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Research Article

A Review on Status of Honey Adulteration and Their Detection Techniques in Ethiopia

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ABSTRACT

Food adulteration is a global concern and developing countries are at higher risk associated with it due to lack of monitoring and policies. However, this is one of the most common phenomena that have been overlooked in many countries. Honey is a wholesome nutritious and medicinal bee product and is consumed by a majority of the population world. The high price of the natural honey encourages workers in the honey industry, including beekeepers and merchants to adulterate honey either directly or indirectly with look-alike and low quality substance worldwide, which leads to deterioration of honey quality, but increase honey quantity that is sold at the same price of natural authentic honey. Various instances of adulteration of honey have been reported globally, where in, the most common substances usually added to honey as adulterants are as sugar, ripened banana, water, molasses, sugar syrup, maize and/or wheat flour syrup, and sweet potato flour/syrup in Ethiopia. Hence adulteration of honey often takes place alter physicochemical nutritional and rheology of honey, resulting in reduction in its nutritive and medicinal value, several methods have been employed over the last few decades for unambiguous discrimination of adulterant and accurate quantification of the adulterants. Nowadays honey is being adulterated in more sophisticated ways that demands for cutting edge research for the detection of the adulterants. This review intends to contribute towards the common knowledge base regarding possible honey adulterants and their detection techniques trends associated with honey from Ethiopia.

Keywords: Honey, honey adulteration, detection, Ethiopia

INTRODUCTION

Honey bees produce honey from the nectar of plants or from secretions of living parts of plants or excretions of plant sucking insects on the living parts of plants, which the bees collect, transform by combining with specific substances of their own, deposit, dehydrate, store and leave in the honey comb to ripen and mature (Codex , 2001). Honey contains 80-85% carbohydrates, 15-17% water, 0.3% proteins, 0.2% ashes, and minor quantities of amino acids and vitamins as well as other components in low levels of concentration (Cantarell et al., 2008). It is a complex mixture and presents very great variations in composition and characteristics due to its geographical and botanical origin and its main features depending on the floral origin or the nectar utilized by bees (Saxena et al., 2010; Kebede et al., 2012).

Honey is one of the most widely used sweeteners in food industry and is used in a large number of processed food products (Cozzolino et al., 2011). Its market value is much higher than other commonly utilized sweeteners, such as refined cane sugar, beet sugar, corn syrup, maple sugar, high fructose corn syrup (Paradkar & Irudayaraj, 2002; Ruiz-Matute et al., 2010; Kartheek et al., 2011;Ghosh et al., 2005). Honey, due to its great variability in composition, is often prone to adulteration with artificial sweeteners for intentional or unintentional adulteration or contamination. Adulteration consists of adding external chemical substance into a food product that contains naturally similar substances (Cordella et al., 2003). Honey adulterations can take place by substitution of botanical and geographical origin, confusion of honeydew honey with floral honey, selling of artificial honey, and failure to comply with quality and

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hygiene requirements (unauthorized quantities of residues of antibiotics and sulphonamides).Honey adulterating may include even heating or storage under unsatisfactory conditions (Ciskova et al.,2010).The most common adulterant materials mixed with honey are sucrose, corn syrup, molasses, banana molasses, starch solution, glucose, water and inverted sugar or other harmless or harmful materials (Sharbt & Abdel- Fattah, 1994; Ruoff & Bogdanov, 2004; Bogdanov, 2010;Gemeda & Negera, 2017;Ambaw & Teklehaimanot, 2018)

Honey adulteration is causing severe impact on the domestic and international market opportunities of the product and may result in nutritional and health problems on consumers (Gary et al., 2000). Detection of honey adulteration is not simple. The identity and quality parameters of honey are considered useful for detecting these possible adulterations, and also for confirming the hygiene conditions for the manipulation and storage of honey (Puscas et al., 2013). In recent decades, research has tended to focus on instrumental analysis techniques, such as isotopic ratio (Padovan et al., 2003; Simsek et al., 2012), chromatography (Tosun, 2013; Consonni et al., 2013), nuclear magnetic resonance and spectroscopic (Vibrational spectrometry, i.e. NIR, MIR and Raman) (Sivakesava & Irudayaraj, 2002; Ruoff et al., 2006; Ruoff et al., 2007; Bertelli et al., 2010; Chen et al., 2011). It seems quite necessary that preparing an overall review of the applied procedures by researchers in detecting honey adulteration would be useful and serve as a good source in oncoming works. This review compiles updated information regarding major honey adulteration markers in the country so as to help the researchers to develop well organized strategies to improve honey quality in Ethiopia.

OBJECTIVES OF THE STUDY

To review major reported status of adulteration and identification techniques of honey in wide ecological beekeeping areas of Ethiopia

To suggest simple and easy local methods of screening adulterated honey samples from the pure ones

Honey adulteration

Honey being a natural substance of relatively high commercial value and limited supply; it is more prone to adulteration and fraudulent practices such as selling it under a false name or origin. It is big issues also problem in our country Ethiopia as it greatly affecting the quality and marketing honey. Loss of all this benefit cause the problem honey adulteration now days is a cross cutting all over the world in general and in developing countries in particular. Honey adulteration taken place by direct and indirect methods of adulteration.

Direct adulteration (added honey)

Direct adulteration of honey is accomplished by directly addition of external substances to the honey. Honey is adulterated directly; adding industrial sugar or honey into ready-made honey. The addition of sugar after the honey harvesting, which can lead to higher honey production through direct adulteration (Zabrodska & Vorlova, 2014). In Ethiopia different adulterant materials identified and reported are sugar, water, molasses shebab, ripened banana, coca cola, invert sugar, sugar syrup, wheat flour syrup or flower, potato ,sweet potato, maize syrup or flower, pollen, empty combs, melted candy and hot water (Gebremariam & Brhane, 2014;Gemeda & Negera, 2017 Ambaw &Teklehaimanot, 2018).Other methods of adulteration include the addition of fructose or glucose which alters the fructose/glucose ratio (1- 1.2 in pure honey.

Adulteration by sweeteners

As a natural product of a relatively high price, honey has been a target for adulteration for a long time. Addition of sweeteners have been detected in adulterated honeys: sugar syrups and molasses inverted by acids or enzymes from corn, sugar cane, sugar beet and syrups of natural origin such as maple (White , 2000).In Ethiopia the sweeteners adulterant materials like sugar ,sugar syrup ,inverted sugar, mollases ,coca cola and melted candy are detected .Although Ethiopia also imports sugars from China and India, where C3 sugars are available and exported there is no work and reported data the eventual use of C3 sugars for honey adulteration.

Adulteration with corn syrup

Inexpensive homemade or industrial syrups are generally used for this purpose, with well-known adulterants being sugar syrups, corn syrup ,high-fructose corn syrup (HFCS), glucose syrup ,sucrose syrup, inverted syrup or high-fructose inulin syrup ,which are produced from sugar cane or sugar beet (Anklam 1998; Guler et al.,2007; Tosun, 2013) in the world wide and in Ethiopia homemade syrups used for adulteration are wheat flour/ syrup maize flour/ syrup or flower and potato ,sweet potato powder or syrup (Gemeda & Negera, 2017; Ambaw & Teklehaimanot, 2018) For their low price and similar composition to honey, they are used to adulterate honey, although they are known to have a detrimental effect on the colony, the formation HMF and pH resulting colonies and the quality of honey are also affected .

Indirect adulteration (feed to honey bees)

Indirect adulteration is attributed with manual feeding of bees with artificial sugar at the stage during dearth period. This type adulteration can be unintentional, such as when caused by mistakes made by the beekeepers, or misuse of their technology, particularly when there is the need to feed the honey-bee colonies before winter or before the honey flow season. Over feeding of bees with sucrose is also a method of adulteration (Cotte et al., 2003; Guler et al., 2007). Indeed, supplementary feeding with sucrose and inverted sucrose syrup has been shown to affect the water and HMF content, diastase activity, free acidity and pH value of honeys (Ozcan et al., 2006).In-direct adulteration, or feeding honeybees with such solutions or even crystalline sucrose, has recently become a serious problem. Such indirect adulteration is extremely difficult to detect. Aberrantly, feeding honey bees with industrial sugar has recently become a major human concern .The study by Solayman et al.(2016) suggested that external honey bee feeding with artificial syrup in improper protective measures affect the final sugar composition

of sugars .Dumte(2010) suggested the adulteration might have occurred through feeding of the bees with sugar syrup.

Common type of adulterant materials used in honey adulteration

Adulteration of foreign substances to honey such as; molasses, starch solution, glucose, sucrose, water and inverted sugar, were studied by (Sharbt & Abdel- Fattah, 1994;Ruoff &Bogdanov, 2004 ;Bogdanov, 2010) in the world wide and in Ethiopia different authors reported different types of adulterant materials from different parts of the country as shown on (Tab 1 and 2) below (Gebreegziabher et al., 2013; Yadeta, 2014; Gebretsadik & Negash, 2016; Gemeda & Negera, 2017;; Ambaw & Teklehaimanot, 2018) .Ambaw & Teklehaimanot (2018) surveyed 95.5% of actors on adulteration of honey were retailers for their study of Arsi zone. According Gemeda & Negera (2017) adulteration of honey is conducted by boiling sugar with honey directly adding sugar powder to the honey. Adulterating of honey most commonly taken place by mixing, homogenizing, heating or melting adulterant materials with pure honey.

Table 1: Common used adulterant materials with respect area in Ethiopia.

Place/area	Name of adulterant materials	Reference
Arsi	sugar, ripened banana, wheat flower, potato, maize flower, pollen, empty combs, melted candy, molasses and hot water	Ambaw & Teklehaimanot (2018)
Eastern Tigray region	sugar syrup, maize and/or wheat flour syrup, banana and sweet potato	Gebremariam & Brhane(2014)
Oromia region	sugar , candy , molasses sugar banana, orange and cumber	Gemeda & Negera(2017)
Bahirdar	sugar or invert	Ambaw & Teklehaimanot (2018)
Gedo(SNNP)	sugar syrup, maize and/or wheat flour syrup, banana and sweet potato	Sebeho (2015)
Adigrat and surrounding area	Sugar ,water, banana	Gebremariam & Brhane (2014)

Table 2: Techniques of adulterating and identification honey in Ethiopia.

No	Adulterant	Ways of adulteration	Ways of identification	Reference
1	Sugar	Hot water 1litH20+1kg	Sticky by palpation ,	(Ambaw & Teklehaimanot, 2018; Gemeda & Negera, 2017)
		sugar+1/2kg honey or	sweaty by testing, poor	
		01:00.5	viscosity during dropping,	
			low price, testing and smelling ,continuous flow	
2	Banana	Crashed banana	Soily by observation and	(Ambaw & Teklehaimanot, 2018)
		+honey(1:1)	palpation no soft feeling,	
			low price ,cast formation	
3	Banana +sugar	mixture of sugar and banana,	testing and smelling continues flow,cocacola,using fire	(Gemeda & Negera, 2017)
4	Banana +mollase	mixture of sugar and molasses	testing and smelling ,continues flow,,thinkness of honey,cocacola,using fire	(Gemeda & Negera, 2017)
5	Wheat	Simply mixing with	Observation , testing	(Ambaw & Teklehaimanot, 2018)
	flower	honey and hot	viscosity, oily appearance,	
		water(1:1)	price	
6	Buless juice	Buless juice +white	Testing by tongue,	(Ambaw & Teklehaimanot, 2018)
		honey+ empty	inspecting the residue after	
		comb(1:1:0.5	chewing	
7	Empty	Adding the empty	Observation of old and	(Ambaw & Teklehaimanot, 2018)
	comb	comb breaking into	empty comb by necked	

		small pieces	eyes, cheap price	
8	Molasses	Mixing with the ratio	No specific identification	(Ambaw & Teklehaimanot, 2018)
		of 1:1	methods	
9	Sweet	Mixing after roasted	By testing	(Ambaw & Teklehaimanot, 2018)
	potato	by fire		
10	Potato	Mixing after roasted	By testing	(Ambaw & Teklehaimanot, 2018)
	(white)	by fire		
11	Brood comb	Mixing during harvest	Observation	(Ambaw & Teklehaimanot, 2018)
12	Pollen	Mixing during harvest	Observation	(Ambaw & Teklehaimanot, 2018)
13	Pulse	Mixing with honey	Testing	(Ambaw & Teklehaimanot, 2018)
	flower			

Identification/detection method of honey adulteration

Identification of adulterated honey is challenging particularly for consumers with lack of knowledge on characteristics of pure honey. An analyses of chemical composition and physical properties of honey are commonly used to detect direct adulteration (Zabrodska & Vorlova, 2014).Knowing the quality characteristics of pure honey including sensory quality, physic-chemical characteristics, rheological properties, microbiological quality, nutritional quality and antioxidant properties important to easily predict the honey sample is weather adulterated or not.

Method for detection of adulterant in honey

This section describes a set of different test normally used nowadays for beekeepers, at market place for consumers and at laboratory for expert where there is no sophisticated equipment easily to identify honey adulteration. In Ethiopia there are many techniques used detection honey adulteration by using local and laboratory methods.

Test done in the home

Quick tests used to assess the adulterated honey

There are a preliminary assessment to be conducted to know whether honey is adulterated or pure commonly at home and local markets as shown on Table 3 & 4 (Gebremariam & Brhane, 2014; Gemeda & Negera, 2017; Ambaw & Teklehaimanot, 2018).

Flame Test: Pure honey gave smokeless flame when ignited using candle flame or laboratory Bunsen burner. Presence of adulterants was confirmed by observation of smoky flame and/or cracking sound during flame test.

Heating Effect: Upon gentle heating of samples to dissolve crystallized substances: Pure honey melts to clear transparent viscous solution (while wax materials floating on top).A mixture of honey with starch from potato, banana or wheat flour melts to form dispersed and non-transparent liquid. A mixture of honey with commercial sugar (more than 50 % w/w) melts to form thicker, relatively dispersed and partially transparent liquid.

Water test: one table spoon of honey samples was added into a glass of water and observation of the added honey showed either dissolved or settled at the bottom of the glass. Pure honey was settled at the bottom of the glass whereas adulterated (artificial) honey was started dissolving in water immediately after adding in to the water

Light a Fire: when we dip the tip of a matchstick in honey strike it to light. Natural honey gives light the match easily and the flame was burnt off the honey. Adulterated (artificial) honey gave smokes instead of burning because of the high moisture content it contain

Thumb Test: Put a drop of the honey on the thumb. If the honey spreads around right away or spills, the honey is not pure. If it stays intact, it's pure.

Coca cola test: coca cola test method this may be from the content of coca cola and honey which causes fermentation during mixing the two of the them or the time the honey were harvested until the test is undertaken

Shelf life test: The collected honey samples were stored properly in air tit container for one year and seen the crystal formation

Table 3: Simple preliminary tests to identify adulterated honey.

Test type	Honey sample	Purchased	Known pure honey	Intentionally adulterated
	from farmer	Honey from market		honey
	beekeeper			
Glass filled water	26.32%	24.14%	100%settled	100% dissolved
test	settled			
Thumb test	26.32% in intact	21.10%	100%intact	100% spread
Match-lighting test	26.32%	24.14%	100% give light	100% smokes
	give light	give light		
Shelf life (1year)	36.84%	31.03%	100%crystaliz	
	crystallize	crystallize		

Test done in laboratory

Fiehe's test (preliminary)

Fiche's test was used to analyze honey adulteration. About 5 g of honey was mixed with 10 ml of ether in a mortar and pestle.

The ether extract was decanted off into a petri dish. This step was repeated twice with more ether and all the extract was collected in the same dish. The ether was allowed to evaporate off at room temperature. To the remaining residues in the dish, a drop of 1% solution of freshly sublimed resorcinol was added in concentrated hydrochloric acid. Immediate appearance of a cherry red colour indicates presence of sugar(Mansuri, 2011).Woldemariam & Abera (2014) examined the presence of adulterants in the samples of honey from Bahirdar from 5 market place at three months of time interval by Fiehe's test. Cherry red color in 15% of the samples indicating that the honey was adulterated with sugar or invert sugar

Aniline Chloride Test

Take 5 ml of honey in a porcelain dish. Add Aniline Chloride solution (3 ml of Aniline and 7 ml of 1:3 HCl) and stir well. Orange red color indicates presence of sugar(Abhirami & Radha, 2015)

Physicochemical analysis method to asses honey adulteration

Traditionally, honey adulterants are detected by physicochemical methods. Adulteration of honey by crystallized cane sugar, invert sugar syrup, and cane sugar syrup can be detected with chemical determinations including HMF, glucose, sucrose, fructose, and diastase (Codex,1989; White, 1979).The physical characteristics of pure honey is different from adulterated honey particularly in color, consistency, water content, ash content, and water insoluble materials(Ambew&Teklemedhin,2018).

One of physical parameter of honey mainly used to discriminate between pure and adulterated honey is color .The color difference between pure and adulterated honey could be distinguished by necked eye according to report by (Gebremariam & Brhane, 2014; Gemeda & Negera, 2017).In addition moisture content is another parameter used detect adulteration. From chemical properties honey .Carbohydrate analysis is also a common approach to detect honey adulteration. High performance anion-exchange chromatography pulsed amperometric detection technique was used in an study on oligosaccharides, fractionated by activated charcoal, for detecting honey adulteration by corn and high fructose corn syrups (Morales et al., 2008). In General the physicochemical tell us what honey looks like and the variation of the properties is directly related with adulteration although other factors considered. Chemical analysis of these honey highlighted that samples were adulterated or heated as shown on the Table.4.

Table 4: Physicochemical comparison between pure and adulterated honey

Parameter	Study in Pakistan		Study in Ethiopia		Reference
	Pure honey	Adulterated	Pure honey	Adulterated honey	
Surface tension, dynes·cm-1	55.02	68	-	-	(Rehman et al., 2008)
pH	4.2	5.4	3.66-3.97	4.56-5.87	(Gebremariam & Brhane, 2014; Rehman et al., 2008)
Electrical Conductivity ms·cm-1	0.01	0.06	0.22-0.34	0.09-0.34	(Gebremariam & Brhane, 2014b; Rehman et al., 2008)
Moisture, %	16.7	19.3	16.56-17.98	17.23-22.01	Gebremariam & Brhane, 2014; Rehman et al., 2008)
Ash, g/ 100g	0.38	0.25	0.09-0.42	0.008-0.13	Gebremariam & Brhane, 2014; Rehman et al., 2008)
Refractive index, n	1.472	1.456			Rehman et al., 2008)
Freee Acidity Meq/kg	30	24.2	9.67-20.67	7.58-13.12	Gebremariam & Brhane, 2014; Rehman et al., 2008)
Density, g·cm-1	1.55	1.62			Gebremariam & Brhane, 2014; Rehman et al., 2008)
Reducing sugar	-	-	65.68-75.96	32.90-51.65	(Gebremariam & Brhane, 2014)
Sucrose	-	-	2.24-5.42	7.53-12.25	(Gebremariam & Brhane, 2014)

Hydroxy methylfurfural(mg kg-1)	-	-	4.32-20.54	38.91-60.45	(Gebremariam & Brhane, 2014)

Microscopic analysis on honey could reveal some adulterants in addition to the geographical and botanical origin of the honey. Gebremariam & Brhane (2014) reported that microscopic analysis for detection of adulterated honey mixed with banana showed that showed that some fibers and plant tissue were observed in mixtures of honey in their study from Adigrat and its surrounding areas in Tigray region .So microscopic analysis it can possible to detect adulteration of honey. In summary instead of the use of only microscopic analysis for adulterants, it is more accurate to combine it with other methods such as physicochemical analysis, HPLC, and PCR. Microscopic methods may be most useful in developing countries where alternative methods are impractical due to high cost(Naila et al., 2018)

Harmful effect of adulterated honey

Pure honey, also known as natural honey, is a predigested food and it is the best alternative sweetener for many people who could not digest plain cane sugar. It may be originated from either nectar in flowers or plant saps which is processed in the bee's stomach (Codex 2001; Rahaman et al. 2013). It contains 80% of simple sugars such as fructose and glucose, which are readily to be broken down by the digestive system. Therefore, it is directly absorbed into our bloodstream and is converted directly into energy. Besides simple sugar, approximately 200 substances were recorded from pure honey such as antioxidant properties, water, vitamins, minerals, phenolic acids, proteins and enzymes (Bogdanov et al., 2008). However, the exact composition of honey may vary according to the plant species on which the bee forages, but the main constituents are almost similar in all honeys (Almeida-Muradian et al., 2013). Several researches proved that all compositions in the honey showed synergistic action and may contribute several health benefits to our health instead of the individual component (Zainol & Mohd, 2013; Chavan et al., 2014). On the other hand, adulterated honey is made from table sugar, molasses, water, sucrose syrup or high fructose corn syrup which is not originated from the honey bee stomach (Weihrauch & Diehl, 2004).Adulteration alters the quality and safety of honey. For instance, honey adulterated with chemicals lower the medicinal value as well as may harm the consumers (Anthony & Balasuriya, 2016).Gemeda & Negera,(2017) surveyed the users of honey on problem encountered because of adulteration, listed that majorly loss of satisfaction, health problem and loss value of the product on their study from Oromia region.

Similarly, several researches were conducted in vivo and in vitro on harmful effect adulterated materials on health of rat, mice and mouse with comparable with pure honey as control. Intriguingly, data obtained from in vivo study can be used as guidelines or notion for human study (Hau & Hoosier, 2003). The similar effects may observe when human consumes the adulterated honey for long period. Samat et al.(2018) investigated chronic effects of the adulterated honey consumption using short-term(14 days) and long-term effects(16 weeks) with daily of consumption of adulterated honey compared to normal control rats and rats fed with natural honey using male Sprague dawley rats. Throughout the experiment, the rest rats from both groups fed with the adulterated honeys showed abnormal behavioral activities like aggressive, excessive drinking intake compare to control rats and rats fed with pineapple honey. The author confirmed that rats fed with adulterated honeys fulfilled all the criteria of obesity and hyperglycemia such as increased body weight gain, fat pads, BMI, triglyceride, cholesterol and glucose levels, which indicates adulterated honey consumption leads to obesity and potentially diabetes (Bocarsly et al.,2010; Belobrajdic et al.,2012) in contrast the pure honey which significantly reduced the level of triglycerides, cholesterol and glucose compared to rats fed with both adulterated honeys. In another studies that long-term consumption of golden syrup, sucrose or/and fructose diet or fructose cane syrup alone demonstrated a high mean total percent body fat, increased visceral fat pads which then leads to hypercholesterolemia, hyper triglyceridemia and hyperinsulinemia (Bocarsly et al., 2010; Cao et al., 2012; Ajibola et al.,2013). Simple sugar such as glucose and fructose supply instant energy to human's cells and have low glycemic index compared to more complex sugars such as sucrose. It reduces blood glucose level and supply energy efficiently (Al-Waili, 2004; Yaghoobi et al.,2008; Mushtaq et al.,2011; Abdulrhman et al., 2013 ;Nazir et al. 2014;). Besides obesity and diabetes, long-term consumption of adulterated honey also demonstrated severe toxicity which shows increase of liver and kidney marker enzymes total bilirubin and total protein, urea and creatinine and induced abnormalities in organs weight according to study by Samat et al.(2018). Cheplius and Starkey (2008), in their research they documented, rats fed with a golden syrup for long period also caused hepatic inflammation, which manifested as Kupffer cells accumulation in the liver. The severe damages might be due to the high sugar levels in adulterated honey.

Several study prove that pure honey is not toxic, but instead exhibited extraordinary medicinal effects by reducing excess body weight gain and other obesity and diabetes parameters. Meanwhile, adulterated honeys display contrasting effects that are harmful to body and could induce several diseases (Jurgens et al. 2005; Lindqvist et al., 2008;Light et al., 2009 Cao et al., 2012). The reason is because pure honey contains not only simple sugars (fructose and glucose) but also other nutrients such as proteins, antioxidants and minerals which are essential to our health (Bogdanov et al., 2012). As such, it is commonly used as a natural sweetener and nutritional food and its benefit to our health has been known for thousands of years (Alvarez-Suarez et al., 2010).The adulteration in honey trade the problem in which has negative effect on curing of humans' folk medicine. So adulterated honey will lead to hazard specially for diabetics. In addition adulteration negatively influences market growth by damaging customer confidence.

CONCLUSION

Honey like other foods is prone to various types of contaminations and adulterations. Adulteration in honey is the result of direct and indirect adulteration of honey and poor beekeeping handling, uncontrolled of beekeeping practice. This problem is more serious in the developing, under developed countries as well as in Ethiopia due to lack of adequate knowledge and training of beekeepers on quality, lack of awareness on quality of honey and its adulteration, adequate monitoring system and law enforcement. In Ethiopia the most common currently adulterant materials usually added to honey as adulterants are sugar ,banana, molasses, water, shebeb ,sugar syrup, maize and/or wheat flour syrup. Existing common detection techniques are not always convenient and accessible in the Ethiopia making it difficult to address the diverse ways of fraudulent adulteration in honey. In above discussion simple and different methods are discussed for detection of adulterants. Thus combined efforts is needed from scientific communities and the regulatory authorities through the development, implementation and dissemination of better techniques for the detection of honey adulteration

Therefore, the following recommendations forwarded

- Strict national legislation passed on apiculture sector to avoid unnecessary mix of adulterant materials in honey
- Training beekeepers and other stakeholders on how to handle the quality of honey, how to identify the adulterated honey, about good manufacturing practices and monitoring are useful to reduce honey adulteration.
- Further research on the effect honey adulteration to human and alternative control system should be encouraged
- Developing simple and cost-effective techniques to detect honey adulteration which could be used with high degree of repeatability.
- Health authorities in all nations have to introduce firm legislations and laws that control and regulate honey production, handling, and analysis to ascertain its safety.

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