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Assessment on Post-Harvest Losses of Mango (*Mangifera indica* L) and Allied Fungal Pathogens in Gambella Town Market, Southwest Ethiopia

Solomon Nigusu*and MihretuYonas*
*Gmbella UniversityCollege of Agriculture and Natural
Resource Department of Plant Science and Horticulture, Gambella, Ethiopia, P.O.Box 126

Abstract:- The matter of post-harvest losses is extremely important in the efforts to fightfamine, increaserevenue generations and recover food security in the world's poorest countries. The greatestsignificantissues causing countless economical loss of mango fruits are postharvest fungal diseases caused by absence of proper management along postharvest chains. This study was carried out to assess mango fruits postharvest loss, managementdoes and recognize the main allied agents of postharvest fungal pathogens in Gambella town market. Assessment was carried out by means of purposive sampling to select the study part, followed by simple chance sampling to gather data through observation and interview. Fungi isolation was done at laboratory by culturing on potato dextrose agar media under controlled growth conditions. The studyoutcomeshowed that losses of mango fruits due to spoilage and physical damage were common problems for all fruit sellers. Post-harvest loss of mango fruit was occurred in different quantity along value chain actors. The most post-harvest loss of mango fruits occurred at market stage 23.33% and followed by harvesting stage 20%. Market handling does such as lack of hygiene, temperature management;inadequate packaging and transportation problems were recognised among the mutual causes for mango fruit losses. The maximum mango fruit injury 40% was noted in sample taken from retailers' and the allied disease incidence 32% and severity were 16% in the study part. Morphological documentation of pure culture indicated that most fungi associated with mango fruits loss was *Colletotrichumspp* 40.51% among six genera of fungi isolated from mango fruits in Gambella town market. In general post-harvestlosses of mango fruits in the study part were accelerated by different factors. Furthermore, the pathogenic of isolated fungi need to study to state their effect on post-harvest loss of mango fruits including to controlling methods.

Keywords:- *Incidence and severity, post-harvest fungal pathogen, mango fruit handling, Value chain actors.*

I. INTRODUCTION

The mango (*Mangiferaindica*L.) is origin to India (Yadav and Singh, 2017) and most important fruit commerciallycultured in tropical and subtropical areas of the world (Mitra, 1997; Esguerra*et al.*, 2018). Gradually, the mango moved from its centre of origin from Asia to the Middle East, East Africa and South America startabout 300-400 AD (Yadav and Singh, 2017). It is the second among fruit crops in Ethiopia in its production coverage and economicstanding next to banana in Ethiopia. The largest mango producing areas in Ethiopia are Harari region, west and east Oromia, Southern Nations, Nationalities, and People's Region (SNNPR), BenishangulGumuz Region, Gambella Region and Amhara region which are valued to be producing 35% of the majority of fruits produced about the country (Akrong 2020; Fleming, 2020; Hagos*et al.*, 2020). Western Ethiopia, especially the two zones (East and West) of Wollega, of Oromia regional state, which is located in the upper Blue Nile valley, is suitable for the production of mangoes (Temesgen, 2014). Mangoes are full-grown by the mainstream of farmers living in aboutGambella town near Baro bank River and farmers in the region were depend on on old and largeincontrollable mango plants found in nature.

Mango fruits are extremely healthful, simplyedible and wide consumption is due to its sensory features, and mainly its good-looking texture and essencetype mango fruit popular by the clients. Mango fruit has a high nutritive value and health welfares due to significant components such as phytochemicals. It is rich source of vitamins C, minerals, in dietary fiber, provitamin A, carotenoids and varied polyphenols (Esguerra*et al.*, 2018). According to Maldonado-Celis*et al* (2019) studies,mango fruit components can be assembled into macronutrients (carbohydrates, proteins, amino acids, lipids, fatty, and organic acids), micronutrients (vitamins and minerals), and phytochemicals (phenolic, polyphenol, pigments, and volatile constituents). The nutritional, non-nutritional, and water contents of mango fruit differreliant of the cultivar and numerous pre harvest and post-harvestissues (Corrales-Bernal *et al*., 2014).

Even though mango fruits are extremelyessential as nutritious and economically significant fruits, they knew by different production limitations. According to some studies, erratic rainfall, pest problems, improper agronomy practices, lack of improved varieties, post-harvest losses and problem of infrastructure were bottleneck of mango production in Ethiopia (Honja, 2014; Siddiq*et al.*, 2017). Mango is anextremely perishable fruit, has a short shelf life and vulnerable to environmental stress especially high temperature. The perishable nature of harvest, lower technology, and absence of awareness among makers as well as market performerscaused in poor management of the mango fruits (Abera*et al.*, 2020). Substantialamounts of mangoes are lost each year during collecting, transport and marketing (Hassan, 2010; Alam*et al.*, 2019). Due to its

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perishable nature mango fruits necessitysupreme care throughcollecting, cooling, storing, transporting, grading and storing (Kayier*et al.*, 2019).Fungal pathogens are frequently encountered on rotting mango fruits and were the main agents of fruit rot after harvest and responsible for postharvest diseases studied early by Sangchote (1989), Rawal (1998) and Johnson (2008). The matter of post-harvest losses is extremelysignificant in the efforts to fight hunger, increaseincome and progress food security in the world's humblest countries like Ethiopia. A lot of researcherstraced the decrease of post-harvest losses is stated as akeysubjectconstituent of ensuring upcomingworldwide food sanctuary (Aulakh*et al*., 2013; Garikai, 2014; Belik, 2018).

Moreover, bestinvestigationdirected on postharvest losses of mango attentive on determinants Market Supply (Wake *et al*., 2013; Husen and Yimer, 20014; Kabeta and Alemu, 2019; Hagos*et al*., 2020). Recently, Tarekegn and Kelem (2022) studied about postharvest loss of mango along value chain in Gamo zone SNNPR. However, not at allwide study has been done to findpost-harvest loss of mango from farm entrance to the point of eating due to unsuitablecollecting, post-harvestmanagement, carriage, intermediaries' misconducts, storage and other details in Gambella region, Ethiopia. There is no more information about mango fruits handling practice in Gambella town market and causing agents of mango fruits loss. Therefore, it suitspredictable to find the procedures and networks where important losses and at what degree occur. A better understanding mango fruits handling practices could lead to developing technology and does to decreasepost-harvest losses of mango. However, little is understood about the effectallied fungal deterioration of the mango fruits. Additional, not at allwide study has been carried out so distant to trace fungi allied with mango fruit spoilage causing losses and fungal deterioration. Hence, there is a vigorousessential to appreciate the impact of fungi spoilage during mango fruit marketing on the postharvest losses due to fungal pathogens. Therefore, this study expected to evaluatedifferent postharvest doesaffecting postharvest losses and identified fungal pathogens accountable for the main postharvest deterioration of mango fruits in Gambella town market.

II. MATERIALS THEN METHODS

A. Explanation of the Study Areas

The postharvest loss valuation was carried out in Gambella town market, Gambella regional state of Ethiopia. Gambella region is one of eleven regional states of Ethiopia found at the south western region of the country and bounded by South Sudan to the west, KellemWollega Zone, Ilu Ababor Zone and Sheka Zone.Gambella is a name for both the regional state and the capital city of the region, which is located about 753 kilometres southwest of the capital city of the country Addis Ababa perched at an elevation of 526 meters above sea level. Gambella town market is located in Gambella regional state capital city where fruits, vegetables, cereals and other products were sold. The laboratory investigation was directed at Jimma University College of Agriculture and Veterinary Medicine, plant pathology laboratory. Jimma University is located in the city of Jimma Zone, located around 352 kilometres southwest of Addis Ababa in Oromia region, Ethiopia. Mango fruits post-harvest loss valuation and experiments were done from March, 2021 to January, 2022.

B. Sampling and Data Collections Methods

Pertinent data were collected using altered questionnaires accepted from La Gra (1990) with semi structured interviews, formal questionnaires, direct observations and retrospective method (organizational diagrams). The post-harvestmanagementlinkedstudies were ready; pre tested with sample defendants, rechecked for its precision for clear sympathetic and replying, and spread to the respective selected representative respondents in Gambella town market. The data were collected both from survey (Primary and secondary data) and laboratory experiments. Yamane (1967) sampling formula with a 90 percent confidence level and population proportional to size (PPS) to each residence of market was applied to get representative households respondents. Where "n" is sample size for this study were (98), "N" is total number of mango fruits sellers were (4228) and "e" is margin of error at 10 percent.

$$n = \frac{N}{1+N\,(e)^2}.$$

Lastly, focus group discussions (FGDs) were led with importantgoal groups to get observations of different stakeholders along with the product chain system and to cross check the reliability of the information was gained. Accordingly, the group discussions of producers were separated into two subgroups (men and women) for the FGD. Extra and essentialdata was also gotten from key informants, like development agents, agricultural officers, and research professionals by connecting two FGDs with 7 members. The mango fruits postharvest management doeswere also detected and noted. Mango fruits were bought from Gambella market traders (whole seller, retailer, farmer and open market) and used for laboratory experiments to find the fungi allied mango fruit losing in the study area.

C. Data collected

- *Mango fruits harvesting tools*

To collect data regarding tools of mango fruits harvesting, the farmers were assessed and interviewed. During this data collected, about labour, harvesting tools, harvesting method and time of harvesting was discussed and interviewed in the study area. All activities of postharvest organization such as pre-cooling, grading, packaging, storage, loading and carriage were interviewed and stated.

- *Mango fruit post-harvest loss along value chain*

Information were collected on mango fruits losses happened in the harvesting, pre-cooling, field storage, sorting and grading, packaging, loading/unloading, transportation and marketing stages. Amount of producing /buying/ and losing of mango fruits were interviewed in the study area.

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➢ *Mango fruits handling practices in the Gambella town market*

Information concentrating on issues linked to loss and their causes, farmer's exercise of management the mango fruits from production pending they take it to their buyer; their contact with the respective actors and government and physical flows of produce were collected. Moreover, through data collection, temperature of the marketing part was noted three times in a day (morning, afternoon, and evening) for successive 5 days, and the temperature of one day was averaged.

➢ *Fruit damage, disease incidence and severity valuation*

To measure percentage of mango fruits injury and test for fungal pathogen infection, representative samples (a total of 100 mango fruits) composed of both damaged and apparently healthy looking were sampled purposively centred on the capacity sell from the farmers selling fruits in farmers (n= 25), open market (n = 25), wholesalers (n =25), and retailers (n = 25) with three replications. All the mango fruits were transported to the laboratory and kept at room temperature for additionalstudy of fruit injury and quiescent (latent) contagion of the pathogens. The contagion of fungal pathogens were documented using different approaches such as looking at the appearance of rotten fruit, including the color sign of the pathogen spore, and site of contagionplaces. Following the documentation of infections, disease incidence was calculated as number of infected fruits display any single symptom out of entire number of mango fruits sampled.

$$\text{Percent of disease incidence} = \frac{\text{Number of infected fruits x100}}{\text{Total number of fruit samples}}$$

Percentages of mango fruit damage were assessed and calculated using the following equation.

$$\text{Percentage of mango fruits damage} = \frac{\text{Number of damaged mango fruits x 100}}{\text{Total number of mango fruit samples}}$$

The disease harshness study was undertaken by detecting the fungal symptom record of disease levels according to the diseased surface part on the fruits. It was measured on a 1–6 scale in which no diseased surface part scored 1, whereas the diseased surface parts of >0%–5%, >5%–25%, >25%–50%, >50%–75%, and >75% scored 2, 3, 4, 5, and 6, respectively (Duamkhanmanee, 2008). The percent severity index of fungal impurity was then measured from the numerical grades of the entire samples using the next formula.

$$\text{Percent severity index} = \frac{\text{Sum of numerical ratings x 100}}{\text{Total number of mango fruit examined x maximum grade}}$$

➢ *Media preparation and growth conditions for fungi culture*

The media was prepared from PDA for fungi growth according to media fungi media preparation methods. Potato dextrose agar is the common media for any fungi growth in the laboratory under controlled growth conditions. PDA 39 gram was mixed in 1L of sterilized water. The mixed PDA was stirred by magnet stirrer to mix well under hot condition. The well stirred and mixed media of PDA was sterilized at 120 ^{O}C temperature and 105Kpa pressure for 15 minute in autoclave. The sterilized media was poured in Petri dish under laminar air flow cabinet and left for 30 minute to media solidify and cool. The solidified and cooled media were used for the experiments. The inoculated media were placed in growth chamber at 25 ^{O}C temperatures with good moisture. These media were replaced randomly in the growth chamber with completely randomized design. The experiment done two times to get proper results and reducing error in the study. All growth conditions recommend for fungi growth were controlled and well noted in the laboratory. Similar and the some condition were maintained for each experiment and all activities were equally applied for the study.

➢ *Isolation and documentation of fungal pathogens allied with mango fruit*

The samples collected from unalike mango sellers were first eroded in blow water and then the fruits that showedindications of fungal contagion were designated for fungal separation. The tissues were cut from lively lesions and symptom showed surface of the mango fruits was used. The exterior of mango fruits tissues were sterilized by soaking in freshly readyNaOCl (25 v/v) for 5 min. After three sequential washings in sterile purified water, mango fruit tissues were engaged (four pieces per plate) on Potato Dextrose Agar (PDA) and nursed at 25°C in the incubator for 3-7 days. The colonies emerged from each plated fruit tissues were cleaned and sub-cultured on the PDA media after 6 days. The plates were nursed at 25°C under comparablesituations, and the arrangements were detectedpending the organisms convertedcompletely grown. Single spore cultures of the fungus was then organized on PDA slants in test tubes, and the empathy and description of the fungal separates were carried out centred on cultural and morphological structures labelled in Marasas*et al.*, (2001). The structure and morphological description was done by preparing fungi fully grew on slide for identify under microscope. The prepared slide where place under microscope and morphology of fungi were considered with three times pre Petri dish.

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Fig. 1: Photo captured during data collection (A) Transporting mango fruits by cart, (B) Mango fruits transporting by human shoulder, (C) Packaging materials at market, (D) mango fruits in the Gambella town market captured by /CdeAyom, 2020/, (C) temperature management and (F) Mango fruits not sort and graded.

D. Data Analysis

The freshinformation from the survey questionnaire wasnoted, ordered and investigated using SPSS (version 16.0) and Microsoft Excel 2007. Appropriate mathematical calculations and inferences were made consequently. Expressive statistical examination (means, standard deviation, percentage and Chi-square) were used in describing socio demographic, post-harvestmanagementperforms and alliedpost-harvest loss of mango fruits. Correlation analysis was used to search the relationship between post-harvest handling does and post-harvest losses of mango fruits. An independent sample t-test was also conducted to observe the significant effect of post-harvest handling practices along with the mango fruits supply chain on its loss. Matrix grade was used to label the relationship between socio demographic and mango fruits post-harvest loss and to vital mango fruit marketing difficulties.

III. RESULTS AND DISCUSSIONS

A. Socio-Demographic Characteristics of the Study Area

Among 98 mango fruits sellers interviewed, their gender, age, marital status, and educational ranks were specified (Table 1). As result traced in Table 1, in gender group, 35 (64.29 %) of respondents were females and rest of them were males and showed that the females were tangled much in mango fruits sale. Among the age clusters, the maximum of 30.61% members were between 35-45 years of age. The level of education differs among the gender and age groups, 36.74% of them were illiterates, 63.26% of them were in different levels (elementary to high school) education. More than 63.26% of literate respondents have attentiveness on the effect of inadequatemanagementdoes on the quality of mango fruits. Alikethought was made by Olayemi, Adegbola, Bamishaiye, and Awagu (2012) who stated that peoples on secondary educational stages can simplyknow the postharvest managementdoes more than peoples on primary educational ranks. Babalola (2011) also stated that education allowsunderstanding the result of managementdoes on the postharvest loss of the produces and mains to better managementensure than illiterate.

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Table 1: Socio-demographic features of mango fruit sellers in Gambella town market

Variables in the study		Frequency	Percentage
Sex	Male	35	35.71
	Female	63	64.29
Age	< 25	15	15.31
	25 – 35	22	22.45
	35 – 45	30	30.61
	45 – 55	21	21.43
	>55	10	10.20
Marital status	Single	33	33.67
	Married	60	61.23
	Divorced	5	5.10
Education level	Literate	36	36.74
	Illiterate	62	63.26

Source: Own data computations (2022)

B. Post-Harvest Loss along the Mango Fruit Value Chain and their Practices in the study area

Rendering to survey outcome mango fruits losses were happened at collecting, pre-cooling, storing, sorting and grading, packaging, loading/unloading, transportation, and marketing and consumers stage with different percent of loss due to mismanagement and handling practices. Activities of the value chain actors and their contribution in mango fruits post-harvest losses were stated in the following.

➢ *Mango fruit harvesting practices and loss*

Rendering to anemphasis group conversation with mango producers, mango is collectedtypically once a year in the study part. This season for harvesting mango fruit starts from February to May. In the study part, mango fruits were harvested regularly by family labor (78.5%), while the rest were harvested by daily laborers (21.5%). Through the harvesting time they were harvesting both matured and immature mango by mixing. With respects to harvesting implements, the defendantssettle that the better harvesting apparatuses and mechanisms were not extensivelyexperienced by mango producers in Gambella. They were harvesting mango fruits in traditional ways and hand picking by ascending the mango tree. Old-styleways of collectinginstruments like trembling of the mango tree branches, picking with a twig and cutting the fruit outlet were used in the study part. The farmers were harvesting the mango fruits with stalk of the fruits in the study part. There were no technology provided in the study area to support farmers to harvest in suitable manner and they were not trained how to harvesting the mango fruits in safety ways.

Post-harvest loss and excellencedecline during collecting and managementmethods were recognised by 20% of the respondents (Figure 3). As the respondents stated, they did not use the suggestedapparatus and resources for collecting and management due to absence of admittance to bettercollecting technologies in the study part. These serious the risks of postharvest loss and quality deterioration of mango fruits in the study area. This study was not agree with the finding of Tarekegn and Kelem, (2022) mango fruit lost was 73% at Gamo zone in SNNPR in Ethiopia. This was due difference of harvesting methods and techniques in the study area. Therefore, lack of harvesting technology, awareness of societies about harvesting strategies, lack of harvesting materials, mishandling during harvest and mismanagement were the driving force to mango fruits post-harvest loss in Gambella. At harvesting, separating the mango fruit from the stem grounds the issue of resin and the sap, which has a low pH, can injury the fruit superficial. This injuryincreases the addition of red and black spots and deteriorationgrowth on the peel, and concessions the fruit's excellence. The harvesters were not drained the sap from the fruit or preserved to reduce the occurrence of sap burn. This was also one causative agent that enhancing post-harvest losing of mango fruits. The losing at harvesting stage 20% in this study held second rank from value chain actors next to market loss according to survey result (Figure 3). Therefore, lack of harvesting technology, awareness of societies about harvesting strategies, lack of harvesting materials, mishandling during harvest and mismanagement were the driving force to mango fruits post-harvest loss in Gambella.

➢ *Pre-cooling and field storage of mango fruits and loss*

In this study area the farmers were not pre-cooling of mango fruits to keep the excellence of fruits due to lack of awareness of pre-cooling values. According to respondents in the study area the developed green fruits were not reserved at room temperature for around 4-10 days liable upon the maturity for storage. The shelf life of mango fruits were not lengthy by pre-cooling, chemical treatments, low temperature and in another mechanizes according to respondent reflect. This study in line with Alkan and Kumar, (2018) studies stated thatover ripe mango fruits were more vulnerable to post-harvest illness and mechanical injury, while young fruit are prone to chilling pressurethrough cold storage.

According to result in this study producers were directly took the mango fruits to the markets without any pre-cooling and field storage, due to this activities mango fruits lost in the study around 6.66% and 3.33% respectively (Figure 3). This losing was lower than another mango fruits value chain actors according result revealed in (Figure 3) when compared with each other. Pre-cooling really not recommended for mango fruits being put through typical postharvest handling and it was not showed more effect on post-harvest loss of mango fruits in the study part. However,

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pre-cooling was an effective and important strategy used for maintaining the quality of produce postharvest, to implement pre-cooling into producing systems to prolong the life and reservation the health of fresh mango fruits if adopted.

➢ *Sorting and grading mango fruit loss*

Mango fruits producers in study area about 65% were sorting and grading the mango fruits based on the maturity, size, shape, freedom from disease, weight and color for selling and transporting. According to the producers responding most of producers were sorting the mango fruits before selling and estimated prices of each sorted mango fruits and some of them were not sort and grading (Figure 1 C and F). For fresh marketing, the recognized methods of classifying of mango fruits were physicalclassifying in the study part. There was no technology and machine developed for mango fruits grading and sorting in Gambella town market. Farmers and producers were majorly sorting mango based on maturity and prices according respondent confirm in the study area.Mango fruits loss was occurred about 10% according result traced in (Figure 3) and it was lower post-harvest loss of mango fruits when compared with another value chain actors. Over ripening, mechanical injuring during harvest, immature, deformed shape, damaged due to bird feeding and insect, cracking and price levels were some causing agents of mango fruit losing at this stage of value chain actor according to respondent confirms. Mango fruits lost at this stage were lower than mango lost at marketing levels according result stated (Figure 3).

➢ *Mango fruits packaging practices*

Wooden boxes, Plastic, sack, *safa* and basket were commonly used for packaging materials according to respondent (Figure 1 C). Some of farmers were not used packaging materials instead they were cutting the mango fruits with stalk and hanging on the stem to take the markets (Figure 1 B). About 31.25% of the defendants were used *Safa* for wrapping mango fruits (Figure 2 C) and charted wooden box 25%, whereas the lingering of them were used basket, plastic, and sack (Figure 2). We detected that the timber boxes they have been used were too large and too uneven to deliverdefence and abundant of the fruits on the lowest of the timber boxes were crumpled and classicallywaste before sale. However, the *Safa* was the best packaging materials in the study area and no more mango fruits damaged at the bottom due to over load. In this study area *safa*was most prominent packaging materials and best tools people used in mango fruits holding and it held first rank among all packaging materials stated (Figure 2) with 31.25 % according observation and respondent reflect (Figure 1 C).

Mango fruits post-harvest loss at packaging stage lower than another value chain actors according to respondents confirm about 3.33% were lost (Figure 3). Related observation was made by Tarekegn and Kelem, (2022) who stated a high mechanical damage to mango fruits crowded in timberbanger which could be due to density and exteriorstaininginjuries. Mango fruits produced around Gambella town were directly transported to market and packaging material encourage them to reducing loss according respondent confirm. Focus group discussion and key informative also encourage the idea of defendants in the study part and stated that mango fruit packaging materials help producers to reduce loss when compared with other value chain actors (Figure 4).

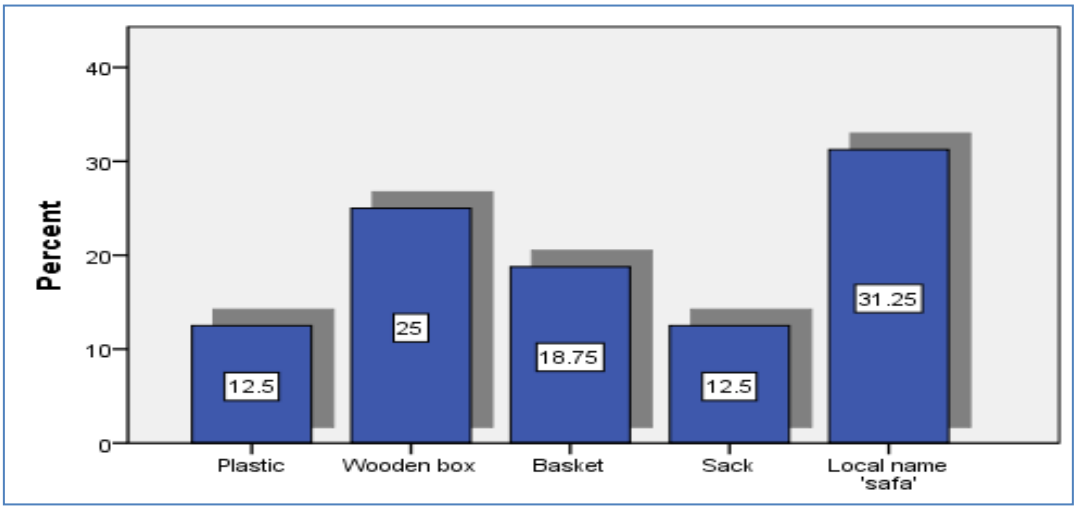

Fig. 2: Percentage of respondent handling mango fruits using different packaging materials

➢ *Mango fruits transportation to the market and loss*

The producers were transporting the mango fruits to the markets using human labors, cart, Bajaj and other vehicles in the study area. Under active carriage situations shaking affects in staining, deterioration and low price of mango fruits. The truck has been accepted as the greatestsuitablestyle of carriage due to its informaltactic from the orchards, but they were not accepted in the study area in Gambella. Technology such as refrigerated vans/ vesselsvaluable for extended distance carriage and help in decreasing the postharvest losses was not adopted in this study area. For carriagedrives, around 60% of defendants used an old-style trolley, shoulder hanging and cart (Figure 1 A and B), while nativegatherers and vendors use cars to

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carriage mango fruits. This study was not related with the finding of Tarekegn and Kelem, (2022) mango fruits transportation 87% at Gamo Zone in SNNPR by trolley and cart. This may due to difference place of production area, condition, strategies of transporting, management and infrastructure in the study area.

Due to transportation about 16.67% of mango fruits were lost in this study area (Figure 3) and it was ranked third among value chain actors in quantity of mango fruit loss. The producers were transported mango fruits to the markets in old-style ways this enhancing post-harvest loss of fruits. A study by Benyam*et al*, (2018) in Ethiopia stated that the use of old-style ways of carriage was increased post-harvest loss. Means of their transportation such shoulder holding fruits, hand cart, *safa* and other materials were open and directly sunlight gain the fruits that increasing metabolism activities of fruits. There were no technology accepted for fruits management in the study area and there were trained men power encases of post-harvest management of fruits. According to respondent in study area mango fruits lost due to transportation services were high and focus group and key informative also confirm this result. Generally, lack of refrigerated transport, Lack of suitable transport system, poor infrastructure, loading and unloading doeswere enhancedpost-harvest loss of mango fruits in Gambella town market according the respondent direction.

- *Mango fruits market accesses and loss*

The nativedealersbought mango fruits from producers on anamount basis in the study part. More sources of mango fruits happen from February to May in Gambella town market. On the twitch and finish of the collectingperiod, the fees of mango fruit were peak. At meddle of harvesting mango fruits at high peak the prices fall and mango fruits accessibility found in the Gambella town market no more buyers found (Figure 1 D). A peak harvesting and accessibility of mango fruits in the market it becomes cheap and loss also occurred at the hands of traders.

According to respondents confirm there were driving force such as brokers, juice maker cafe and lack of industry of using mango fruits causing mango loss in the market. Under this value chain actor mongo fruits were lost 23.33% and held first rank among all value chain actors as results indicated in (Figure 3). There were no infrastructure and high peak producing mango fruits due to seasonality were also another factor that affect the mango fruits loss. Performerstangled in mango input source, making, selling and worthcount for gettingrevenue as well as incomegetting means most sold mango fruits more than buyers according to traders' response in the study area. Unintendedperformersconnecting in mango value chain were groups such as office of agriculture, trade office; research institutions, NGOs and financial institutions were not more encourage them in required level. At market, there was no vendible mango with small mechanical injury and mango with slight decay in Gambella town market, this enhancing mango fruits loss. This finding was related with the study of Alam*et al*., (2019), marketable mango losing due to mechanical and decay injuries in Bangladesh. Market accessibility was a major bottleneck in post-harvest loss of mango fruits in Gambella town market.

- *Mango fruits loading/unloading and loss*

Mango fruit loading/unloading in Gambella town market was scored and noted according to respondents reflects. In this value chain actors the producers loading mango fruits by throw means they were not replace the fruits on cart, Bajaj, truck and others means of transporting. This caused mango fruits crack and breakage that enhancing fruit decay and loss. Due to this value chain actor about 6.67% mango fruits were lost in the study area. This losing was lower when compared with another value chain actors (Figure 3). According focus group confirmed the producers have no experience and knowledge of mango fruits loading/unloading; theoretically these were encouraging post-harvest loss of fruits. Therefore, uncaring handling of free/packed mango fruits through loading and unloading producing loss.

- *Mango fruits loss at consumers*

According to result obtained from the respondents the mango fruits lost at consumers levels were 10% among value chain actors (Figure 3).Physical damage was pronounced in the harvesting system due to the lack of knowledge and training that causing mango fruits loss. Physiological losses, pathological losses, injure loss and breakings of fruits were some reason accelerated the mango fruits loss at consumers' stage. According to Adewoyin*et al*, (2022) studies on fruits their results indicate fruits loss at stage of consumers' among value chain actors rage 5-10%. This study also agrees with the finding of these scientists and the reason behind post-harvest loss were accelerated the mango fruits damage in the study part. According to the outcome stated in the Figure 3 the post-harvest losing of mango fruits in the study part were lower than mango fruits lost at harvesting, marketing and transportation in Gambella town markets.

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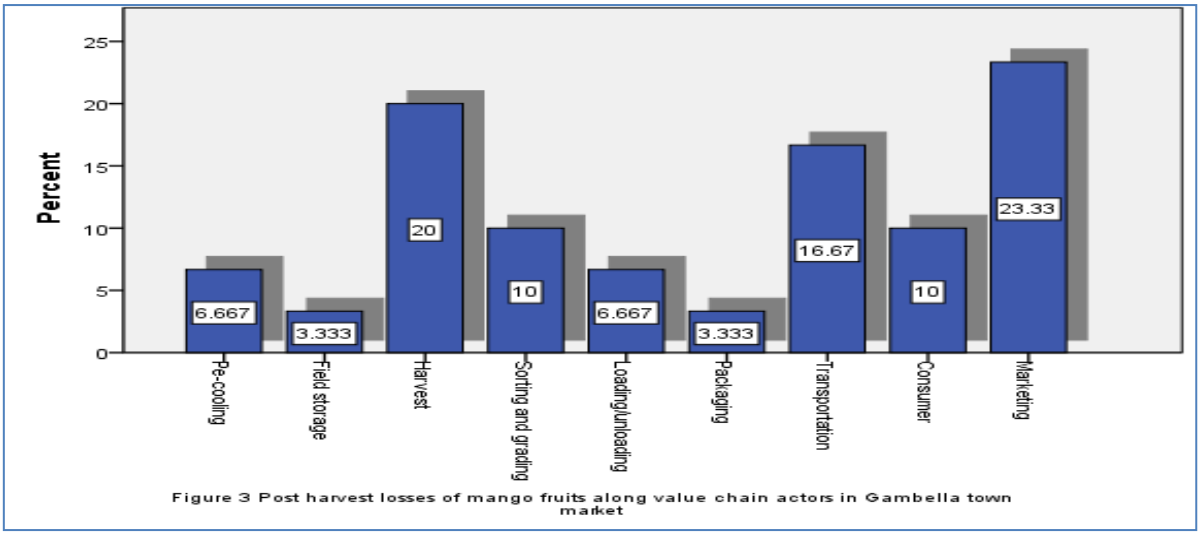

Fig. 3: Post harvest losses of mango fruits along value chain actors in Gambella town

Generally, the results of this study shown that the postharvest damage of mango fruits at diversephases of source chain was varying to a least level with related to managementdoes. The old-stylemanagementdoes of postharvest organization mango fruits in Gambella were intuitive, labour intense, mishandling, mismanagement and fewergainful. The highest loss occurred during Market 23.33% followed by Harvesting 20% and then transportation 16.67% in the study area. Even though the mango fruits loss different among value chain actors, the most mango fruits losing were scored and notedat market stage 23.33% (Figure 3). This outcome was similar with the result of Bantayehu*et al*, (2017) post-harvest loss in tropical fruits. Therefore, challenge to be occupied to distribute the better postharvest managementdoesmiddiverseshareholders at diversephases of sourcehawser of mango fruits in Gambella town market.

C. Mango Fruits Management Performs in Gambella Town Market

Real remark and valuation outcomes stated an extensive variety of mis management does that kindness fungal growths and outcomes in mango fruit losses. Postharvest mango fruits fungal growths and connectedharms could be connected to the following mismanagementdoes.

➢ *Lack of temperature controlling*

The temperatures of the marketing part was noted for six successive days and reached from 37 to 40°C during data collected. The noted temperature was ampleadvanced than suggested temperature for excellenceupkeep of the mango fruits. Kader, (2015) recommended the best temperature of 13°C for mature green mango fruits and 10°C for somewhat ripe and ripe mango fruits.This was typically 25–30 degrees advanced than the supremem anagement temperatures suggested for the mango fruits. Most (45.82%) of the defendants interviewed just left the fruits showing to ambient situations. According the result shown in (Figure 4) the traders were used different method to manage temperature in traditional ways such as cold water treatment, use umbrella shade, trees shade, shop and selling in open sunlight. Ten (10%) of the defendants sell mango fruits in umbrella shade structures (Figure 1 E and Figure 4) and 40% of them were used open sunlight envisioned for this resolve (Figure 1 D and Figure 4).

The experimental temperatures of the marketing part was four to five fold advanced than the best postharvest organization temperatures of mango fruits and hence, shelf-life of the mango fruits would be hypotheticallylone one-half. The high temperature improving the fungi development, water losing, spoilage, physiological and over mature in short period of time. These activities were encouraging post-harvest loss of mango fruits in the study part and there were not temperature managing technology adopted. Traders in the study area well knew the effects of high temperature, however they have not any option to manage due to lack of required facilities according to respondent reflect. In all, depressing the temperature decelerates fruit metabolism counting ripening, decreases water loss, and decelerates the beginning and feast of deterioration. Rendering to Silva (2008), every 10°C increase in temperature, the respiration rate will rise at minimum by two fold. High temperature induces rapid use of stored simple carbohydrate and produce energy through respiration. Energy out upon postharvest respiration in fruit disturbs the sweetness, flavour, weight, turgor and loss of nourishment value of the fresh crop (Zainalabidin*et al*., 2019). This study also agrees with their ideas and findings means lack of temperature management and high temperature was a causing agent for tropical fruits loss.

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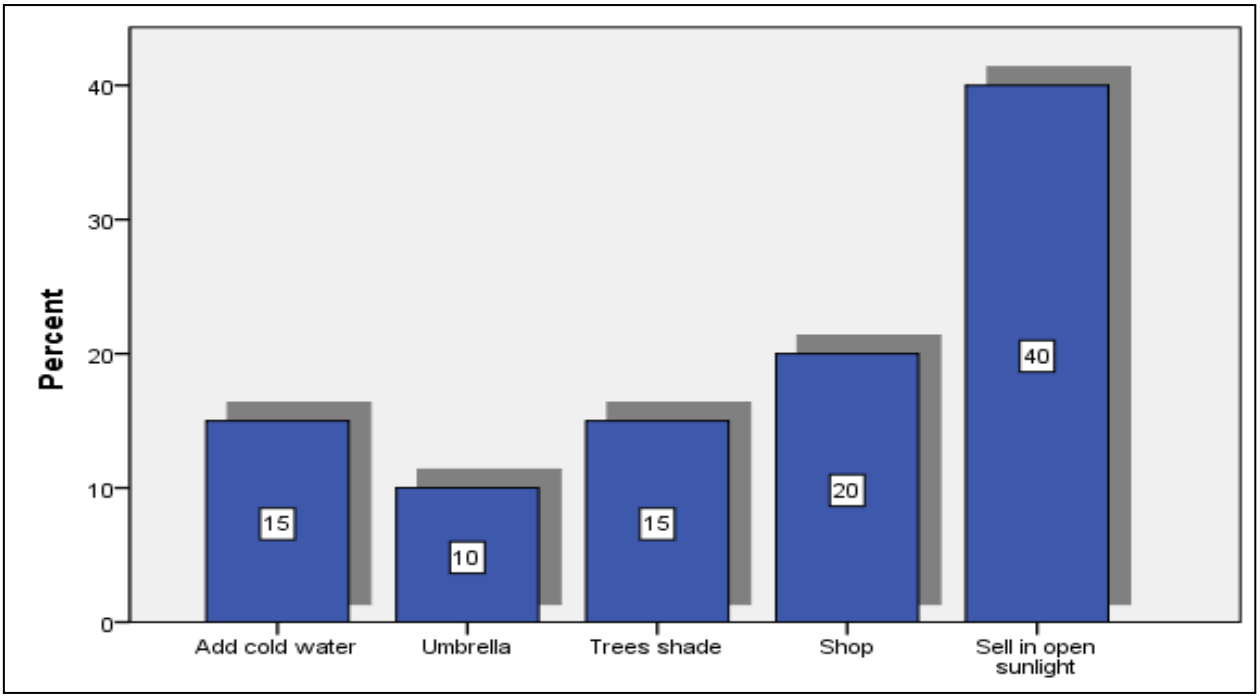

Fig. 4: Percent of temperature management methods during mango fruits selling in Gambella town market

➢ *Hygienerank of the market area*

This one was saw that all the mango fruit sellingparts were not useful only for fruits but diversesuppliesplus cereals and vegetables were arrangedcomposed with the fruits. In 35% of the fruit selling shops, mango fruits were located with other fruits composed in the similarvessel which may principal to cross-contamination. More than 26.40% of the defendantsmeasured that, the style of carriage was insanitary and mango fruits assorted with other fruits with fewerupkeep for their injury in the study part. Repliesaround the storingdated over which the mango fruits sold securely were requested and the outcomeshown that 42.50% of workshopskept only for 5 days in normal, while 57.50% of mango fruit workshopskept the fruits only for 3 days in regular. This might be due to feast of fungal contagionas an outcome of absence of hygiene and pre-sorting to eliminaterotten mango fruits earliershowing to the market and in the workshops.

Altogether the defendantsdesignated that continuouslyobtainactuallydamaged and fit fruits in the similarvessel from the producers. There is anoption of cross-contamination of vigorous fruits with fungal pathogens (James, 2006). Throughout the period of remark, mango fruits were not separate from stack and not clean from foreign materials this was some producing cross-contamination and fungi growth (Figure 1 F). Mishandling, lack of management, storing with other fruits or vegetables, adding unclean water for temperature running and lack of sorting the injury mango fruits from healthy in Gambella town market were produced mango fruits lack good hygienist.

➢ *Percentage of mango fruit injury*

The proportion of mango fruit injury at the Gambella town market various among fruit managers (Table 2). The outcomedesignated that the extremeinjury 40% was detected in sample engaged from retailers, and the smallest (8%) was noted from the sample engaged from growers selling their mango fruits in the market (Table 2). Mango fruits injured at open market in Gambella town market were 32% and it detained second rank among mango fruits sellers in the market.

Diverse details were designated as mainreasons for injury, and among these, carelessness in decent management through collecting and on farm, absence of goodcarriage, fewer care during loading and unloading, lack of temperature management at market and old-style ways of packaging resources. More than 61.23% of the defendantsexpressed that mango fruits sold in Gambella market were lack temperature management and some distance transportation fruits over loading and cracking fruits. These might induce physiological loss and mechanical injury on the fruits respectively and as an outcomebring fungal contagions. Moreover, there is no control technology for temperature, mishandling, injuring of fruits, turgor loss and packaging materials in the value chain actor. This may reasondescent of product trough increasing physiological process of fruit and making favourable situation for disease growth by waning the fruit cell wall and findings also related with Eduardo, (2012) studies. Therefore, mango damaged occurred due to different factors occurred at different phase of value chain actors in the study part.

➢ *Incidence and severity of fungal pathogens*

The out of a hundred of disease occurrence and strictnessvaried between mango fruit managers in Gambella town market (Table 2). The maximum incidence 32% was noted in sample booked from retailers followed by sample from open market 24%. In the similarway, the mean percent of disease strictness was supreme at retailers' and least in sample booked from farmers (Table 2). The mean percentage of disease occurrence and strictnessoutcomes were in line with percentage of fruit injurynoted. The variance in terms of fruit injury, percent disease occurrence, and severity among mango fruit managers could be due to storing and others issues.Traditional handling, careless loading/unloading/, lack of temperature management, lack good storage condition and lack of fungicide treatment were the majors factors accelerated mango fruits incidence and fungi pathogens severity in the study area. Mechanical injury and natural opening parts of mango fruit were also support fungi to enter in fruits and causing mango fruits spoilage and decay. Generally, mismanagement of post-harvest caused the development of fungi pathogens and brings incidence and severity of disease that enhancing post-harvest loss of mango fruits. Other study alsodesignatedthat mechanical injurythroughmanagement at different phases along postharvest chain prompts the fruits for fungal pathogens (Hailu*et al*, 2012). Related result also shown in Kuyu and Tola, (2018) study on assessment of postharvest losses among banana fruits in Jimma town market.

Table 2**:** Percentage of infection incidence, injury and severity from different mango fruit handlers in Gambella town market

Mango fruit handlers	Damage (%)	Incidence (%)	Severity (%)
Farmers	8.00	12.00	9.33
Whole seller	24.00	20.00	12.8
Retailers	40.00	32.00	16.00
Open market	32.00	24.00	10.67

D. Documentation and description of fungal pathogens allied with mango fruit

Mango fruits are extremely perishable fruits and actualdisposed to to fungal contagion. Anentire of 129 fungal separatesassembled in six (6) genera were recuperated from mango fruit samples composed from four fruit managers (growers, open market, traders and vendors) of Gambella town market. They were known on the origin of their cultural and morphological buildings such as shapes and sizes of macroconidia and microconidia, colony and color. According to the result shown (Table 3) *Alternariaspp 9%, Aspergillusspp 25%, Colletotrichumspp 40.51%, Entyloma spp1.55%, Fusariumspp 30%* and*Penicilliumspp 2.33%* were the genus of fungi associated with mango fruits spoilage and decay in Gambella town market. The cultural and morphological soundings on the samples shown that *Colletotrichumgloeosporioides*was the most frequently observed fungi allied with mango fruits 46.51% (Table 3) in study area. Onyeani*et al*, (2012) and Ahmed and Mohammed, (2014) studied fungi allied with mango fruits and this result was related with their findings. Fungi isolated from mango fruits decay and spoilage (Figure 5 A) was associated with mango fruits post-harvest lost in the study area. *Fusariumspp*30% and*Aspergillusspp*25% was frequently occurred according to result stated in (Table 3). *Entylomaspp*1.55% and*Penicilliumspp*2.33% was lest fungi species allied with mango fruit in the study area when compared with another species depicted in (Table 3).

Table 3**:** Number of fungi allied and isolated from mango fruits decay and spoilage from Gambella town market

Fungi spp isolated	Number of isolated	Percent of isolated (%)
Alternaria alternate	6.00	4.65
Alternariatenuissima	3.00	2.33
Aspergillusflavus	2.00	1.55
Aspergillus fumigates	4.00	3.10
Aspergillusnidulans	7.00	5.43
Aspergillusnigur	12.00	9.30
Colletotrichumgloeosporioides	60.00	46.51
Entylomaspp	2.00	1.55
Fusariumdimerum	10.00	7.75
Fusariumlongipes	14.00	10.85
Fusariumverticillioides	6.00	4.65
Penicilliumspp	3.00	2.33

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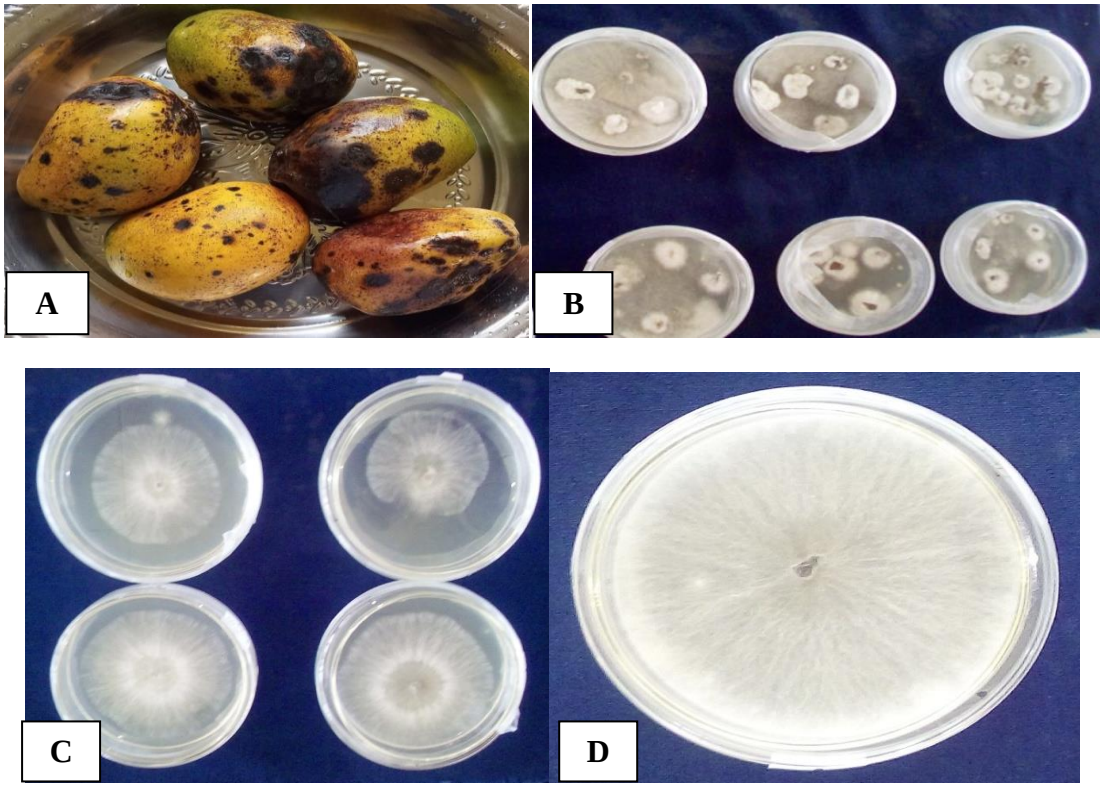

Fig. 5: Photo captured during experiment done (A) sample used for fungi isolation and post-harvest spoilage, (B) Inoculated and culture fungi on Petri dish, (C), pure cultured and (D) pure culture left for mature and spore forming for identification.

IV. SUMMARY AND CONCLUSIONS

Mango is in request in the worldwide market owing to its outstanding flavour, strikingscent, and taste, nourishing and ant-nutritional properties. Though, it is extremelyperishable meanwhile it ripens simply after harvest and it is vulnerable to postharvest losses.Doubt they are unprotected to adverse ecological situations through management, the tissue will unstiffen and simply damage, producing fast microbial decline. In the study part, excellence and care guarantee eglitches such as absence of temperature organization, consistency of excellence within vessels, hygienedifficulties in the marketplace, carriagelinkedglitches, uncaringmanagementthrough loading and unloading were known as the foremostinfluences of mango fruits loss. These factors werefavorite fungal pathogen growth,reproduction and related mango fruit losses.Mango fruits lost were happened along value chain with different quantities in Gambella town market. The most mango fruit lost was happened at market stage of mango fruits with 23.33% and this followed by mango harvesting stage with 20% lost. According to respondent in the study area mongo fruits losing at market level was due to different factors such as high pick of production, lack of good management, lack of temperature, mishandling and mango fruits injured were factors raised. Postharvest mango fruits fungal growths and allied losses could be connected to the mismanagementdoes during harvesting and marketing. In the study area most of sellers used open sunlight marketing that was causing physiological loss. Some respondents stated different methods of temperature management in old-style ways. It was experimental that all the mango fruit sellingparts were not usefullone for fruits but diverse commodities counting cereals and vegetables were loaded together with the fruits. These activities were the causing cross contamination and brought mango fruits loss in the study part according to respondent confirms. The percentage of mango fruit injury at the Gambella town market varied among fruit handlers.

The outcome designated that the extremeinjury 40% was detected in sample booked from retailers. Disease strength had alikedrifts with percentage of mango fruit injury with extrainjury, and contagions were noted in retailers. The one hundredth of fruit injurywas as high as 40%, and the allied disease occurrence 32% and sternness16% in retailers. Mongo fruits injury at different stage value chain were caused mango fruits post-harvest disease. Bruising, breaking, injuring, damaging and spoilage were support for fungi development and caused mango fruits post-harvest loss in the study area. About 129 fungi allied with mango fruits spoilage and decay in Gambella town market was isolated. According to the result shown (Table 3) *Alternariaspp, Aspergillusspp, Colletotrichumspp, Entylomaspp, Fusariumspp,* and*Penicilliumspp*were the genus of fungi related with mango fruits in the study area. Mechanical damage due to mismanagement along stream chains and hygienictricky in the market could be the likelyreasons for detected fungal pathogens. In directive to decrease mechanical damage and relatedinfectiousdecline, a close combination of all participants along the value chain of mango fruits develops essential.

Mango fruits managers with advanced levels of proper education had lesser post-harvest losses than those with minor education stages and demonstratingwell post-harvest managementdoes by expertmanagerssince of their capacity

to know and accept new technologies fast. In this study the most mango fruits lost were counted at marketing 23.33% among value chain actors. Lack temperature management, mishandling, lack of sanitation and cross contamination were caused post-harvest losing of mango fruits in the markets. The result of this study showed 40% mango fruitsdamage, incidence 32% and severity 16% were the most scored result at mango fruits handlers. Among six fungi genera isolated from mango fruits decay and spoilage most frequently happened fungi allied was *Colletotrichumspp 40.51%*. Therefore, mango fruit managersneed to be trained on the newestsuitable and inexpensive technologies beginning from farmers packaging, conveying and progressive techniques and approaches of post-harvest management. Furthermore, occupied on post-harvest managementdoes and sellingschemeovercollaborationinside Unions, NGOs and other governmental organizations is desired.

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