or goldenrod. It was interesting to note that even all batches of clover honey did not react in a similar way. Some batches permitted very slow fermentation whereas in others there was almost no fermentation without addition of supplementary growth factors. Nevertheless, it was possible to ferment all types of honey tested by adding growth factors[24]. Honey produced even from buckwheat in two different years from two different places produced mead with different characteristics due to climatic and geographical factors on source material[2, 25].

Addition of honey to fresh apple juice helped in juice clarification and this property is related to protein-phenolic compound interactions and the compounds which are responsible for clarifying of apple juice have characteristics similar to gelatine. Gelatine when added to hazy juice entraps the particles and coagulates them[26-29]. Keeping in view the property of clarifying juice and sugars as major constituent, honey has been used in apple wine making[30]. The lightly flavoured fruity honeys produce apple wines as clear as those made by using sugar. But the overall sensory quality of honey-treated apple wine is higher than that of conventionally prepared apple wines with sugar. The protein in honey is responsible for clarifying apple juice has been reported to originate from honey

Table 1 : Composition of major uni-floral honeys in India[22]

	Moisture (%)	Total dissolved solids (%)	Total reducing sugars (%)	Non-reducing sugars (%)	Acidity (%
Litchi	19.25	80.75	76.37	0.02	0
Jamun	18.25	81.75	74.69	3.14	0.162
Mustard	21.5	78.5	74.70	1.44	0.070
Eucalyptus	21.75	78.25	72.06	2.04	0.102
Rubber	24.75	75.25	70.84	1.84	0.085
Neem	27	73	68.68	3.02	0.106
Coriander	20.75	79.25	73.80	2.09	0.094
Tamarind	21.5	78.5	75.44	2.02	0.08
Soapnut	19.25	80.75	75.20	2.42	0.14
Cardamom	21.5	78.50	76	0.14	0.12
Sunflower	18	81.40	80	0.60	0.09
Clover	17	83	78.14	2.34	0.07
Khesari	17.5	82.5	78.80	1.42	0.18

bees and not from plant nectaries from where the bees collect nectar[31].

Honey also contains many minor constituents which are responsible for antioxidant property. It also has alpha-tocopherol, ascorbic acid, beta-carotene, catalase and peroxidase which act as antioxidant under some conditions[1, 32-34]. Polyphenolic compounds, peptides, organic acids, enzymes, vitamins and Maillard's reaction products responsible for antioxidant property of honey have also been listed. Phenolic profile of honey also varies with floral source[25]. Antioxidant capacity of honey from 14 different floral sources has been determined by spectrophotometric assay[35] and it has been reported that highest concentration of antioxidants was 20.3 times that of the lowest indicating the extent of variations in honey from different sources (Table 2). The antioxidant content was found positively correlated with both moisture contents and colour of honey. Honey is also known to have anti-inflammatory and antibacterial properties and has been used as natural food preservative[36-37]. Due to all these special properties of honey it has been hypothesized that mead will also have this antioxidant quality. Studies conducted on heat treatment in mead production have revealed that drastic heat treatment have potential to alter the antioxidant capacity of mead by changing phenolic profiles[25]. Antioxidant levels in honey is quite low as compared to traditional dietary sources like fruits, vegetables and tea and may not serve as a major source of dietary antioxidants yet it has the potential for honey to play an important role in providing antioxidant in highly palatable form[35]. Mead can be one such product incorporating this property and antioxidant capacity of honey may be extended through fermentation into mead[25].

***Other additives*:** Fruit juices, salts and acids have been used as additives to stimulate fermentation and improve flavour[38]. In general, honey drinks lack body and are too sweet. Fruit juices can be added to contribute acid and growth factors for yeast fermentation. Addition of potassium tartrate and ammonium phosphate (0.04%) to diluted honey produced a bland alcoholic drink in about 6 weeks. In another experiment, addition of ammonium chloride, potassium bicarbonate and sodium phosphate in concentrations of 0.04 to 0.08% could produce mead in about 4 weeks. Rate of fermentation varies with different nutritive salts used. Addition of 0.2% cream of tartar, 0.1% ammonium phosphate, 0.5% citric acid, 0.025% magnesium chloride and 0.025% calcium chloride resulted in fermentation producing 12-13% alcohol in about 25 days[39]. Honey although contains fermentable sugars, but it is deficient in nitrogen, minerals and growth factors that stimulate yeast growth and fermentation. These problems can be overcome by adding 250 mg diammonium phosphate and potassium bitartarate 250mg/l. For adjusting acidity, 1.875g of tartaric acid or 1.750g/l of citric acid are added[40]. Citric acid has been reported to provide better flavour but tartaric acid has been recommended as it is less easily metabolized by undesirable lactic acid bacteria. To prevent growth of lactic bacteria, 25 to 50 mg sulphurous anhydride or potassium metabisulphite 50 to 100mg/l can be added.

Two groups of additives in mead preparation have been tested[24]. Formula I contained inorganic salts and citric acid whereas formula II contained a wide spectrum of vitamins and small amounts of both organic and inorganic nitrogen stimulatory to yeast growth (Table 3). It was observed that fermentability level varied with floral source and additives. The addition of both I and II formulae resulted in rapid fermentation of clover honey base using yeast 618. This indicates the significance of additives in quality mead production.

Table 2: Water content (%) and antioxidant content of different unifloral honey[35]

Honey	% water	Antioxidant content ($\times 10^{-5}$ µg)
Sage	14.2	21.3
Mesquite	15.0	28.9
Fireweed	16.0	31.2
Soyabean	18.6	45.2
Clover	14.2	50.7
Sweet clover	14.2	52.7
Christmas berry	17.2	147.0
Sunflower	16.6	169.7
Buckwheat	18.4	432.0

Microbiology of mead fermentation

Selection of yeast type for fermentation process is an important aspect as it affects flavour and other quality parameters of the mead. There are several strains, some of the best yeasts for this purpose are Maury and Vierke yeasts[7]. Immobilized whole cells of

Table 3 : Composition of growth stimulants in formula 1 and 2 used for mead preparation[24]

Formula 1		Formula 2	
Constituents	**Quantity* (g)**	**Constituents**	**Quantity** (g)**
Ammonium sulphate	1.0	Biotin	0.05
Potassium phosphate	0.5	Pyridoxine	1.0
Magnesium chloride	0.2	Meso-inositol	7.5
Sodium hydrogen sulphate	0.05	Calcium pentothenate	10.0
Citric acid	5.0	Thiamine	20.0
		Peptone (Roche)	100.0
		Ammonium sulphate	861.45
Total	**6.75**	**Total**	**1000.00**

*To be added in each litre of dilute honey base;
**To be added in 0.25g/l of dilute honey base

Saccharomyces cerevisiae for mead production have also been tried. For this purpose, a strain with high sugar and alcohol tolerance and quick fermentation ability was grown and then the cells were immobilized by mixing with sodium alginate and activated charcoal to produce slurry and extruded in 0.15M $CaCl_2$. Diluted honey mashes were then used in continuous reactor and stationary cultures under different fermentation conditions. The continuous alcohol production was stable at *p*H 2.5-6 and 18-30°C temperature. This process reduced problems of contamination and secondary fermentation associated with traditional mead production[41]. There is variation in the mead prepared using wine yeast or mead yeast. Fermentation with wine yeast proceeded faster and gave higher alcohol and lower residual sugar concentrations than fermentation with mead yeast at 20 or 30°C. Time of fermentation was same at both temperatures but at 30°C the chemical reaction proceeded more rapidly in the earlier stages of fermentation[23].

Samples of naturally fermenting honey from different floral sources have been analysed for different strains of yeast[42]. Physical properties and chemical composition of fermented honey did not differ from those of non-fermenting honey except for high water content in the former. Twenty strains of yeast were isolated from honey and all were identified as *Zygosaccharomyces rouxii* (or its imperfect form). Morphological and physiological properties of the strains were similar, as were some of their fermentation properties.

Strains of *Zymomonas mobilis* have been used in Brazil to produce ethanol from sugarcane-derived materials[43]. Contamination can be minimized by adding Bactol Q. Cells of *Z. mobilis* are smaller than *S. cerevisiae* and centrifugation of the former is more difficult and, therefore, it has been advised to use flocculent strains. *Z. mobilis* competes advantageously with yeast on glucose substrate. In comparison to *Z. mobilis* Ag11 and 3 yeast strains, *Z. mobilis* T2 was judged to promote better mead from dark honey originating from sugarcane exudates. Characteristics of fermentation yeast isolated from traditional Ethiopian honey wine, locally known as *ogol* have also been studied[44]. A strain of fermentation yeast designated as ET99 with globose or sub-globose cells was isolated from *ogol*. This strain was identified as belonging to the genus *Saccharomyces* and closely resembled *S. cerevisiae*. Another yeast strain was also isolated from *ogol* and identified as *Pichia membranifaciens*, but this yeast strain did not show any fermentation ability. *P. membranifaciens* is well known as pellicle-forming yeast and is often isolated from various alcoholic beverages and spoiled foods. Mead made by using *S. cerevisiae* ET99 contained 16.5 % ethanol. Higher amount of propan-1-ol (43mg/l) was found in honey wine than in those made with wine yeast W4 and sake yeast K7. The aroma characteristics of mead from yeast ET99 were acceptable as determined by sensory evaluation[44].

Yeasts vary in their ability to ferment honey. Among the different strains tested, strain Steinberg 618 gave rapid fermentation and the mead had higher alcohol content with fine flavour and gave better than average stability on storage. Some of the yeast though produced rapid fermentation but there was problem of haze and the resulting mead was difficult to clarify and stabilize. Yeast 605 was close to strain 618 but yeast 223 which is excellent for grape juice fermentation and champagnes did not yield as high alcohol content as 618 in honey fermentation[24].

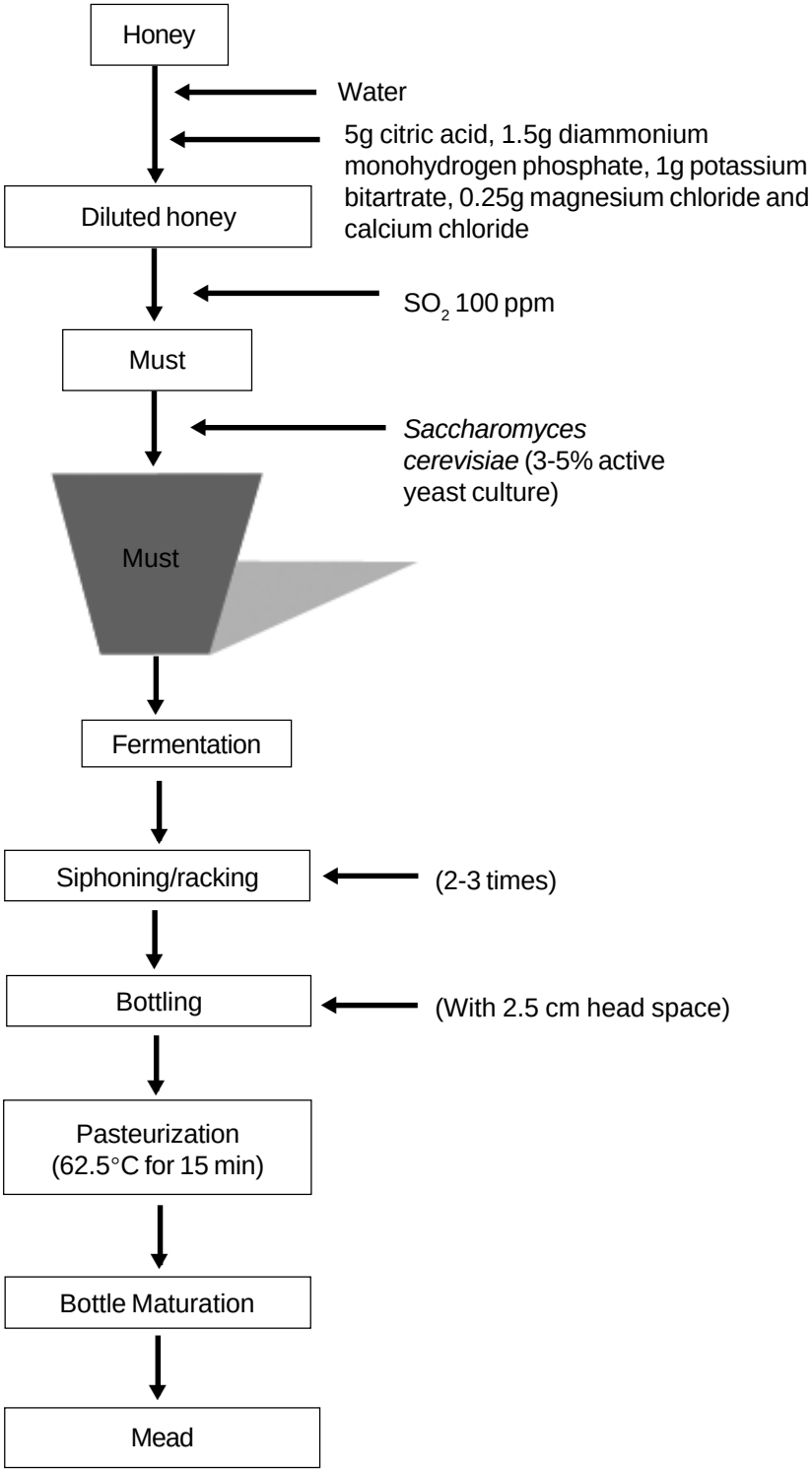

Fig. 1 : Flow sheet of different unit operations in production of mead

Preparation of mead

Basic method

For preparation of mead, honey is diluted with water to make a concentration of 22 °Brix[6]. To each litre of this diluted honey solution additives are incorporated. These includes; 5g citric acid, 1.5g diammonium monohydrogen, 1g potassium bitartarate, 0.25g magnesium chloride and calcium chloride along with 100 ppm SO_2. For starting fermentation process, 3 to 5% active yeast culture is added. The fermentation process is continued till TSS gets stabilized. The mead is then siphoned, matured and bottled (Fig. 1).

Variations in method

Different types of honey with different ingredients have been used to prepare meads[1]. For preparing must or wort either comb honey (honey sealed in the combs by bees) or extracted honey can be used. To make mead from comb honey, the combs are immersed in simmering water. Wax on heating will float and it is skimmed-off. If extracted honey is used then, the scum formed during boiling is skimmed. For preparing must, honey is diluted with six parts of water and required spices are added. Honey without any heat treatment produced more aromatic and tasty mead but such mead has tendency to sour quickly as compared to that prepared from boiled honey. The must for heated honey mead is boiled for 2 to 4h, is strained and allowed to ferment. White foam appears on the surface with initiation of fermentation process but it disappears when fermentation process is complete. Mead should be matured at a temperature below 12°C and final stage of fermentation

should be done at 2-4°C. On completion of fermentation, the mead is strained through muslin cloth. Mature mead is bottled and is allowed to stand for two more weeks before drinking. Based on the composition and additives following different types of meads have been labelled[1]:

***Latvian mead*:** 5 l water, 800g honey, 25g yeast and juice of two lemons.

Lemon mead: 2kg honey, 100g hops, juice of 6-8 lemons, 100g yeast, 3g isinglass, 12 l water.

***Red mead*:** 4kg honey, 25 l water, 100g hops, 6g Orris root, 1 tablespoon burnt sugar, 2-3 grains of cardamom and for preparing white mead, burnt sugar is not added.

Russian mead: 4kg honey, 15 l water, 200g yeast, 200g hops.

Tatar mead: 2.5kg honey, 8 l boiled water, 100g yeast.

Varieties of mead

Meads can have a lot of flavours depending on the source of honey and additives (adjuncts or gruit), type of yeast used in fermentation and ageing procedure. Different terminology has been used[3, 7-12] for the mead prepared by using honey with fruit juices, spices, herbs, etc.– Metheglin (mead which contains spices or herbs); Melomel (mead containing fruit juices); Cyser (mead with apple juice); Pyment (mead with grape juice); Hippocras (pyment with herbs and spices); Meade (it is not mead but white wine with added honey). Other varieties of meads are: Sack mead (mead made with more copious amount of honey than usual. The finished product retains elevated level of sweetness), Rhodomel (made from honey and rose petals).

Pilot-plant procedure for production of clover honey mead

Based on laboratory studies, a pilot-plant procedure has also been developed for production of clover honey mead[24] and is described here.

***Procedure for preparing dry mead*:** Liquid clover honey is diluted with water to 21% solids. In case of granulated honey, it is first heated at 60-65°C to liquefy and then diluted. Different nutrients are added in each gallon (about 4.5 l) of diluted honey, viz. citric acid (18.9g), ammonium sulphate (4.65g), potassium phosphate (1.9g), magnesium chloride (0.7g), peptone (0.1g), sodium hydrogen sulphate (0.2g), thiamine (20mg), calcium pantothenate (10mg), inositol (7.5mg), pyridoxine (1mg) and biotin (0.05 mg).

The *p*H of the solution is adjusted to 3.7-4.0 with sodium hydroxide or hydrochloric acid. On cooling the contents to 27°C, 40 gallons (about 180 l) of solution is placed in 55 gallon (about 247 l) barrel and inoculated with 0.5 % (v/v) of actively growing culture of yeast 618 and the container is sealed with a bubbler. The fermentation is carried at 18°C and mead is allowed to age for 6 months. After ageing it is decanted and filtered through Celite 503 and acidity adjusted to 0.6% with citric or tartaric acid. The mead is then pasteurized at 63°C for 5 min and bottled while hot. This process yielded dry mead with alcoholic content of 12 % (v/v).

***Procedure for preparing mead champagne*:** For this purpose, clover honey is diluted to 18-19% solids. Formulae I and II (Table 3) are added to the diluted honey. This yielded mead (cuvee) with alcoholic content of 10%. Sucrose (2% by weight) was added to cuvee with yeast nutrients per gallon (about 4.5 l), viz. peptone 0.1g, thiamine 20 mg, calcium pantothenate 10 mg, inositol 7.5 mg, ammonium sulphate 0.86 mg, pyridoxine 1.0 mg and biotin 0.5 mg.

The cuvee was inoculated with 7 % yeast made of equal quantities of yeast 223 which is champagne yeast and yeast 618 which is adapted to honey fermentation. It is bottled in champagne bottles sealed with metal caps and incubated at 18°C. In 20 days, the alcohol contents increased to 11.9 % and carbon dioxide pressure to 4.6 atmospheres (at room temperature). This mead had a pleasant flavour and retained its carbonation very well. There was more tendencies to form a head than found in grape champagnes.

***Sherry production from mead*:** Clover honey mead can be made into a light sherry by re-fermenting it with flor sherry yeast, *S. oviformis* (strain 31). The acetaldehyde content was raised by passing the mead through glass column filled with ceramic tile pieces inoculated with yeast from 48 to 190mg/l in 48h. Sherry produced from mead was preferred by many tasters to the original mead. Due to low acidity, mead offers good base for production of sherry.

Production of honey-fruit wine

Fruit pulps/juices of apple, apricot, peach, plum, grapes, black berry, raspberry, black cherries, red currants, black currants and gooseberries have been

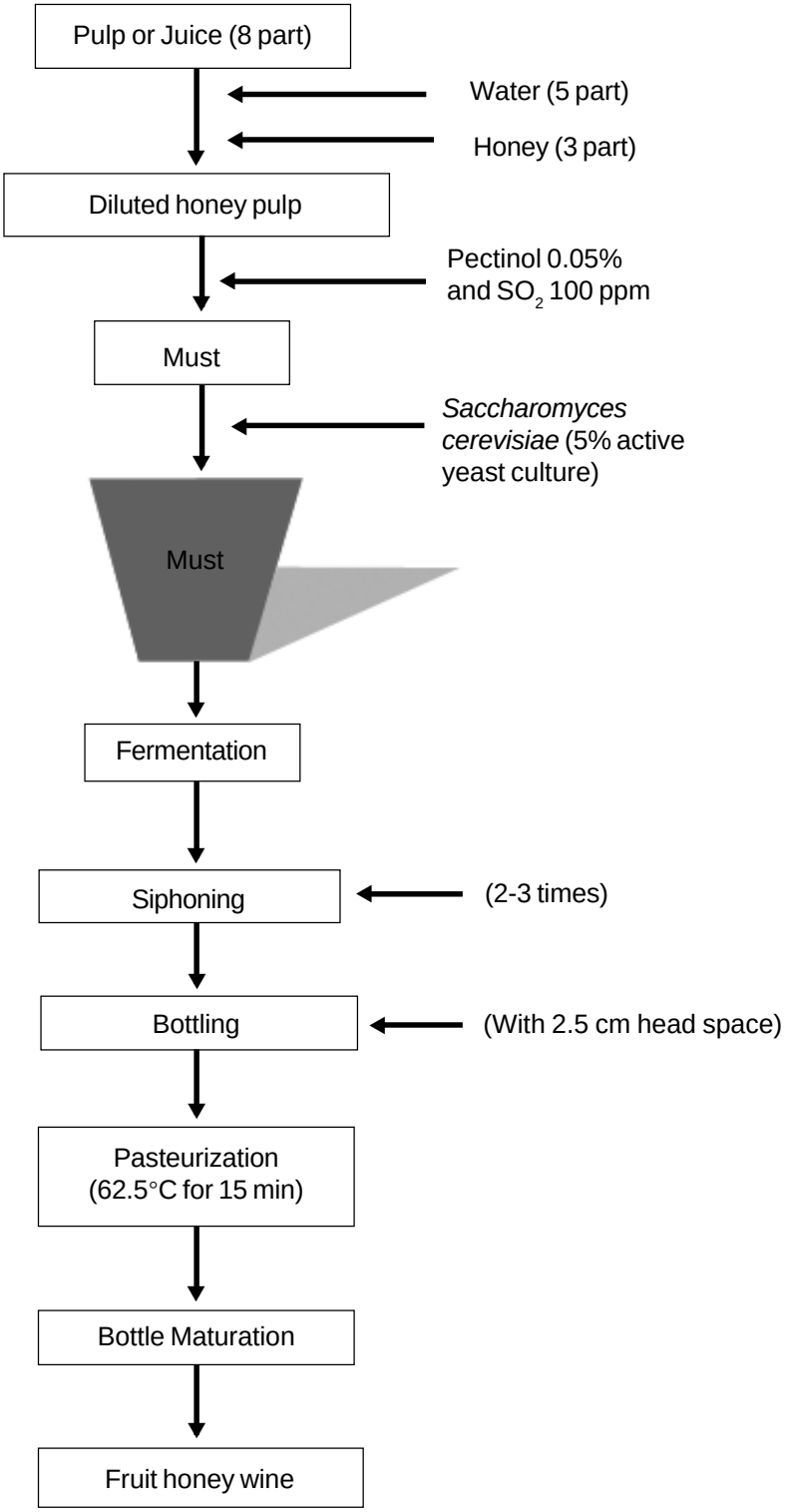

Fig. 2: Flow sheet of different unit operations in production of fruit-honey wine

used and added to must for preparation of mead. For preparing fruit-honey wine, a constant blending ratio of 8:5:3 for pulp/juice, water and honey has been tried[45]. Procedure involved is given in Fig. 2.

Quality characteristics of mead

Quality of mead depends on the source of honey, yeast and additives used. Heating of honey during must preparation has influenced the aroma and taste of the mead. Preheated and unheated dilute experimental honey solution fermented with inoculated yeast for 21 days at 25-26°C produced mead acceptable to sensory assessor. But the product made from the preheated honey preserved better than unheated one after storage for two months at ambient temperatures (24-32°C). However, for extended shelf-life of product subsequent secondary decantation or filtration and proper airtight bottling of mead prepared from cassava honey[46] is needed. The adverse effect of heating the diluted honey is the production of undesirable flavour that develops in the resulting mead[47]. Long heating induced a darkening of the honey and was darker than those receiving short time or no heating. After fermentation, all three meads were lighter in colour than those before fermentation due to sedimentation but the mead made from long heated method was still much darker than the others. The *p*H, acidity and residual sugar contents of these types of mead were, however, almost the same. Sensory tests indicated that mead with no heat was lighter than others but the panel members noticed an acidic taste with a veggie and hay-like flavour and highest score was awarded to mead samples that received

short heat treatment in the form of flash heating. There was no undesirable flavour due to heat treatment except for a slight harshness which can be eliminated by ageing. Mead made by conventional method with long heat time was darker in colour, showing strong harshness and off taste which has been described as rubbery and resin like taste.

Heating of honey is required for pasteurization and to precipitate proteins and other compounds causing haze but it produced undesirable flavours and, therefore, attempts have been made to develop technique that does not require heating of honey solution. For this purpose ultra-filter, using a 10K molecular weight cut-off has been used to remove high molecular compounds. After filtering mead produced from the filtered honey solution was smooth, clean and good in flavour with no undesirable after taste typical of heated method. Comparison has been made between the meads prepared from clover honey using conventional method, flash heating method and ultra filtration with molecular cut-off of 50K[48]. Ultra-filtered (UF) mead was clear immediately after fermentation requiring no long clarification and stabilization period as required by conventional mead. Sensory tests (Table 4) showed UF-treated mead to be superior to mead made by conventional method. Moreover, UF-treated mead does not require a long storage. Analysis of volatile aroma components of mead prepared from honey of different floral sources (buckwheat and soyabean) is also available[25] (Table 5).

Fermenting behaviour of honey solution varies to a great extent depending on the floral source from where bees have collected nectar. On the basis of sensory evaluation panel members described apple wine made with clover-locust and orange blossom honeys as pleasant and desirable fruity wines with regards to flavour and aroma as compared to that made using sugar. However, no honey flavour was noticed in the wines prepared. The wine made from buckwheat honey had a strong and distinctive odour and flavour of buckwheat and wine made from this source was ranked poorly[30] (Table 6a & 6b). Thus, it is important to select honey from appropriate floral source to make quality mead.

Table 4 : Effect of heat treatment on characteristics of clover mead[48]

Treatment	*p*H	Total acidity (%)	Alcohol (%)	Flavour description	"Good" rating
Conventional mead	2.9	0.48	11.9	Harsh, resin-like taste	10%
Flash heated mead	2.9	0.51	11.4	Slightly harsh	50%
50K-UF-mead	2.9	0.49	12.3	Clean, smooth	90%

Table 5 : Volatile aroma components in buckwheat and soya mead[25]

Compound	Odour property	Buckwheat mead (µg/l)	Soya mead (µg/l)
Ethyl-butanoate	Fruity, bubble gum	978.6	619.8
Ethyl 2-methyl-butanoate	Fruity, berry	264.2	69.87
Ethyl 3-methyl-butanoate	Fruity, blueberry	84.48	Not detected
Isoamyl acetate	Fruity, banana	532.7	277.4
Ethyl hexanoate	Fruity, apple	306.5	373.2
Ethyl octanoate	Fruity	350.4	360.5
Ethyl decanoate	Sweet, nutty	121.2	114.0
Isoamyl alcohol	Malty, sour	104312	95680
2-Phenyllethanol	Rosy	10279	56691
4-Methylphenol	Phenolic	Not detected	526.5

Table 6a : Physico-chemical characteristics of apple wines made with sugar and honey from different floral sources[30]

Treatment	*p*H	Acidity (%)	Alcohol (v/v %)	Residual sugar
Sucrose	3.86	0.56	10.5	0.1
Clover honey	3.57	0.59	9.8	0.4
Buckwheat honey	3.59	0.62	9.8	0.4

Table 6b : Sensory characteristics of apple wines made with sugar and honey[30]

Treatment	Colour	Rank	Description
Sucrose	Light Yellow	3.3	Clean and neutral flavour
Clover honey	Light Yellow	2.3	Clear, fruity and desirable
Buckwheat honey	Dark brown	4.2	Strong and distinctive undesirable buckwheat odour

In addition to floral source of honey, mead prepared by using different types of yeasts has also been analysed for its final ethanol contents and aromatic components[44]. Yeast ET99 (Isolated from *ogol*) when used produced mead having higher level of propan-1-ol and acetaldehyde (Table 7) as compared to wine yeast (W4) or Sake yeast (K7).

Quality parameters of different types of mead have also been compared[25]. The ethanol contents can vary from 4.6 to 11.8% in home brewed and commercial meads made from soya honey (Table 8).

Legal limits for table wines have also been prescribed which are in terms of total SO_2, volatile acidity and % ethanol (for red wine respective limits are 350, 1.4 and 14 whereas for white wine these are 350, 1.2 and 14). Antioxidant activity of these different types of mead is given in Table 9.

Fermentation behaviour, physico-chemical characteristics and qualities of various fruit honey wines have been studied and compared to those with mead[45]. Juices and pulps from apple, plum and pear have been used with honey to prepare musts. Variations were found even in physico-chemical characteristics of wines and musts prepared from fruit juices and honey (Table 10). The desirable level of various attributes like colour, ester and aldehyde contents were found in this mead as compared to that prepared only from honey. Sensory evaluation revealed apple honey wine to be the best where as plum-honey wine was found unacceptable due to poor TSS-acid ratio.

Table 8 : General quality characteristics of different meads[25]

Type of mead	Free SO_2 (ppm)	Bound SO_2 (ppm)	Titratable acidity (g/l tartaric)	Volatile acidity (g/l acetic)	% Ethanol	°Brix	*p*H	Residual sugars (%)
Commercial mead from soya honey	43.2	56.8	5.9	0.6	11.8	8.2	3.64	1.0
Home-brewed mead from soya honey	3.2	16.0	2.1	1.3	4.6	13.0	3.3	20.0
Buckwheat experimental mead	9.5	14.1	2.97	0.48	11.5	7.9	3.23	18.0
Soy experimental mead	7.4	20.0	3.89	0.91	6.4	14.0	2.74	20.6

Table 7 : Effect of type of yeast used in preparation of mead[44]

Yeast type	Ethanol (final) v/v (%)	Aromatic components
ET99	16.5	Higher level of propan-1-ol and acetaldehyde
W4	17.5	Higher level of 2-methyl propanol, ethyl acetate and iso-amyl-acetate
K7	17.5	Higher level of 3-methyl-butanol

Table 9 : Antioxidant activity of different types of mead[25]

Type of mead	Total phenolic (mg/l gallic acid equivalents)	Oxygen radical absorbance capacity (mmol Trolox equivalents/l)
Commercial mead	3102.93	16.06
Home-brewed mead from soya honey	163.63	7.12
Buckwheat experimental mead	300.6	3.79
Soy experimental mead	167.16	3.47

Table 10 : Physico-chemical characteristics of juices/pulps/honey, their musts and the fermentation rates[45]

Characteristics	Apple		Plum		Pear		Honey	
	Juice	Must	Juice	Must	Juice	Must	Honey	Must
Total soluble solids (°B)	12.0	28.0	10.5	20.0	9.5	20.0	80.0	20.0
Acidity (% M A)	0.44	0.40	2.14	1.76	0.38	0.30	0.06	0.28
*p*H	3.68	3.72	3.12	3.18	3.99	3.84	4.52	3.94
Colour (Units)								
Red	2.0	3.4	21.0	12.4	2.4	2.0	3.4	2.3
Yellow	10.0	13.0	4.0	5.0	9.0	7.4	50.0	7.5
Blue	0.1	0.1	0.1	0.2	0.1	0.2	0.0	0.2
Fermentation rates (°B/24h)	-	1.4	-	1.28	-	1.20	-	1.10

Conclusion

The research efforts made towards preparation of mead are sporadic without systematic investigation. The recent survey of literature has given some encouraging trends for the mead production and evaluation. Preparation of fruit honey wine is another step in this direction. Inspite of a lot of research on mead, the product is not available in the market commercially. It is documented that mead has been prepared from the time immemorial, but barring a few investigations other appear to be that of home scale wine.

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