AN APPLICATION OF PARETO ANALYSIS AND CAUSE-AND-EFFECT DIAGRAM IN RAW HIDE AND SKIN DEFECTS MINIMIZATION IN ETHIOPIA: SELECTED CASE DIRE DAWA CITY SLAUGHTERHOUSE (ETHIOPIA)

Berihun NEGASH[*]

Dire Dawa University, Institute of Technology, Postal Address: 1362, Postal Code: 3000, Dire Dawa, Ethiopia, email:

negashber2005@gmail.com

AN APPLICATION OF PARETO ANALYSIS AND CAUSE-AND-EFFECT DIAGRAM IN RAW HIDE AND SKIN DEFECTS MINIMIZATION IN ETHIOPIA: SELECTED CASE DIRE DAWA CITY SLAUGHTERHOUSE (ETHIOPIA)

ABSTRACT. According to the reports of CSA (Central Statistics Agency) 2020 Ethiopia is the 10th in the world and 1st in Africa by cattle production. Furthermore, the leather sector is the priority sector in Ethiopia. Leather industries are facing challenges in improving productivity and quality in the competitive market nowadays. The input materials for leather industries are goat and sheep skin, and cattle hide in Ethiopia. However, there are raw hide and skin defects due to preslaughter, during slaughter and post-slaughter process. This study focuses on the minimization of the major defects in preslaughter and during the slaughter of raw hide and skin process by application of Pareto analysis and fishbone diagram in Ethiopia in the case of Dire Dawa city. The Pareto analysis reveals that priority should be given to solving the problems of pre-slaughter and during-slaughter defects of raw hide and skin. Based on cause-and-effect diagram analysis, the main causes are: machine, material, environment, man, measures and management, root causes, heated metal shape for brand mark, during diseases different action is taken, hit animal using different steel, grass used for food, animals home making material, drinking water, stick, topography, hot area, old area, lack of awareness about hide and skin outputs, traditional methods of water in forage for the animals during farming, traditional methods used for medications for raw hide and defects identified. Finally, a few recommendations are made to reduce raw hide and skin defects.
KEY WORDS: raw hide and skin quality management in preslaughter and during slaughter, leather, Pareto and fishbone diagram

O APLICAȚIE A ANALIZEI PARETO ȘI A DIAGRAMEI CAUZĂ-EFECT ÎN MINIMIZAREA DEFECTELOR PIELII BRUTE ÎN ETIOPIA: STUDIU DE CAZ – ABATORUL DIN DIRE DAWA (ETIOPIA)

REZUMAT. Potrivit rapoartelor CSA (Agenția Centrală de Statistică) din 2020, Etiopia este pe locul 10 în lume și pe primul loc în Africa la producția de vite. În plus, sectorul de pielărie este sectorul prioritar în Etiopia. Industria de pielărie se confruntă în prezent cu provocări în ceea ce privește îmbunătățirea productivității și calității pe piața competitivă. Materiile prime pentru industria de pielărie din Etiopia sunt pieile de capră, de oaie și de bovine. Cu toate acestea, există defecte ale pielii brute apărute în urma prelucrării înaintea, în timpul și după sacrificare. Acest studiu se concentrează pe minimizarea defectelor majore ale pieilor brute în etapa de dinaintea sacrificării și în timpul sacrificării prin aplicarea analizei Pareto și a diagramei cauză-efect în cazul orașului Dire Dawa din Etiopia. Analiza Pareto dezvăluie că trebuie să se acorde prioritate soluționării problemelor defectelor pielii brute înaintea și în timpul sacrificării. Conform analizei diagramei cauză-efect, s-au identificat cauze-rădăcină ale defectelor pielii, împărțite în patru mari categorii, și anume defecte cauzate de utilaje, mediu, om, de natură materială, care includ: forma metalului cu care se marchează animalul, diferite acțiuni întreprinse în timpul îmbolnăvirii, scarificarea animalului folosind tipuri diferite de oțel, iarba folosită pentru hrană, materialele din care sunt făcute adăposturile animalelor, apa potabilă, ustensilele folosite, topografia, zona fierbinte, zona veche, lipsa de conștientizare privind destinația pielii, metode tradiționale de a hrăni și adăpa animalele, metode tradiționale de a trata animalele cu medicamente. În cele din urmă, se fac câteva recomandări pentru a reduce defectele pielii brute.
CUVINTE CHEIE: gestionarea calității pielii brute înaintea și în timpul sacrificării, piele, analiza Pareto și diagrama cauză-efect

UNE APPLICATION DE L'ANALYSE DE PARETO ET DU DIAGRAMME DE CAUSES ET EFFETS DANS LA MINIMISATION DES DÉFAUTS DE LA PEAU EN ÉTHIOPIE : CAS SÉLECTIONNÉ DE L'ABATTOIR DE LA VILLE DE DIRE DAWA (ÉTHIOPIE)

RÉSUMÉ. Selon les rapports du CSA (Agence Centrale des Statistiques) de 2020, l'Éthiopie se classe au 10e rang mondial et au 1er en Afrique pour la production bovine. Par ailleurs, le secteur du cuir est le secteur prioritaire en Éthiopie. L'industrie du cuir est actuellement confrontée à des défis pour améliorer la productivité et la qualité sur un marché concurrentiel. Les matières premières pour les industries du cuir en Éthiopie sont la peau de chèvre, de mouton et de bovin. Cependant, il y a des défauts dans le cuir brut résultant de la transformation avant, pendant et après l'abattage. Cette étude se concentre sur la minimisation des défauts majeurs des peaux brutes au stade de pré-abattage et pendant l'abattage en appliquant l'analyse de Pareto et le diagramme de causes et effets au cas de Dire Dawa, en Éthiopie. L'analyse de Pareto révèle que la priorité devrait être accordée au traitement des défauts de la peau brute avant et pendant l'abattage. Selon l'analyse du diagramme cause-effet, les causes profondes des défauts cutanés ont été identifiées, réparties en quatre grandes catégories, à savoir les défauts causés par les machines, l'environnement, l'homme, la nature matérielle, qui comprennent : la forme du métal avec lequel l'animal est marqué, les différentes actions menées pendant la maladie, la scarification de l'animal à l'aide de différents types d'acier, l'herbe utilisée pour l'alimentation, les matériaux dont sont faits les abris pour animaux, l'eau potable, les ustensiles utilisés, la topographie, la zone chaude, la zone ancienne, la méconnaissance de la destination de la production de cuir, les méthodes traditionnelles d'alimentation et d'abreuvement des animaux, les méthodes traditionnelles de traitement des animaux avec des médicaments. Enfin, quelques recommandations sont faites pour réduire les défauts de la peau brute.
MOTS CLÉS : gestion de la qualité des peaux brutes avant et pendant l'abattage, cuir, analyse de Pareto et diagramme de causes et effets

[*] *Correspondence to: Berihun NEGASH, Dire Dawa University, Institute of Technology, Postal Address: 1362, Postal Code: 3000, Dire Dawa, Ethiopia, email: negashber2005@gmail.com*

INTRODUCTION

The words "hides and skins" are often used interchangeably; however, according to the British standard definitions, hide is the raw skin of mature animals of larger kinds, such as cattle, horses, and other large animals [1]. Raw hide and skin, the main byproducts of the meat industry are the basic raw materials for the leather industry [2]. Raw hides and skins, the most valuable byproduct of the meat industry, are normally converted into leather [3].

The bovine animal hide and ovine animal skin have different steps to convert them into different leather products. Generally, leather is the output of hide and skin. According to the reports of CSA (Central Statistics Agency) 2020, Ethiopia is the 10th in the world and 1st in Africa by cattle production. However, in Ethiopia, there is a high incidence of raw hide and skin defects caused by different mechanisms or sources. Generally, the defects happen during pre-slaughter, during slaughter, and post-slaughter process. The leather industry is one of the fastest-growing economic sectors in Ethiopia [4]. The 26 operational tanneries in the country have a soaking capacity for 15,650 sheep and goat skins and 9,725 cattle hides per day [5].

The leather sector in Ethiopia faces several challenges. Large numbers of hides and skins are discarded or their quality is substantially reduced by factors that can be avoided. Some of these factors are inherent to the production structure and animal husbandry practices, whereas others arise from the dispersal of the slaughter facilities, unfavorable marketing structures, poor handling (e.g., presentation and transportation) of the raw stock, and insufficient collection and preparation for further processing and export [6]. In pre-slaughter stage or cattle cultivation, breeding and different traditional cattle handling systems affect the raw hide and skin during the growth of the animal. During the slaughter of animals a lot of defects can occur due to the lack of awareness of the abattoirs or butchers, due to using traditional facility, lack of awareness about stunning animals before slaughtering, and position during slaughtering, affecting the quality of raw hides and skins in Ethiopia. This study focuses on analysis of raw hide and skin defects in pre slaughter stage and during slaughter using Pareto analysis and cause and effect diagram to recommend the solutions.

Hides and skins are important economic products contributing to the largest share of the total and agricultural export commodities followed by live animals in Ethiopia [7]. The ones who bear the greatest responsibility in delivering high-quality raw hides and skins to the tanneries are the traders, thus playing a key role in the tanneries' economic viability [8].

Skins and hides defects are classified into two main groups. The first group is those created or acquired during the life of the animal (pre-mortem defects) and the second group is those that occur during and after the slaughtering of animals (post-mortem defects) [9]. This study focuses on preslaughter and during slaughter stages to minimize raw hide and skin defects because for post-slaughter stage there is no tannery or other industry in Dire Dawa.

Pre-Slaughter Defects

The pre-slaughter defects include cockle, which is due to an allergic skin hypersensitivity reaction to parasitic infestation, grain scratches, pox lesions, warts, tick damage,

branding, age (shrinkage) and poor substance (thickness of the skin or hide, toughness of the fibres and the closeness of the texture of the fibres). The following defects are the same defects happening in Ethiopian cattle cultivation (Figures 1-3, source: https://www.iowabeefcenter.org/bch/CongenitalDefectsCattle.pdf; Figure 4, source: https://encrypted-tbn0.gstatic.com/images, and Figure 5, source: https://www.mdpi.com/2076-2615/8/8/13).

Figure 1. Hairlessness (hypotrichosis) in a calf

Figure 2. Extra toes (polydactyly)

Figure 3. Weaver calf

Figure 4. Brand mark

Figure 5. Fire-heated irons used for branding on farm

During Slaughter Defects

The major slaughter defects are fly cuts (scores), holes (a complete perforation of the skin or hide resulting from a knife or flaying appliance), poor pattern (an asymmetric skin or hide due to bad opening cuts or distortion during drying because of uneven tension), and vein marks (traces of blood vessels in the skin where the blood was not completely drained).

Figure 6. Lack of skill in the slaughtering house
Source: Addis Ababa Abattoirs enterprise

Figure 7. Lack of skills in traditional slaughtering
Source: Photo taken in Raya region in 2018

To the best of my knowledge, there is no study that focuses on raw hide and skin defect minimization in pre-slaughter and during slaughter stages or Pareto diagram and fishbone diagram implementation in literature concerning raw hide and skin defects. Importantly, motivation from a real-life leather industry problem in the context of Ethiopia drives me to conduct this study. The researcher thus believes this study has practical managerial application in a slaughterhouse to minimize the defects of raw hide and skin in Ethiopia, Dire Dawa city.

EXPERIMENTAL

Material and Methods

Cattle hide, goat and sheep skins were used for this study to minimize the defects in preslaughter, during slaughter and post slaughtering process in Dire Dawa city. To minimize the defects in each process, a checklist was used for gathering and organizing the frequency or defect data, a Pareto chart was used to prioritize the defect to solve the problem based on the 80/20 rule, and a cause-and-effect diagram to identify the root causes, main cause and to overcome the problems at each stage.

An Overview of the Pareto Chart and Cause-and-Effect Diagrams

The Pareto chart is useful for non-numeric data, such as 'cause', 'type' or 'classification', and is useful to prioritize where action and process changes should be focused and are commonly used for identifying the downtime and other wastages. It uses bar diagrams to sort problems based on frequency, severity, nature, or source and displays the size of which problems are vital ones [10]. Pareto analysis helps to identify different defects and classify them according to their significance. These defects often lead to the rejection of raw materials [11]. Pareto chart is important to give priority based on frequency, time, and costs and to solve it by the 80/20 rule.

To determine possible root causes of rejection, the Cause-and-Effect Diagram (CED) is also a very useful tool. It helps to identify, sort, and display the causes of a specific problem or quality characteristic. It graphically illustrates the relationship between a given outcome and all the factors that influence the outcome and hence identifies the possible root causes i.e., basic reasons for a specific effect, problem, or condition [11]. Fish bone diagram was used to show the relationship among all possible grouped causes and main cause [12]. Therefore, in this study cause and effect

diagram helps to identify the root cause of defects in preslaughter and during the

slaughter of bovine and ovine animals in Ethiopia (Dire Dawa slaughterhouse).

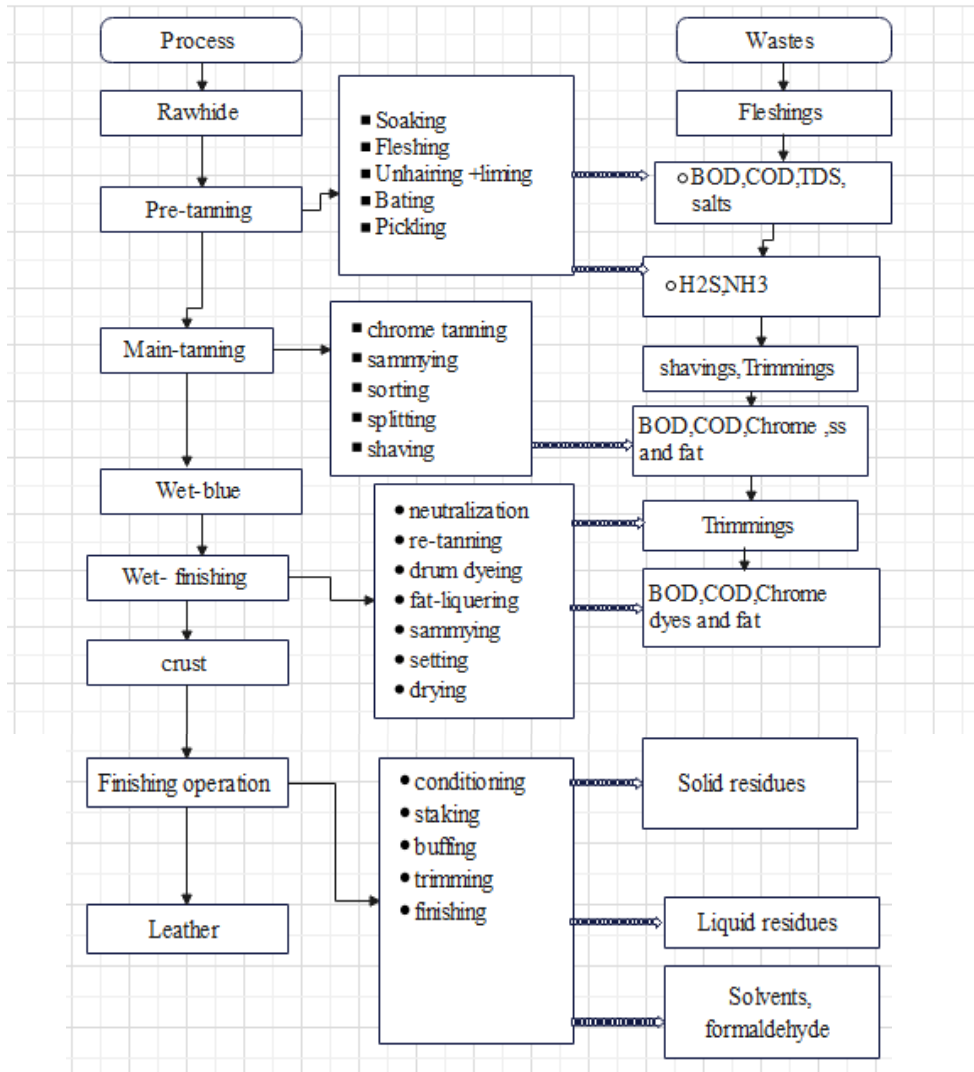**An Overview of Leather Processing in Ethiopia**

Figure 8. Leather processing in Ethiopia

Leather processing involves converting raw hides and skins into finished leather, by carrying out processes such as soaking, fleshing, unhairing, bating and pickling in the first stage. The above figure shows different processes for converting raw hide and skin into leather by using different mechanisms, process parameters and technical parameters.

Figure 1 illustrates the process flow chart of leather manufacturing. Raw hides and skins are collected from different parts/areas of Ethiopia and preserved in raw hide and skin storehouse. Using a soaking drum, the soaking operation is carried out to remove blood, salts and other external materials. Then, liming process is carried out on the flesh side to remove the hair from the skin or hide. Deliming process is done with different chemicals to open up the fiber of skin or hides and make them suitable for bating, pickling and tanning process. As shown in the above figure the raw hide chrome tanning is applied in Ethiopia and the wet blue leather is passed through

different mechanisms and processes to produce finished leather outputs.

Methodology

The study was conducted on slaughter house in Dire Dawa where cattle were flayed for meat production. Data were collected from the slaughter house where fresh raw hide and skin were collected. The raw hides and skins have defects due to different root causes. A Pareto chart was constructed to analyze the defects and to identify significant rejections of raw hide and skin.
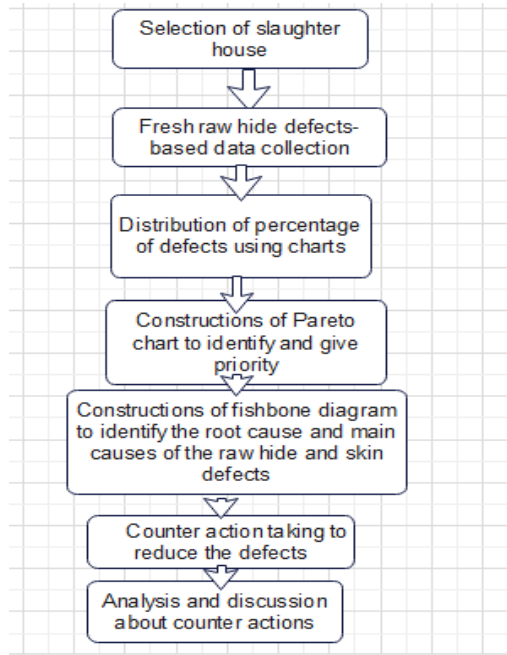

Figure 9. Research design framework

Data Collection and Analysis

Table 1: Raw hide and skin defects analysis using Pareto chart at preslaughter stages

Types of defects observed at slaughter	Number of defects happening during growth	0.0%
Cockle	1500	22.8%
Shrinkage	1000	38.1%
Scratch	950	52.5%
Brand marks	870	65.8%
Pox lesions	800	77.9%
Pox lesions	720	88.9%
Scar from wounds	400	95.0%
Tick mark	250	98.8%
Poor substance	80	100.0%

From Table 1 the data showed the frequency of different defects occurring in different stages but not ordered based on Pareto analysis principles. The defects occurring with a higher frequency at slaughter stage are cockle (1500), shrinkage (1000) and others listed above, due to different reasons. Therefore, in the pre-slaughter stage, raw hide and skin defects affect the leather quality. Proper handling system, creating awareness

for cattle cultivators (husbandry stages), solving genetics problems, and their feeding system are very important to minimize pre-slaughter raw hide and skin defects.

Furthermore, prioritizing has been done to use for Pareto chart analysis.

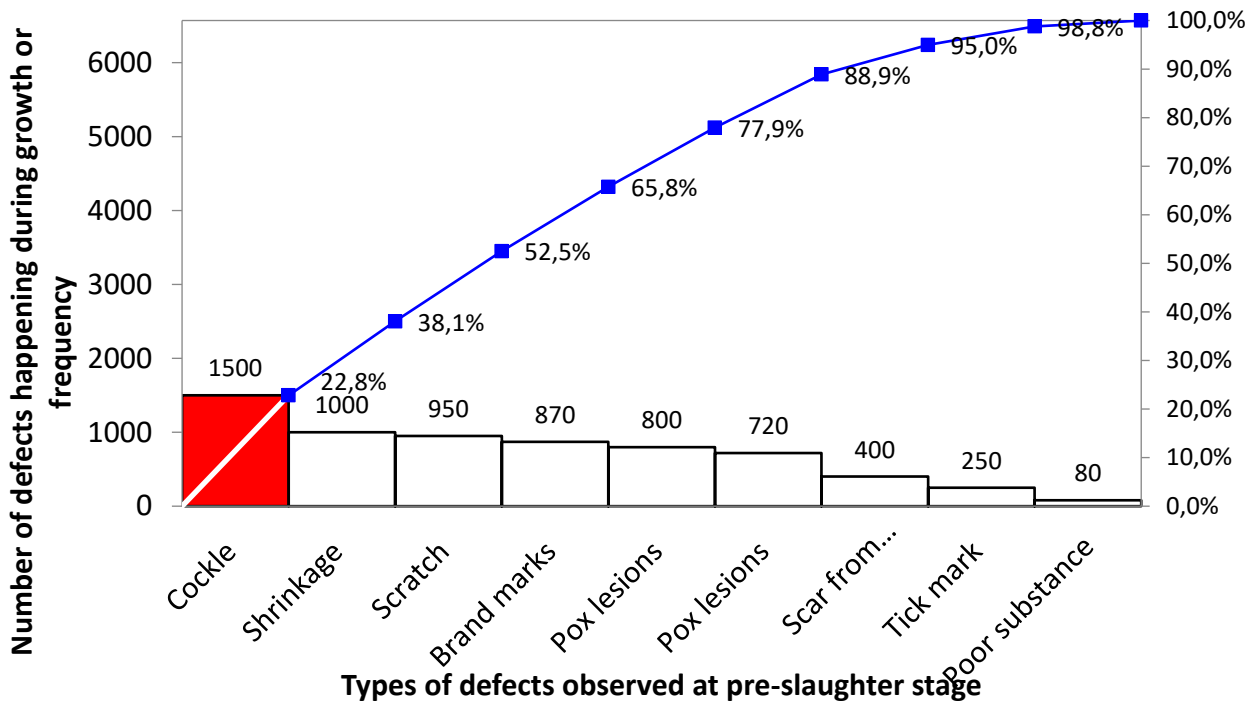**Number of defects happening during growth or frequency**

Figure 10. Pareto chart analysis in pre-slaughter stage

From the Pareto analysis (Figure 10), it is seen that the most significant source of defects of raw hide and skin in the preslaughter stages is cockles (22.8) and the second is shrinkage

(38.1). Here, the cockle and shrinkage are the few factors causing 60.9% of raw hide and skin defects.
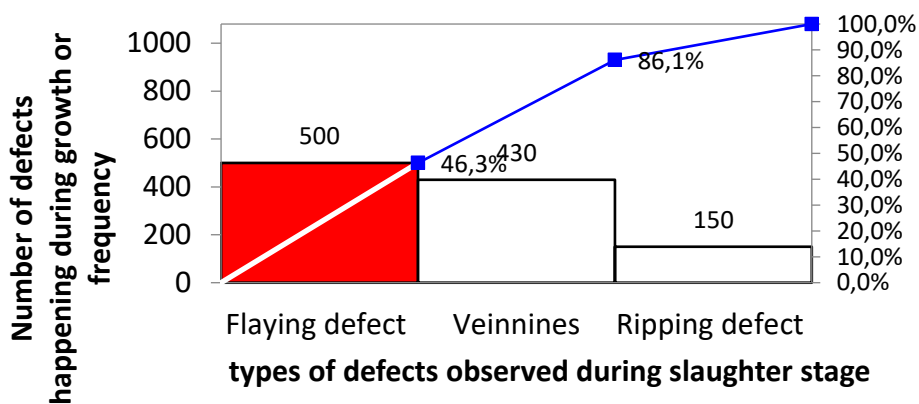
Number of defects happening during growth or frequency

Figure 11. Pareto chart analysis in slaughtering stage

From the Pareto analysis (Figure 11), it is seen that the most significant source of defects of raw hide and skin during the slaughtering stage is flaying (46.3), followed by veininess (86.1). Here, the flaying and veininess are the few factors causing 132.4% of raw hide and skin defects.

In both cases, Pareto chart principle or 80/20 rule can be applied in this process and by removing 20% of the major defects we can improve 80% of the leather product and satisfy our customers' needs.

Cause-and-Effect Diagram Application in Raw Hide and Skin Defect in Preslaughter of Cattle
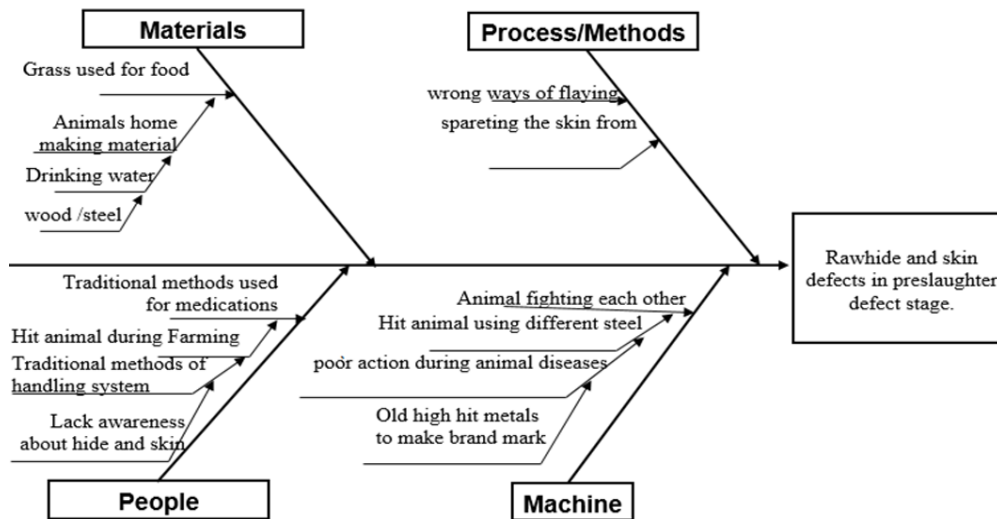

Figure 12. Cause and effect diagram application in preslaughter stages

The cause-and-effect diagram for raw hide and skin defects is illustrated in Figure 12, the main causes for raw hide and skin defects in the preslaughter stages are categorized on the basis of the influence of peoples, machines, materials, and processes/ methods. Due to a lack of skills/awareness of husbandry, traditional methods of handling animals during farming and traditional methods used for medications. For machine-related causes, heated metal shape for brand mark, poor action during animals' diseases, hit animals using different steel and animals fighting each other and the root cause of materials, grass used for food, animal home making material, drinking water and wood/steel for animals' houses. Furthermore, in the process of flaying, the root causes of raw hide and skin defects are the wrong ways of separating skin or hide from the corpse.

Cause-and-Effect Diagram Application in Raw Hide and Skin Defects During Slaughtering Process
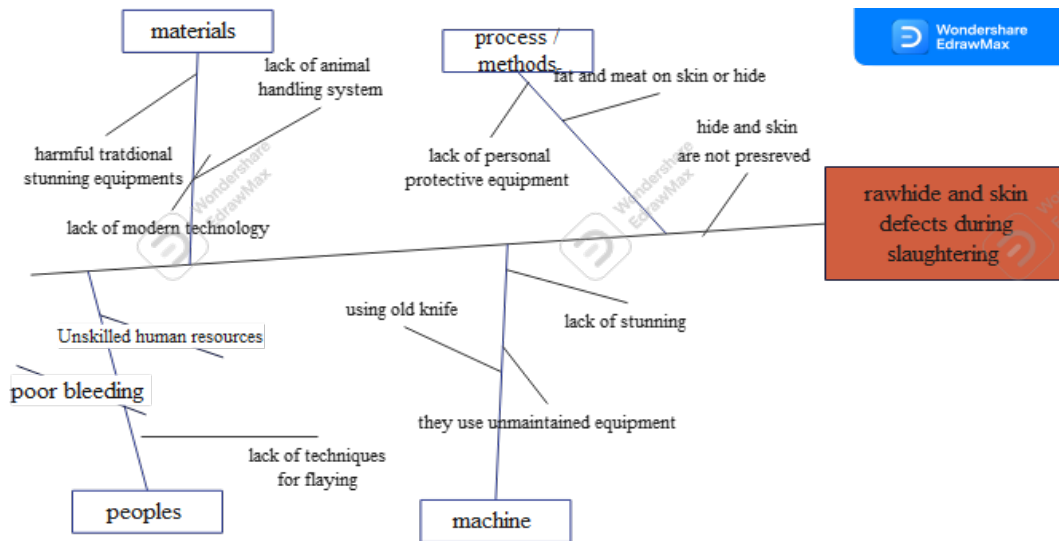

Figure 13. Fishbone diagram analysis during slaughtering process

The cause-and-effect diagram for raw hide and skin defects is illustrated in Figure 13, showing the main causes for raw hide and skin defects during slaughtering stages are categorized on the basis of the influence of people, machine, materials, and processes/methods. A lack of skills/awareness of butchers, poor bleeding, and inappropriate methods of flaying, are affecting the quality of raw hide and skin during slaughtering. Machine-related causes include old or unsuitable knives, no use of stunning/electronic or mechanical equipment, poor quality steel. High skin or hide-defected animals, traditional stock used to fall down the animals, poor quality gloves, poor quality footwear, and poor protective clothes are the root causes of raw hide and skin defects in terms of materials and processes.

RESULTS AND DISCUSSIONS

Table 2 shows that the main causes (machine, processes/ methods, people and materials) have their own root causes that affect the quality of raw cattle hide and goat (sheep) skins. Therefore Table 2 showed that main causes and root causes of raw hide and skin were identified and corrective actions were recommended for minimizing the defects of raw hides and skins. Hence, by implementing the corrective actions, the defects of the raw hide and skins were minimized in the pre-slaughter stage.

Table 2: Recommended actions for pre-slaughter hide and skin defects

S. No.	Main causes	Root causes	Recommended corrective actions to minimize the raw hide and skin defects
1	Machine	• Old high-hit metals to make brand marks	✓ Equipment used for stunning and correct stunning position
		• Poor action during animal disease	✓ Stunner in the correct position
		• Hit animals using different steel	✓ Using scientific medications for animal health
		• Animals fighting each other	✓ Prepare handling in the husbandry stage
2	Process/methods	• Wrong ways of flaying	✓ Sterilize the cutting knife in water at 82°C
		• Separating the skin from meat	✓ Remove head after skinning

S. No.	Main causes	Root causes	Recommended corrective actions to minimize the raw hide and skin defects
3	People	• Lack of awareness about hide and skin • Traditional methods of handling system • Hit animals during farming • Traditional methods used for medications	✓ Do not leave any hair or skin pieces on the skin or hide ✓ Do not leave the carcass to bleed while flaying ✓ Create awareness about the advantages of raw hide and skin ✓ Acquiring knowledge for husbandry about handling of their cattle, goat and sheep. ✓ Using systems and technologies for farmers
4	Materials	• Grass used for animal food • Animal home making materials • Drinking water, wood/steel	✓ Animals presented for slaughter should be sufficiently clean ✓ Animals be allowed enough rest (24 hours) before slaughter to improve quality of meat and hides and skins ✓ The animals should be given a good drink of water for cooling them down and facilitating the loosening of the attachment between the hide/skin and the flesh for ease of flaying ✓ Good animal rest pre-slaughter

As shown in Table 3, the main causes (machine, process/method, people, and materials) and root causes that affect the raw hide and skin quality during the slaughtering process in Dire Dawa city. As a result, the recommended actions were important to minimize the defects of cattle hide and sheep/goat skin during the slaughtering process in the Dire Dawa slaughterhouse (Dire Dawa administration city).

Table 3: Recommended corrective action during the slaughtering stage

S. No.	Main causes	Root causes	Recommended corrective actions
1	Machine	• Unsuitable knife • Poor quality steel • Using old facility • Not using electronic or mechanical stunning methods	✓ Flay cuts, scores and gouges ✓ Use clean hooks, knives and protective clothes ✓ Good quality and modern knives ✓ Using electronic and mechanical stunning methods
2	Process/ Methods	• Leaving meat/fats in the skin or hide • Not removing heads after skinning • Unpreserved raw hide and skin • Poor quality of protective apron, cloth and gloves	✓ Using proper methods to remove fats to get high-quality skin and hide ✓ Fresh raw hide should be properly preserved
3	People	• Unskilled human power • Wrong methods of flaying • Poor bleeding	✓ Best bleeding practice ✓ Used flaying sequence operations ✓ Using the best evisceration technique

S. No.	Main causes	Root causes	Recommended corrective actions
4	Materials	• High skin or hide defective animals • Traditional rope to fall down the animals for slaughtering • Poor quality glove • Poor quality footwear • Poor protective apron	✓ Checking the skin of animals during slaughtering to prevent defects ✓ Instead of using traditional methods of rope to fall down the animals better to use electronic or mechanical stunning methods ✓ Good quality glove ✓ Good quality footwear ✓ Good protective apron

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

Raw hide and skins are one of the most common problems in the leather manufacturing industry in Ethiopia. It should be minimized to ensure the highest quality level of the raw hide and skin at pre-slaughter and during slaughter stages. In this work, Pareto analysis and cause-and-effect diagram are used to identify and evaluate different types of defects that occurred in the Dire Dawa slaughterhouse. After Pareto analysis, it is found that cockle and shrinkage constitute above 80% of total defects at pre-slaughter stage. Furthermore, the raw hide and skin defects during the slaughter process are analyzed using a Pareto chart that shows 86.1% of defects of raw hide and skin can be minimized by using 80/20 rules. Then root causes of the raw hide and skin defects at preslaughter stages are analyzed using a cause-and-effect diagram. Four different main cause areas and different types of root causes that are responsible for raw hide and skin defects at pre-slaughter and during slaughter stages are found. Finally, a few corrective actions are taken and some suggestions are recommended for minimizing raw hide and skin defects to increase the quality and productivity of Ethiopian leather industry.

REFERENCES

1. Adem, M., Production of Hide and Skin in Ethiopia; Marketing Opportunities and Constraints: A Review Paper, *Cogent Food Agric*, **2019**, 5, 1, https://doi.org/10.1080/23311932.2019.1565078.

2. Sarker, M.I., Long, W., Liu, C.K., Preservation of Bovine Hide using Less Salt with Low Concentration of Antiseptic, Part I: Effectiveness of Developed Formulations, *J Am Leather Chem Assoc*, **2017**, 113, 1, 12-18.

3. Wu, J., Zhao, L., Liu, X., Chen, W., Gu, H., Recent Progress in Cleaner Preservation of Raw Hides and Skins, *J Clean Prod*, **2017**, 148, 158-173, https://doi.org/10.1016/j.jclepro.2017.01.113.

4. Abadi, Y., Current Problems of the Leather Industry, in: R.C. Merkel, G. Abebe and A.L. Goetsch (eds.), *The Opportunities and Challenges of Enhancing Goat Production in East Africa*, Proceedings of a conference held at Debub University, Awassa, Ethiopia from November 10 to 12, **2000**, pp. 139-143.

5. United Nations Industrial Development Organization, Annual Report 2008, Industrial Development Board, Vienna, **2009**.

6. Kahsay, T., Negash, G., Hagos, Y., Hadush, B., Pre-slaughter, Slaughter and Post-slaughter Defects of Skins and Hides at the Sheba Tannery and Leather Industry, Tigray Region, Northern Ethiopia, *Onderstepoort J Vet Res*, **2015**, 82, 1, https://doi.org/10.4102/ojvr.v82i1.931.

7. Alemnesh, B., Getachew, T., Tariku, J., Assessment of Quality and Marketing of Hide and Skin in Adamitulu Jidokombolcha and Bora Woreda in East Shewa Zone of

Oromia Regional State, Ethiopia, *Int J Livest Prod,* **2018**, 9, 10, 269-279, https://doi.org/10.5897/IJLP2017.0372.

8. Jabbar, M.A., Kiruthu, S., Gebremedhin, B., Ehui, S., Essential Actions to Meet Quality Requirements of Hides, Skins and Semi-Processed Leather from Africa, A Report Prepared for The Common Fund for Commodities, Amsterdam, The Netherlands, **2002**.

9. Tolossa, Y.H., Skin Defects in Small Ruminates and Their Nature and Economic Importance: The Case of Ethiopia, *Glob Vet,* **2013**, 11, 5, 552-559, https://doi.org/10.5829/idosi.gv.2013.11.5.76200.

10. Benjamin, S.J., Marathamuthu, M.S., Murugaiah, U., The Use of 5-WHYs Technique to Eliminate OEE's Speed Loss in a Manufacturing Firm, *J Qual Maint Eng,* **2015**, 21, 4, 419-435, https://doi.org/10.1108/JQME-09-2013-0062.

11. Ahmed, M., Ahmad, N., An Application of Pareto Analysis and Cause-and-Effect Diagram (CED) for Minimizing Rejection of Raw Materials in Lamp Production Process, *Management Science and Engineering,* **2011**, 5, 3, 87-95, https://doi.org/10.3968/j.mse.1913035X20110503.320.

12. Hailu, H., Tabuchi, H., Ezawa, H., Jilcha, K., Reduction of Excessive Trimming and Reject Leather by Integration of 7 QC Tools and QC Story Formula: The Case Report of Sheba Leather PLC, *Ind Eng Manage,* **2017**, 6, 3, https://doi.org/10.4172/2169-0316.1000223.