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Some Aspects of Moose Domestication (*Alces Alces* L.) in Russia

By T. P. Sipko, O. V. Golubev, A. A. Zhiguleva, V. A. Ostapenko,
N. S. Marzanov & S. N. Marzanova

Summary- Starting with ancient times, some historical stages of moose domestication in Russia are shown. A review of the results of our own research and published data of domestic and foreign authors for the 117-year period (from 1900 to 2018) is presented. Information from regional archival documents and materials of researchers that are not accessible to the general public is presented. It is shown that the moose has a number of positive qualities favoring its introduction to livestock. Due to the domestication of moose, man is given the opportunity to use moose resources more efficiently than by hunting, to obtain additional types of products and to conduct research and educational activities.

Keywords: moose, breeding, domestication, history.

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Some Aspects of Moose Domestication (*Alces Alces* L.) in Russia

T. P. Sipko ^α, O. V. Golubev ^σ, A. A. Zhiguleva ^ρ, V. A. Ostapenko ^ω, N. S. Marzanov [¥]
& S. N. Marzanova [§]

Summary- Starting with ancient times, some historical stages of moose domestication in Russia are shown. A review of the results of our own research and published data of domestic and foreign authors for the 117-year period (from 1900 to 2018) is presented. Information from regional archival documents and materials of researchers that are not accessible to the general public is presented. It is shown that the moose has a number of positive qualities favoring its introduction to livestock. Due to the domestication of moose, man is given the opportunity to use moose resources more efficiently than by hunting, to obtain additional types of products and to conduct research and educational activities.

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I. INTRODUCTION

Moose (*Alces alces* Linnaeus, 1758) is one of the largest animals of the terrestrial fauna of Eurasia and North America. It is the largest member of the deer family (Cervidae), morphologically isolated from other species of the family and is represented by one monotypic genus *Alces* in the modern fauna Gray, 1821 [1–3]. Currently, the moose lives in Scandinavia, Finland, Eastern Europe, Western Siberia, the Far East (including the northern Chinese territories), and North America (Alaska, Canada, the northern regions of the United States of America) [4].

In English, German, French, Norwegian, Latin and Old Russian, the name of an moose sounds very similar: *elk*, *elch*, *elan*, *elg*, *alces* and *ellen*, respectively, indicating the existence of a common ancient Indo-European name for this animal. The word *moose*, which is now called elk in North America, is Native American [5].

Moose has a significant body weight – up to 500 kg, precociousness, multiple births, unpretentiousness, the ability to feed on coarse vegetative fodder and large-growth forest grass. It is possible to get various products from elk such as dietary meat, skin, pantocrinum (lossekrin), pantoematogen and horns. Milk, which can only be

obtained from moose cows grown under human supervision, is a special product of moose breeding [6].

Attempts at domestication and artificial breeding of moose were made by man repeatedly [7–11]. The attractiveness of introducing this kind of ungulates into livestock is associated with its peaceful nature, high value of carcasses, large size and extraordinary ecological plasticity.

Moose has a number of positive biological qualities favorable for its artificial breeding. Among them are the following: the hierarchy of social organization, the tendency to create groups, the presence of males in the group structure, low level of intraspecific aggression, maturity of newborns, ease of separation of moose calves from cows, ease of domestication, short safety distance, low sensitivity to changes in the environment, low fear, lack of personal space, the absence of the need for special shelters and tolerance for fellow herd members [12].

II. HISTORY OF MOOSE DOMESTICATION BEFORE THE XX CENTURY

The first written information about the domestication and use of moose abroad refers to Sweden. In the XV century, moose were used in the army [13, 14]; in the XVII century – for the transportation of couriers in sleighs [8], and in the second half of the XIX century in Sweden and the USA – as working (trailing) animals. At the same time, some moose bred successfully in captivity [15].

However, in Russia, moose breeding was practiced much earlier: at the end of the stone – the beginning of the Iron Age [9]. This is confirmed by the numerous cave paintings (Fig. 1, 2) found in the Lena, Angara and Yenisei river basins, as well as in Karelia, depicting moose which people graze, lead in halters on the lead, use to ride in sled teams and keep in pens [16].

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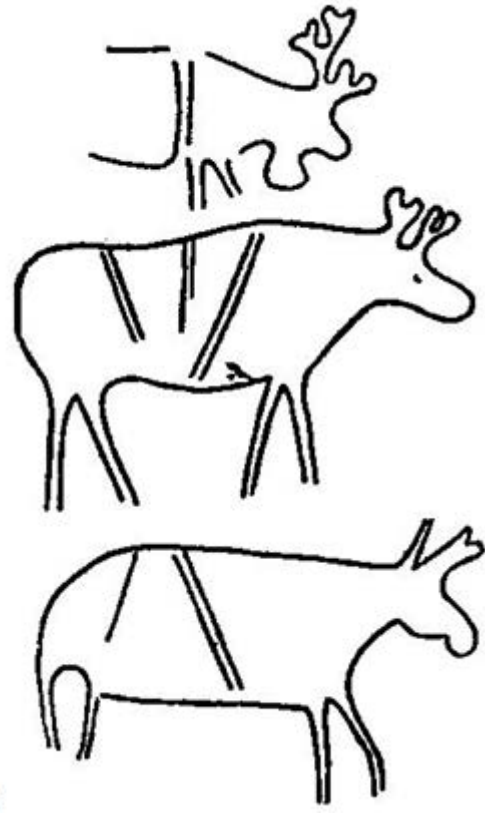
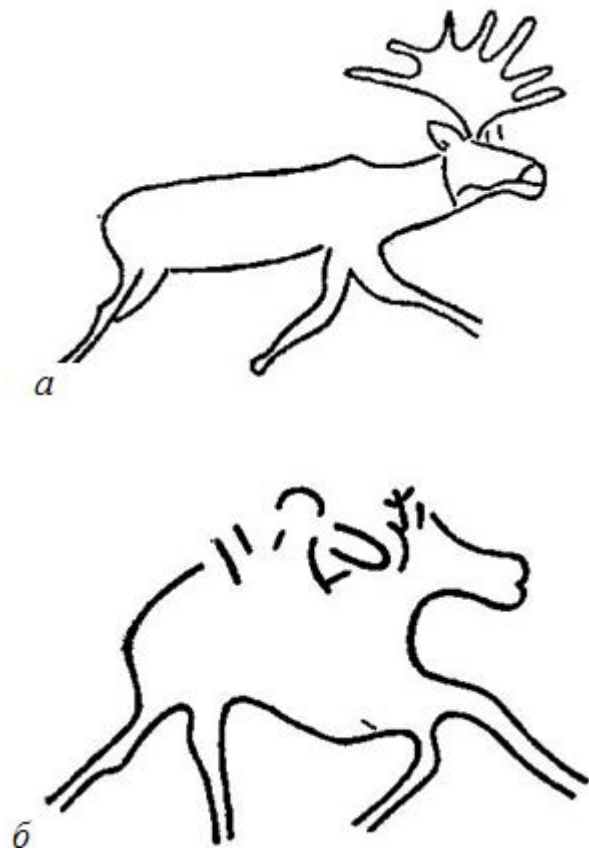


Figure 1: Examples of drawings depicting mooses: a – moose in a harness (rock in the area Yalbak-tash, Altai; sketch by D.I. Kuznetsov); b – a rider on moose (a rock near the village of Kartuhai, the Lena river; a sketch by V.N. Skalon; 3/20 of its full size); c – moose in a harness (rock at the Karmagul cliff, r. Angara; sketch by A.D. Fatyanov; 1/8 of actual size) [16]

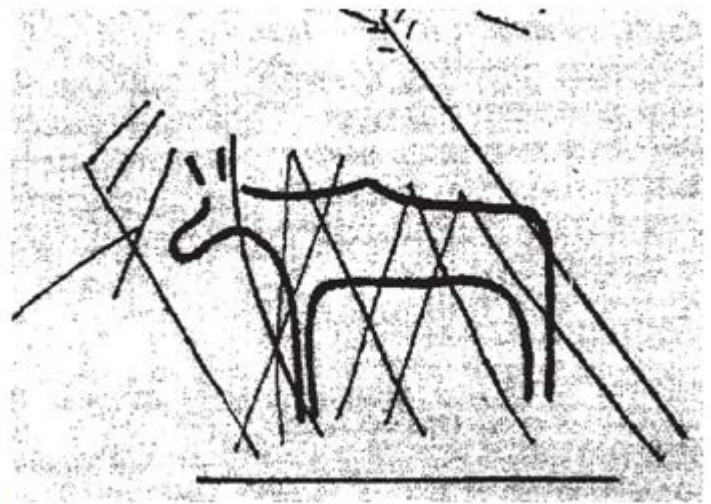


Figure 2: Examples of petroglyphs with the image of mooses: a – towing a person by moose (Karelia, photo by Yu.A. Savateeva, 1970); b – moose in a hedge (image on a plate found inside the settlement on Mount Mankhail in the Kudinsky steppes, sketch by P.P. Khoroshikh) [16, 17]

In the late Middle Ages, domesticated moose were widely used in Siberia as working animals and as a replacement for horses [18]. In Russia, in Lobanovskoye

estate of Smolensk province in 1861, moose were used to transport grain from fields, harnessed in pairs in carts [19].

III. EXPERIENCE IN DOMESTICATION OF MOOSE IN THE XX CENTURY

The resumption of experiments on the domestication of moose was started only in the 20th century, taking into account some features of the mooses lifestyle [20, 21]. The first All-Russian Congress on nature conservation, which was held in Moscow on 01.25.1933 [17], served as the basis for the development of elk farming in Russia. In 1934, the Committee on reserves under the Presidium of the USSR CEC decided to organize moose nurseries in reserves and national parks, where it was supposed to breed and domesticate moose based on the following prerequisites:

- by that time, numerous facts of pasturing of moose in the past were already known [13, 22];
- the distribution of the moose in swampy and forested areas and its feeding habits made it possible to compete a little with other wild and domestic ungulates;
- confidence that a domestic animal is always more productive than a wild one;
- the idea of being domesticated is to make a wild animal the same as a domestic animal [20].

In 1934, the RSFSR CEC decided to organize moose nurseries in nature reserves. Nurseries are organized in the «Buzuluksky Forest» Reserve and in Western Siberia on the Demyanka River [17]. In 1935, research began to be conducted at the Yakutsk Agricultural Experimental Station, where conditions for the domestication, raising, dressing and breeding of moose in captivity were studied for subsequent transfer of experience to the collective farms. On these moose, the Institute of Polar Agriculture conducted a series of observations, experiments and tests during February-March 1937 [23].

At the same time, in 1936, the Vyskinichsky hunting farm was organized, which was later transformed into the Moose Scientific Experimental Hunting Farm (now the federal nature reserve of the Tarusa State Complex), with the organization of an elk farm. Initially, the farm was part of the Soviet Union People's Commissariat of land management, and in May 1941 it was transferred to the Moscow Fur Institute. The farm was a member of the All-Union Exhibition of Agriculture. It had a staff of 20 people, the necessary buildings and equipment. The number of tame mooses reached 40, of which 20 went in harness [17].

A year later, an moose nursery was established in Serpukhov experimental hunting farm of the Moscow region (Fig. 3), where by 1941 there were 24 moose kept, which were tested for use in teams, under saddle and packs. The farm was adjacent to the Vyskinichsky district (Zhukovsky). It is believed that the Serpukhov experimental hunting farm began to engage in moose-

breeding since 1937, and the Vyskinichi farm since 1936. Prof. P.A. Manteifel, Head of the Department of Bio-technique of Moscow Fur Institute, led the work in both farms [24]. During the Great Patriotic War, the German invaders destroyed the farm, shot moose, and burned out buildings [17].

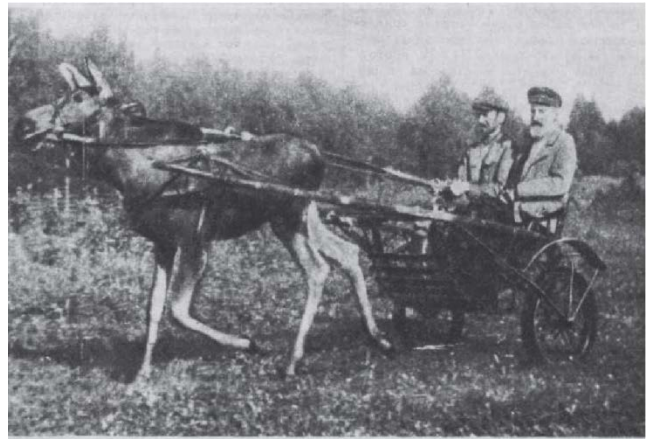


Figure 3: P.A. Manteifel in Serpukhov moose farm, 1952, photo by A. Rykovsky [17]

In 1937–1941 moose domestication was carried out in the Buzuluksky Forest Reserve, an island pine forest on the border of the Samara and Orenburg regions. The experimental herd were started from 12 moose calves, caught in nature and raised at the farm. In the reserve, moose were used not only for sledding, but also for horseback riding. However, in contrast to the experience of Serpukhov moose farm animals were kept on the free-grazing [25, 26].

Before the Soviet-Finnish War, in December 1937, «Volosovsky Special Nursery No. 3» was visited by I.V. Stalin accompanied by A.A. Zhdanov. He was «... particularly impressed by the moment when moose cavalry flew out of the forest, bristling with machine guns. Stalin was pleased with the demonstration, although he noted the fact that the moose are not yet trained to distinguish the Red Army soldiers from the White Finns» [26].

In 1949, by order of the Council of Ministers of the RSFSR, the first experimental moose farm was created in the Pechora-Ilychsky Reserve [19]. Its ultimate goal was to breed for the taiga landscape zone the same specialized domestic animal as the reindeer is for the tundra, yak for the highlands, and camel for the desert. Artificial breeding of moose on a farm in the Pechora-Ilych Reserve began with the acquisition of an experimental herd. For this purpose, the moose calves were caught at a very early age, since the older the calves, the shyer they are of a person and the harder it is to tame them. For this purpose, the most suitable were moose calves aged no more than three days.

The main tasks that were solved by the researchers were to clarify the specific features of the

biology of moose, necessary for feeding, keeping and raising animals caught in the taiga. The method of work was simple: year-round observations were conducted in nature; annual and daily cycles of wild moose kept in large pens in conditions close to natural ones where wild caught mooses were tamed and raised.

After the biology of moose was studied and the mode of feeding, keeping and raising animals in artificial conditions was developed, the researchers began to solve the next block of problems. The main tasks were to achieve the viability and normal breeding of mooses while keeping them in an open-air cage, to clarify the prospects for the economic use of domesticated mooses and to justify the profitability of moose breeding. At the moose farm, a system of manual feeding of moose calves was established. Also, they studied questions of moose physiology, feeding and behavior of moose. They began to milk the moose cows, and studied the milk production and the quality of moose milk. In addition, moose began to be used as a transport animal [8, 9, 19, 27–30].

In 1949–1951, the moose population was staffed mainly by wild moose calves. Since 1949, the first tame moose cows began to breed. By 1952, there were 29 moose on the farm. Since 1960, the moose farm began to carry out breeding work, the purpose of which was to obtain meat and dairy, as well as working animals (Fig. 4).

During the existence of the moose farm, 174 moose were obtained and reared, of which 61 were caught in nature and 113 brought tame moose cows. As a result of the activity of the moose farm, some aspects of moose biology were studied and clarified, which were still unclear, the main economic qualities of the moose were established, as well as the possibilities and ways of its practical use. For the twenty-year period, among the moose raised there were already individuals of the fourth generation.

The meat productivity of animals was also studied there, which supplemented the data obtained by employees in the areas directly adjacent to the Pechora-Ilychsky Reserve. About 7–8 months old moose grown on the farm reached 140–180 kg of live weight. The mass of adult females was 350–467 kg. Adult males weighed 480 kg. One male castrate reached record weight, with a relatively small size its mass reached 500 kg. The slaughter yield of moose carcasses, depending on age, sex and time of slaughter, was 50–70% of live weight. Adult animals, shot before the rut and in its beginning, had higher than average fatness. Males lost 20% of their weight over the rut period and had low fatness by winter. Castrated males maintained high fatness throughout the winter.



Figure 4: Examples of the use of moose in the experimental moose farm of the Pechora-Ilych reserve [31]: a – for riding, b – like a pack animal, c – for carrying goods on sleds, d – for getting milk

On the farm, milk was received from moose cows. Milk productivity was tested in 13 cows, some of which gave milk for eight seasons. Moose calves were collected immediately after birth and fed moose or cow's milk, and moose cows were transferred to manual milking. The maximum milk yield for lactation (milk yield from calving to rut) in moose cows that gave birth for the first time reached 52–78 kg, and in elder moose – up to 203.84 kg. The maximum daily yield reached 3.12 kg. An increase in the multiplicity of milking increased the amount of milk produced to 288.08 kg for heifers and to 447.2 kg for elder moose cows.

At the elk farm, all the moose calves in the first and second year of life underwent training: standing on a leash, walking about, in harness and under the saddle. From the number of neutered moose, individuals were obtained that are not inferior to the average horse in the work of transporting cargo by pack, on sleds and under a saddle. In the sleigh cart, elk transported 400–500 kg, under a pack – 80–120 kg.

In 1963–1965, an experimental moose farm was established at the Kostroma SAES [32]. In 1968, five heads of young stock were brought from the Pechora-Ilychsky Reserve and in 1972 the first managed group of moose calves was established. Scientific management was carried out by a specially created laboratory of moose breeding (Smirnov, 2015), which was eliminated in 1992 [26]. In parallel, several moose farms were established near Gorky, Yaroslavl, Vologda, Leningrad and in a number of other places, but then they were disappeared.

Since the domestication of moose is a national problem, it was coordinated at an appropriate level. In March 1977, after a decision was made by State Committee on Science and Technology of the USSR Council of Ministers (No. 209 of April 23, 1974), the Main Department of Agricultural Science and Propaganda of the RSFSR Ministry of Agriculture approved the composition of the Coordinating Council for the moose domestication with the base farm on the Kostroma SAES. V.I. Mukhortov headed the Council. The Council includes representatives of scientific institutions and organizations of various departments and ministries in the form of applicants for individual topics and events [33].

Since 1974, on the instructions of SCST USSR, the Kostroma SAES began research work on the topic, «Development technology for keeping, feeding, domestication of moose and the use the moose products in national economy». Scientists from more than 20 scientific organizations were involved in this work. The main stages of taming the moose were: artificial rearing of young stock, group domestication and the formation of herds with the subsequent management of their grazing and zootechnical work. Bred moose grazed year-round on forest pastures, which alternated. Up to 45 individual animals grazed on

200 hectares of forest. Animals used low-value food species: willow, mountain ash, aspen, while the landing of spruce and pine were protected.

Subsequently, the Kostroma moose farm was transformed into the «Moose Complex», which included an moose farm with a protected zone, a special hunting farm and a forestry. N.V. Sokolov and the head of the laboratory A.P. Mikhailov [34] managed the complex.

Currently, the number of moose on the Kostroma moose farm is calculated in April before the beginning of the period of delivery. The average annual population from 1966 to 2004 was 24.8 [35]. Since 1976, the number of mature females on the farm has fluctuated around an average of about 16 individuals, and these fluctuations correlate with changes in the total number of mooses in Russia (the correlation coefficient is 0.57) and changes in their numbers in the Kostroma region (the correlation coefficient is 0.47) [36]. The average fertility rates of moose cows at this farm exceed the average for Russia [37].

By the beginning of the XXI century, ration and mode of moose keeping were developed, as well as a system of preventive measures that ensured the survival of 85 to 95% of moose calves in the first year of life [38]. The practical significance of modern moose-breeding is that without the domestication of moose, the existence of this industry is impossible. Only domestication allows milk obtaining [39]. On average, one moose cow can give up to 520 kg of milk per lactation, or more than 5 tons per life [40].

Thanks to the research of V.M. Dzhurovich, moose milk has found its application in medicine [41]. It is used in the treatment of gastric ulcer, duodenal ulcer and gastritis, contributes to the treatment of dysbacteriosis, Hodgkin's disease, leukemia and other neoplastic diseases [42, 43]. In the near future, the possibility of using moose milk as baby food and food for people working in extreme conditions is considered [39, 44].

To date, cost-effective technology has been developed for the maintenance, breeding and reproduction of moose in semi-wilderness conditions [45, 46]. The system of comprehensive assessment of breeding and productive qualities of domesticated moose allows for a more objective and effective selection of animals with given parameters and forming a herd capable of obtaining healthy moose calves with their increased survivability, increase the milk production of moose cows with a high content of milk fat, protein and lysozyme [47].

IV. CURRENT STATUS OF THE QUESTION

However, it should be noted that the domestication of moose has so far proceeded without any understanding of the essence of this process [20]. In their work, researchers were guided only by the

principle of similarity, calling domesticated animals that are not afraid of man, come to the place where they were raised, allow themselves to be milked and harness. In fact, such moose differ from wild animals only by their changed ontogenesis behavior [48].

Tame moose are fed, protected from predators, kept at a higher density than wild, and faced strong stimuli. In principle, these changes in the environment could be enough for the manifestation and selection of certain features of behavior and physiology, especially the rhythms and seasonality of reproduction. The work is mainly devoted to the development of methods for mastering these animals, obtaining products from them, managing their ecology and behavior as one of the initial stages of domestication [20].

At the level of Academician D.K. Belyaev research, the problem of domestication of moose has not been posed or even discussed. Therefore, in 2007, the authors began a study of the biological characteristics of animals from the Kostroma elk farm (the moose farm of the Sumarokovsky State Nature Reserve), taking into account the basic principles of the theory of destabilizing selection [49].

In the course of the research, it was found that moose with pedigrees of 15–20 generations of breeding

under the control of man show altered forms of behavior characteristic of domesticated animals. These include: an active-positive reaction to a person outside the aviary and outside visitors to the moose farm, the moose cow's tendency to be in a group, and the phenomenon of the constant presence of one adult male in a group of cows outside the rut period [48, 50, 51].

An increase in the average fecundity of moose cow families from 0.94 to 1.99 calves per female was established, as well as increase in the number of triplets. This is probably due to abundant feeding and artificial selection for fertility [51]. The average lactation duration of moose cows increased slightly (from 130 to 135 days). Moose cows with an increased level of milk production (over 200 kg of milk per lactation) were identified. Their share was 17% of the total number of dairy cows [48].

A polymorphism of coat color was detected in individual animals (four types). The most numerous aberrants had pale ticks on wool with a diameter of up to 1.5–2.0 cm on the front of the head, shoulders and rump, dark (larger diameter) spotting – in the knees of the hind legs and clarified throughout the frontal part of the head (Fig. 5) [53].



Figure 5: Aberrant variants of coloring in mooses: a – wild, b, c – piebald, d – spotty, d – white-spotted, e – white, f – juvenile-wild [53]

The connection of new phenotypes with the live weight indicators of moose calves at birth, reproductive ability and milk productivity ($p < 0.05$) was established. The average reproductive capacity of moose with piebald wool was about 2 times higher than those with the wild-type wool. The annual milk production of piebald lactating cows was also more than 2 times higher [48, 54].

Among moose with spotted coat color, prevailed (75%) animals with a calmly alert reaction to personnel, and among moose with other types of coloring, there was an active positive reaction to visitors outside the farm enclosure. Probably, new phenotypes are an external manifestation of positively related traits fixed by artificial selection.

The allele pool of 6 loci of microsatellites derived from moose DNA was also studied. The genetic diversity of the breeding population on the Sumarokovsky State Nature Reserve moose farm was determined by the level of heterozygosity of each locus, and the overall level of population diversity was shown [55] and features views of evolution in Eurasia [56].

V. CONCLUSION

Thus, in mooses, as a result of prolonged semi-captive breeding over 15–20 generations, there was a change in behavioral and morphophysiological traits that distinguish them from wild animals. Establishing a breeding control system using modern methods of genodiagnostics and population-genetic analysis is a necessary tool for controlling domestic signs in artificially bred moose groups.

Over time, when breeding for an active-positive reaction to humans, polymorphism of color and high fecundity, controlled by means of genodiagnostics, it is hoped that Russian scientists will be able to obtain a group of moose that will meet the requirements for its inclusion in the State Register of Domesticated Animal Species.

List of Abbreviations CEC– Central Executive Committee; USSR – Union of Soviet Socialist Republics; RSFSR– Russian Soviet Federative Socialist Republic; MA – Ministry of Agriculture; SAES – State Agricultural Experiment Station; SCST USSR – State Committee on Science and Technology of USSR.

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Substituting Fish Meal with Pre-Treated Lima Bean Meal on Growth, Feed Utilization and Nutrient Retention in *Clarias Gariepinus* Fingerlings Reared in Hapa-in-Pond System

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Abstract- The present study was conducted during 56 days to evaluate the effect of substituting fish meal (FM) with pre-treated Lima bean meal (LBM) on growth, feed utilization, and nutrient retention in *Clarias gariepinus* fingerlings weighing 3.00 ± 0.02 g. Four isonitrogenous (40% crude protein) diets containing 0% (D0), 25% (D25), 50% (D50) and 100% (D100) of LBM, as FM substitute were used. D0 was considered a control diet. The results obtained indicate no significant difference in weight gain (11.97 ± 0.67 g and 12.95 ± 2.12 g), specific growth rate ($3.46 \pm 0.23\%$ /day and $2.95 \pm 0.22\%$ /day), protein efficiency ratio (0.89 ± 0.01 and 1.05 ± 0.02), protein retention ($10.83 \pm 0.23\%$ and $12.48 \pm 0.19\%$) and lipid retention ($9.11 \pm 0.55\%$ and $9.45 \pm 0.43\%$) of fish fed D0 and D100 respectively. Fish fed D25 and D50, showed significant growth increase, feed utilization performances, and both protein and lipid retention in comparison with D0 and D100. This study indicates that Lima bean meal can be used up to 50% in formulating feed for *Clarias gariepinus* fingerlings in rural areas.

Keywords: *Clarias gariepinus* fingerlings, fish meal, lima bean, growth, nutrient retention.

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Substituting Fish Meal with Pre-Treated Lima Bean Meal on Growth, Feed Utilization and Nutrient Retention in *Clarias Gariepinus* Fingerlings Reared in Hapa-in-Pond System

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I. INTRODUCTION

Cameroon is considered to be Africa in miniature because it presents a great geo-climatic diversity and a singular plurality of much diversified natural environments that seem to bring together most of the ecosystems of tropical Africa (Tchawa, 2012). These ecosystems are endowed with a rich terrestrial and ichthyologic biodiversity. Of this wealthy ichthyologic potential, only a small proportion such as *Clarias gariepinus* is currently known and valued. *Clarias gariepinus* is endemic to Africa, and it remains one of the most suitable species for local aquaculture (Cacot, 2006). It is a highly-valued species in aquaculture for its hardiness, its omnivorous diet, its fast growth, and the quality of its flesh (Ducarne and Micha, 2003; Tiogué *et al.*, 2018). In Cameroon, aquaculture is widely practiced

in rural areas where there are sufficient land coupled with enough water courses to supply fish ponds, where fish are mainly raised in semi-intensive cropping systems. Despite the country's natural potential, domestic production remains insufficient to meet the fish consumption needs of an ever-growing population. One of the major obstacles to fish production in general and catfish production, in particular, is the cost of production. Feed is one of the most costly resources in fish farming and, depending to the culture system, it represents 40-70% of the total cost of production (De Silva and Aderson, 1995). Fishmeal is an essential constituent in production of fish feed. It is the greatest protein source used in aquaculture feed because of its high protein content, good protein quality and balanced amino acid profile, high digestibility and palatability which is useful to enhance the uptake, digestion and absorption of nutrients in fish (Ariyawansa, 2000; Miles and Chapman, 2006). The use of fish meal for aqua feed industries is increasing by 10% every year, while the availability of fishmeal is declining due to over fishing of wild populations, consequently fish meal supplies witnessed significant fluctuations and also in prices during the last decade (Naylor *et al.* 2000; Rana *et al.*, 2009; FAO 2014). There is, therefore, a pressing need to search for alternative protein sources that are cheap, available, of low human preference with little or no processing (Akinmutimi, 2001). Seeds of leguminous origin provide a promising alternative (Olaniyi *et al.*, 2009a; Agbugui *et al.*, 2011), one of such seeds is Lima bean (*Phaseolus lunatus*) which has potential for use in animal feed, fish inclusive, considering its relatively high protein content of about 28-30% (Ajayi *et al.*, 2010; Heuzé *et al.*, 2015; Seidu *et al.*, 2018). In most parts of Cameroon, Lima bean grows naturally in the fields. Because of its bitter taste, it is neglected in both human and animal foodstuffs, despite its nutritional value comparable to peas and cowpea. Like other grain legumes, it contains anti-nutritional factors that can be adequately eliminated or reduced to a tolerable limit using one or more processing techniques. According to Alonso *et al.* (2000), a variety of processing techniques

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such as soaking in water, heat treatment (soaking and boiling), roasting, fermentation and germination have been used to remove anti-nutritional compounds and hence improve bean nutritional values. Lima bean, if adequately processed, might be a valuable ingredient in fish food formula, and because of its relatively high protein content, it could be used to replace fish meal (Heuzé *et al.*, 2015). The purpose of this study was to determine the effect of fish meal replacement with pre-treated Lima bean meal on growth, feed utilization, and nutrient retention in *Clarias gariepinus* fingerlings.

II. MATERIAL AND METHODS

a) Fish and rearing conditions

The study was carried out in the technical installations of the Common Initiative Group-Aquaculture Integrated of West (CIG-AIW) in the West Region of Cameroon. A total of 380 mixed-sex fingerlings of same brood stock of African catfish (*Clarias gariepinus*) weighing $3.00 \pm 0.02\text{g}$ were obtained from the CIG-AIW hatchery. They were randomly distributed in 16 hapas ($1 \times 1 \times 1\text{m}$, L: W: H) made up of mosquito net cloth and allowed for acclimation for four days before the experiment. During the acclimation, the fish were fed with a standard commercial feed. The hapas were suspended in an earthen pond (200 m^2) with the help of four bamboo poles, one at each corner, such that three-quarters of each hapa were submerged in water whereas one-quarter remained outside. The roof of the hapas was covered with mesh to stop fish from jumping out and to prevent natural predators (snakes, kingfishers, frogs) from getting in.

b) Processing of Lima bean seeds

Lima bean seeds used in this research work were harvested in April 2017 at Batié, in the West region of Cameroon. A set of Lima bean (200g) were soaked in water, in a seed to water ratio of 3:10 (kg/L). Eleven hours after, the soaked beans were removed from water and immediately boiled in water at 100°C for three hours, with the water being changed after every hour (Adeparusi and Ajayi, 2004; Falaye *et al.*, 2014). After boiling, the water was drained off and the boiled seeds were sun-dried, ground into a fine powder, then stored in an airtight container and kept at room temperature until use.

c) Experimental diets and feeding regime

Four isonitrogenous experimental diets were formulated with 40% protein. The first control diet (D0) containing 18.58% fish meal (FM) as the primary source of animal protein without the Lima bean meal (LBM), and three test diets D25, D50, and D100 where fish meal was replaced with Lima bean meal at 25%, 50% and 100%. Two commercial feeds, a floating imported commercial feed called Coppens (C1) and a sinking locally manufactured commercial feed, named minepia-

feed (C2). These feeds were used as second, and third control diets. For the test diets (D25, D50 and D100), the level of other ingredients were adjusted to maintain the same dietary protein when LBM was incorporated at 25%, 50% and 100%. The vitamin, mineral mix, cassava flour, and palm oil as lipid sources were kept constant in all diets. In preparing experimental diets, the dried ingredients were ground into fine particles. After weighing, and mixing manually for 10 minutes, the preparations were moistened with warm water (400 ml kg^{-1}), and mixed for another 20 minutes. During the mixing, palm oil was added slowly along with warm water to achieve proper consistency. The resulting mixture was then passed through a meat extruder to obtain a 2mm pellet. The pelleted feeds were collected in flat trays and sun-dried for 36 hours, after which they were crunched into crumps by breaking them with the hand. The broken crumps were packed in polythene bags, sealed and appropriately labeled before stored in a freezer. Each sample of the dried experimental diet was subjected to proximate analysis according to the method of Association of Official Analytical Chemistry (AOAC, 1990) to determine the percentage composition of the various components of the diet. Moisture was analyzed by drying the sample in an air convection oven at 105°C overnight. Crude protein was analyzed by the Kjeldahl method after acid digestion (% crude protein = % nitrogen x 6.25), while crude lipid was determined by extraction with petroleum ether using the Soxhlet method. The ash content in the diet was analyzed by combustion of samples in a muffle furnace at 550°C for 12 h (table 1).

Table 1: Ingredients, and proximate composition of experimental diets (g/100g dry mater)

Ingredients	D0	D25	D50	D100
% replacement of FM with LBM	0%	25%-	50%	100%
Fish Meal	18.58	13.94	9.90	//
Lima Bean Meal	//	4.65	9.29	15.30
Soybean cake	18.58	20.14	21.69	24.90
Cotton seed cake	18.58	20.14	21.69	24.90
Groundnut cake	18.58	20.14	21.69	24.90
Wheat bran	7.82	5.45	3.17	//
Rice bran	7.82	5.55	3.17	//
CMAV 5%	5	5	5	5
Palm Oil	4	4	4	4
Cassava flour	1	1	1	1
Proximate composition (%.DM)				
Protein	39.99±0.40	39.65±0.30	39.48±0.58	38.95±0.08
Lipid	7.05±0.07	8.70±0.14	8.85±0.9	7.70±0.14
Ash	7.25±0.30	6.55±0.07	6.25±0.30	4.95±0.40
Moisture	8.10±±0.14	7.50±0.18	8.90±0.14	8.20±0.28
Energy (kJ/g DM)	17.00±1.06	17.45±0.99	17.40±1.06	17.48±1.27

d) Experimental procedure and water quality monitoring

Before the start of the experiment, 20 fingerlings were sacrificed and used to determine the initial carcass proximate composition. The rest of the fish, randomly distributed in 18 hapas of 20 fish each was divided in triplicate into six feeding treatments named C1 (Coppens), C2 (minepia-feed), D0 (normal diet or control diet), D25, D50, and D100 corresponding to diets where FM was replaced with LBM at 25%, 50%, and 100%. Before the beginning of the feeding trials, fingerlings were starved for 24 hours to increase appetite and reception for new diets. All the fish in each hapa were counted and bulk weighed. They were hand-fed to apparent satiation with outmost care to minimize feed waste three times daily (09:00 a.m, 13:00 p.m and 17:00 p.m respectively) at a rate of 3-5% of their body weight. Growth was monitored through intermediate samplings carried out every 14 days, by counting and

recording bulk weights of three separate subsamples from each hapa (representing approximately 30% of the population), using a scoop net of fish concentrated in the corner of the hapa. Fish were starved for 24 hours before sampling in order to limit stress and mortality related to handling. Feeding rates were then adjusted based on the weight gain of each group of fish per fourteen days. At the end of the experiment, a sample of three fish per hapa was randomly collected and sacrificed for the measurement of final whole-body proximate composition.

Water quality parameters in each hapa were measured daily before feeding. The temperature was measured using a Maximum-minimum thermometer; pH was monitored using electronic pH meter, dissolved oxygen (O₂) was determined using JBL Test Kits, nitrate (NO₃⁻), nitrite (NO₂⁻) and ammonia (NH₃) were measured using Test strips (JBL Easy Test 6in1) (table 2).

Table 2: Water quality parameters (Mean±SD) during 56 days of the experimental period

Parameter	Value obtained	Optimum values (Zaykov and Staykov, 2013)
Temperature, °C	22.1±0.47	8-35
Dissolved oxygen, mg.l ⁻¹	6.66±0.78	>5
pH	7.55±0.8	6.5-8.5
Ammonia, mg.l ⁻¹	0.14±0.01	0.5-2
Nitrite, mg.l ⁻¹	0.24±0.02	<0.3
Nitrate, mg.l ⁻¹	0.32±0.02	<25

e) Measurement of zootechnical parameters

Growth performances, feed utilization, and nutrient retention were assessed by determination of weight gain (WG), specific growth rate (SGR), feed intake (FI), condition factor (K), feed conversion ratio

(FCR), protein efficiency ratio (PER), survival rate (SR), and nutrient retention (NR). Calculations were carried out using the following formulae: Weight Gain (g) = final weight – initial weight; Specific growth rate (%/day) = 100 (lnW2 – lnW1) / T, where W1 and W2 were the initial

and final weights respectively, and T, the number of days in the experimental period; Survival rate (%) = final number of fish \times 100 / initial number of fish; Condition factor = 100 (Weight / Length³); Feed intake = total dry feed / number of fish; Feed conversion ratio (FCR) = feed intake / live weight gain; Protein efficiency ratio (PER) = live weight gain / protein fed, where Protein fed = % protein in diet \times total diet consumed / 100; Protein efficiency ratio (PER) = wet weight gain / protein fed, where Protein fed = % protein in diet \times total diet consumed / 100; Nutrient retention (%) was calculated as: 100 ((Final carcass composition - Initial carcass composition) / Amount of nutrient fed)

III. STATISTICAL ANALYSIS

All results were expressed as mean \pm SD. The data collected during every fish sampling were analyzed by one-way analysis of variance (ANOVA-1) repeated measure followed by Tukey's multiple comparisons test with n=3 replications containing 20 fish each. Differences were regarded as significant when P<0.05; All statistical analyses were conducted using GraphPad Prism version 6.0.

IV. RESULTS

a) Growth performances

Growth performances of *Clarias gariepinus* fingerlings fed with the control and experimental diets in

terms of weight gain, daily weight gain, and specific growth rate are presented in figures 1 and 2. The weight gain curve (fig 1A), and the daily weight gain curve (fig 1B) obtained from the data recorded during fish sampling show almost the same evolution tendency. In general, the growth curve of *C. gariepinus* fingerlings was initially quite similar in all groups. But as from the 14th day of the rearing period up to the end of the experiment, it is observed a significant (p<0.05) size variation of fish that received Coppens (C1) diet compared to the rest of fish in other groups; followed by fish fed with diet D25, and D50 compared to C2, D0, and D100. At the end of the experimental period, fingerlings of *C. gariepinus* fed with C1, D25, and D50 present a weight gain of 33.19 \pm 2.14g, 17.18 \pm 1.63g, and 18.17 \pm 2.75g significantly (p<0.05) high by 77.22%, 55.88%, and 58.28% respectively to C1, D25, and D50, compared to C2 (7.58 \pm 1.83g) and by 63.93%, 30.33%, and 34.12% respectively, compared to control diet D0 (11.97 \pm 0.67g).

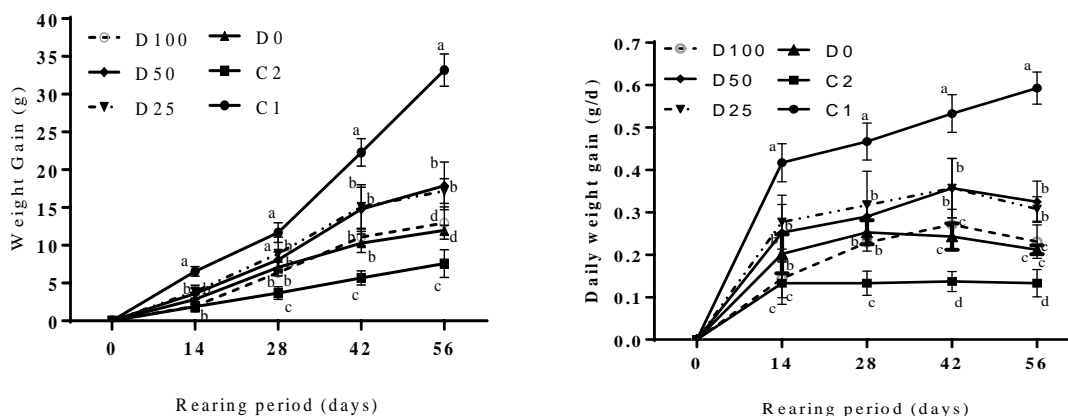


Figure 1: Mean weight gain (A), and daily weight gain (B) of *Clarias gariepinus* fingerlings fed on experimental diets for 56 days. Means on the same rearing period carrying the same superscript were not significantly different at p<0.05

The specific growth rate of *Clarias gariepinus* fingerlings to the experimental diets depending to the rearing period is presented in figure 2. During the first sampling, fish in group C1 (8.25 \pm 0.53% / d) showed the most significant increase in the specific growth rate, followed by that in groups D25 (5.85 \pm 0.85% / d) and D50 (5.45 \pm 1% / d) compared to C2 (3.40 \pm 1.02% / d), and D0 (4.69 \pm 0.78% / d). This specific growth rate then decreased in all groups to stabilize at the 56th day

of experimentation around values significantly high of 50% and 35.58% in the fish of group C1 (4.44 \pm 0.11% / d) compared to the fish of the groups C2 (2.22 \pm 0.29% / d) and D0 (2.86 \pm 0.08% / d) respectively. In the D25 group (3.39 \pm 0.15% / d) and D50 (3.46 \pm 0.23% / d) the specific growth rates also remained significantly high by 34.51% and 15.63% and by 35.83% and 17.34%, respectively to D25 and D50 as compared to C2 and D0.

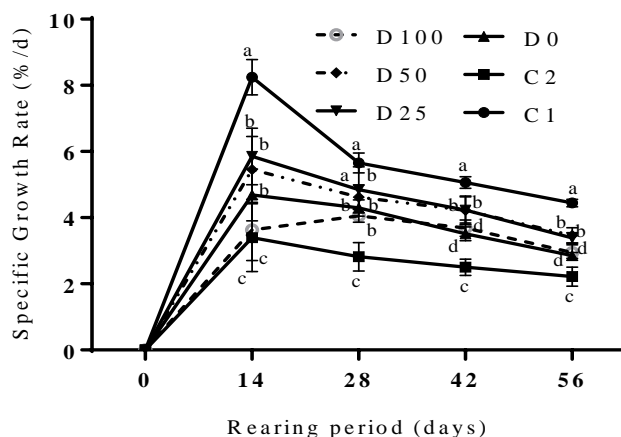


Figure 2: Specific growth rates of *Clarias gariepinus* fingerlings fed on experimental diets for 56 days. Means on the same rearing period carrying the same superscript were not significantly different at $p < 0.05$

b) Survival and feed utilization

Table 3 below illustrates the survival and feed utilization in *C. gariepinus* fingerlings after 56 days of feeding. It can be noted that only two mortalities were recorded in fish fed with diets C2 and D100, respectively. Regarding feed efficiency, it can be noticed that no significant difference was observed between the experimental groups (D25, D50, and D100) compared to the control group D0. Nevertheless, the best values of

food conversion ratio (1.12 ± 0.02) and protein efficiency ratio (2.23 ± 0.04) were obtained in fingerlings fed with diet C1 followed by that in diets D25 (FCR= 1.80 ± 0.05 , PER= 1.39 ± 0.04) and D50 (FCR= 1.88 ± 0.08 , PER= 1.33 ± 0.06) which are significantly different ($p < 0.05$) compared to that in diets C2 (FCR= 3.58 ± 0.03 , PER= 0.70 ± 0.01) and D0 (FCR= 2.80 ± 0.02 , PER= 0.89 ± 0.01).

Table 3: Survival and feed utilization of *Clarias gariepinus* fingerlings at the end of the feeding trial

Parameter	Control diets		Experimental diets			
	C1	C2	D0	D25	D50	D100
IN	60	60	60	60	60	60
FN	60	58	60	60	60	58
IB (g)	176.6	177.2	180	180	174.5	175.4
FB (g)	2148	603.2	855	1192	1288	965
SR (%)	100±00 ^a	97±5.77 ^a	100±00 ^a	100±00 ^a	100±00 ^a	97±3.00 ^a
FI (g/fish)	36.84±0.5 ^a	26.39±1.63 ^b	31.48±0.02 ^{ab}	30.42±0.38 ^{ab}	34.92±1.66 ^{ab}	32.46±0.95 ^{ab}
FCR	1.12±0.02 ^a	3.58±0.03 ^b	2.80±0.02 ^b	1.80±0.05 ^a	1.88±0.08 ^a	2.38±0.06 ^{ab}
FER	89.22±1.88 ^a	27.90±0.31 ^b	35.74±0.30 ^b	55.47±1.63 ^d	53.23±2.52 ^d	41.97±1.17 ^e
PI (g/fish)	14.73±0.2 ^a	10.56±0.65 ^b	12.59±0.01 ^{ab}	12.17±0.15 ^{ab}	13.97±0.66 ^{ac}	12.98±0.38 ^{ab}
PER	2.23±0.04 ^a	0.70±0.01 ^b	0.89±0.01 ^b	1.39±0.04 ^a	1.33±0.06 ^a	1.05±0.02 ^{ab}

Mean within the row with different superscripts are significantly different at $p < 0.05$. IN, initial number; FN, final number; IB, initial biomass; FB, final biomass; SR, survival rate; FI, feed intake; FCR, food conversion ratio; FER, food efficiency ratio; PI, protein intake; PER, protein efficiency ratio.

c) Whole-body proximate composition and nutrient retention

As shown in Table 4, the whole-body composition of the different fish groups (% wet weight basis) and nutrient retention are significantly affected ($p < 0.05$) by the different dietary treatments. In all fish

groups in general, there were no significant impact of dietary treatment on whole-body moisture, ash, lipid and energy contents. However, the whole-body protein contents of fish fed normal diet (D0 = 11.69 ± 0.30) was significantly ($p < 0.05$) lower than that of fish fed experimental diets D25 (16.33 ± 0.62) and D50 (16.73 ± 0.01) as well as Coppens (18.41 ± 0.17). Nutrient retention of *C. gariepinus* juveniles obtained after 56 days of rearing indicates that, substitution of fish meal with Lima bean meal as well as Coppens diet (C1) significantly affects their nutrient retention. In fish fed experimental diets D25 and D50, as well as in those fed

with the Coppens diet, the results show that the nutrient retention of dry matter, protein, lipid, ash and energy significantly increased compared to control diets D0 and C2.

Table 4: Proximate composition of the whole body and nutrient retention

Parameter	Control diets		Experimental diets			
	C1	C2	D0	D25	D50	D100
Whole body Composition^{IBC} (% or kJ/g WW)						
Moisture	69.57±0.32 ^a	62.63±0.27 ^a	70.74±0.89 ^a	66.55±0.32 ^a	67.99±0.01 ^a	71.48±0.37 ^a
Ash	3.58±0.18 ^a	4.02±0.08 ^a	3.88±0.00 ^a	3.76±0.20 ^a	3.52±0.03 ^a	2.99±0.29 ^a
Protein	18.41±0.17 ^a	15.13±0.58 ^{ab}	11.69±0.30 ^b	16.73±0.01 ^a	16.33±0.62 ^a	11.69±0.15 ^b
Lipid	1.03±0.03 ^a	1.10±0.02 ^a	0.72±0.08 ^a	0.82±0.01 ^a	0.82±0.00 ^a	0.53±0.02 ^b
Energy	4.69±0.17 ^a	5.77±0.14 ^a	4.39±0.26 ^a	5.10±0.04 ^a	4.94±0.07 ^a	4.39±0.12 ^a
Nutrient Retention (% intake)						
Dry matter	26.89±0.45 ^a	11.16±0.01 ^b	11.74±0.66 ^b	19.13±0.17 ^c	19.15±0.20 ^c	13.10±0.19 ^b
Ash	37.12±1.21 ^a	17.78±1.42 ^b	24.57±0.15 ^c	26.72±1.68 ^c	24.92±1.72 ^c	11.41±1.59 ^b
Protein	38.83±0.29 ^a	10.58±0.39 ^b	10.83±0.23 ^b	22.48±0.65 ^c	23.76±0.24 ^c	12.48±0.19 ^b
Lipid	36.50±1.00 ^a	10.36±0.13 ^b	9.11±0.55 ^b	15.52±0.23 ^c	16.17±0.05 ^c	9.45±0.43 ^b
Energy	22.39±0.71 ^a	9.05±0.21 ^b	9.20±0.52 ^b	15.18±0.02 ^c	15.25±0.46 ^c	10.94±0.18 ^b

^{IBC} initial body composition, on % wet weight basis, were: moisture: 73.50±2.12^a; ash: 2.29±0.16^b; protein: 10.59±0.47^b; lipid: 0.94±0.06^a; energy: 4.22±0.11^akJ/g WW

Data are presented as mean ± standard deviation of three replicates groups of fish, with 15 fish per group (n =3). Mean in each row with different superscripts have significant differences at p<0.05.

V. DISCUSSION

Fish is an important foodstuff in Cameroon because of its high nutritional value. It is the main source of accessible or affordable animal protein for poor households in urban or semi-urban areas. Recent trends indicate that like elsewhere, most natural fisheries have reached or exceeded maximum sustainable yields. Moreover, although aquaculture started in Cameroon as far back as the late 1940s, out of the national demand of about 400000t, the country “currently” meets only about half domestic demand for fish from fishing and aquaculture (180000t), with fish farming contributing less than 0.1% (Ndah *et al.*, 2011). One of the reasons for low aquaculture production in general and fish farming in particular has been attributed to limited access to quality feed. In aquaculture, fish feed costs the maximum expenditure and this is because of using animal protein sources such as fish meal, known as the best dietary protein source because it is quite palatable, and provides an excellent balance of essential amino acids, fatty acids, and some other substances (Omoregie, 2001; Hardy, 2010). Moreover, fish meal is the preferred animal protein supplement in the diets of aquatic animals. It carries huge quantities of energy and serves as the benchmark ingredient in aquaculture diets because of its high nutrient content and digestibility (Udo *et al.*, 2012). Fish meal in animal diets increases

feed consumption, feed efficiency, and growth through better feed palatability, and also improves nutrient uptake, digestion, and absorption among other ingredients (Yisa *et al.*, 2013; Rahman *et al.*, 2016).

Results from the current study indicate that substitution of fish meal (FM) with Lima bean meal (LBM) at 25% (D25) and 50% (D50), just like Coppens feed, significantly increased the growth in *C. gariepinus* fingerlings, compared to those fed with the normal diet and diet in which FM was completely replaced with LBM. These results are in conformity with those obtained by Nyadjeu *et al.* (2018) on the effect of fish meal substitution with Lima bean meal on growth and feed utilization in common carp fry (*Cyprinus carpio*). Therefore, the results demonstrate that partial substitution of FM with LBM enhances nutrient utilization in *C. gariepinus* fingerlings, which was reflected in improved weight gain, specific growth rate, feed intake, feed conversion ratio, protein intake, and protein efficiency ratio. Even though some of the problems with the use of non-conventional vegetable protein sources in aquaculture feeding are poor palatability, decreased digestibility, and decreased both nutrient uptake and fish metabolism, with consequences on both the growth and health, are attributed to the antinutritional factors; it is known that feed processing such as cooking, increase nutrients digestibility in all aquatic species by enhancing the action of the secretions of gastric juices and intestinal enzymes (Moro *et al.*, 2017; Liu *et al.*, 2017). Thus, the best growths observed in fish fed D25 and D50 could be partially attributed to different methods of treating Lima bean seeds before use.

Previous studies have shown that different processing methods, such as soaking and cooking, effectively reduce the antinutrients content (trypsin inhibitor, oxalate, saponin and phytates) and improve the nutritional value of Lima bean (Jayalaxmi *et al.*, 2016, Farinde *et al.*, 2018). According to Mortuza *et al.* (2009) and Seidu *et al.* (2018) Lima bean, like all legumes, contains high concentrations of all essential amino acids except methionine/cysteine, which can be overcome by supplementing the diet with cereal proteins. It is known that essential amino acids such as lysine, methionine, tryptophan and arginine are the essential limiting amino acids that determine the growth and body development of higher vertebrates as well as fish. As fishmeal is an excellent source of the above-mentioned essential amino acids in fish feed (Pike and Barlow, 2003), the beneficial effects of experimental diets (D25 and D50) on fish growth performance could be attributed to the combined action of these nutrients supplied by Lima bean meal and supplemented by those of fishmeal and other ingredients such as soybean cake, rice bran, wheat bran. The results of the present work showed that alternative protein source is well utilized by the *C. gariepinus* fingerlings, because the experimental diets fed groups showed significant improvement in survival, weight gain, specific growth rate, and nutritional indices such as feed conversion ratio and protein efficiency ratio. In the present study, the values of the feed conversion ratio of Lima beans meal substituted groups were significantly lower than in the control group with the protein efficiency ratio comparatively higher in the experimental groups than in the control group. These results indicate that partial substitution of fish meal with Lima bean could improve the profitability of *C. gariepinus* fish farming by reducing the cost of production due to the shortening of the production cycle and the use of less quantity of feed for a large production.

Fish perform all its bodily functions such as feeding, growth, respiration, excretion and reproduction in water. These functions are directly affected by the water quality which refers to all the physical, chemical and biological factors that influence its use. Therefore, the success of an aquaculture operation depends on the water quality parameters that need to be monitored and controlled. Water quality parameters such as temperature, pH, dissolved oxygen, nitrite, nitrate and ammonia recorded throughout the present study were consistent with the findings of Adebola *et al.* (2015), Okomoda *et al.* (2016) and Ajang *et al.* (2019). Thus, the only mortality observed in groups C2 and D100 would not be attributed to the quality of the water, but probably to the stress induced by the handling of the fish since this mortality was observed one to two days after the fish sampling. The water quality parameters recorded throughout this work proved to be adequate for the good survival of *Clarias gariepinus* fingerlings. These

parameters have also been found to be suitable to induce good growth in *Clarias gariepinus* fingerlings through the maintenance of good physiological conditions which can be reflected through the carcass composition and the nutrient retention in the fish produced.

Carcass composition of *Clarias gariepinus* fingerlings fed all diets have more protein retained in the body at the end of the experiment compared to the start of the experiment. This is an indication that the protein to energy ratio in all diets formulated were enough to meet the energy need of the fish and so there was no sparing of protein to energy hence the reduction in lipid deposits in the carcass of fish fed experimental diets D25 and D50 since dietary lipids function as a ready source of energy for fish metabolic activity. Tihamiyu *et al.* (2014) made similar observations when they were evaluating the growth performance of *Clarias gariepinus* fingerlings fed with varying levels of *Luffa cylindrical* meal in outdoor hapas; Okomoda *et al.* (2017) also obtained similar results during the nutritional evaluation of toasted *Mucuna utilis* seed meal and its utilization in the diet of *Clarias gariepinus* (Burchell, 1822). Body composition is the resultant of nutrient retention that refers to feed nutrient proportion stored as a nutrient in fish body tissue during the rearing process. Thus, better carcass composition is an indication of a good nutrient retention of mainly proteins and lipids, which are of particular interest in nutritional studies due to their association with the quality of the product, and also because they serve as important indicators of true growth involving an increase in the structural tissues such as muscles (Fafioye *et al.*, 2005; Zehra and Khan, 2012). The present study shows that both protein and lipid retentions of *C. gariepinus* juvenile obtained after feeding with D25 and D50, like Coppens, were significantly greater in comparison with those of fish fed D0 and D100. These results are in accordance with the findings of Syahailatua *et al.* (2017) who studied the effect of artificial feed composition for growth and protein and fat retention of humpback grouper, *Cromileptes altivelis*; they clearly indicate that *C. gariepinus* fingerlings fed D25 and D50 would have optimally used the feed so that the body weight increases obtained were due to optimum digestion, absorption, and being able to convert feed nutrient into flesh. Thus, the low nutrient retention observed in fish fed C2, D0 as well as D100 feed that could be explained by poor digestibility with insufficient absorption of nutrients in the digestive tract and poor conversion of these nutrients to the flesh, could be a partial justification for the low growth observed in fish from these groups.

VI. CONCLUSION

The present study showed that partial substitution of fish meal by Lima bean meal up to 50% in



the diet of *Clarias gariepinus* fingerlings had improved the overall performance in terms of growth response, feed utilization and nutrient retention. Thus, the use of Lima bean meal as a possible alternative feed ingredient in the diet of *C. gariepinus* fingerlings could reduce the cost of feed, and increase the fish farmer's income. Future studies, therefore, can be carried out to evaluate the effects of the inclusion level of this unconventional feedstuff ingredient in the diet of African catfish juveniles and other species as Tilapia.

Competing Interests

The authors declare that there are no competing interests regarding the publication of this paper.

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The Influence of Fertilizer Application on Color, Size and Number of Grains in Ecological Wheat Production

By Besim Salkić, Emina Mešinović, Adela Mujić, Ahmed Salkić
& Ernad Kucalović

Abstract- Plant nutrition is one of the most important measures for obtaining high yields and quality of products in agricultural production. Unlike conventional production where is possible to directly feed the plant, in ecological production nutrients are primarily introduced into the soil, therefore fertile soil forms the basis of a balanced nutrition of plants. In addition, ecological farming is defined as sustainable management of resources, which should be conserved and aim to use local resources through cycle closing, especially in terms of nutrients and organic matter. It is very important to apply fertilizer in an adequate period, having in mind the characteristics of the soil, the nutrient content in it, as well as the needs of the cultivated plants, so it can therefore be said that the efficiency of the nutrients depends on the type of fertilizer and its time of application. When specifically talking about phosphorus as a biogenic element that forms part of many organic compounds, it has an impact on the processes of growth, development, resistance to low temperatures and grain quality. The grain color, as one of the physical properties is generally a varietal characteristic. However, often under the influence of certain factors, insufficient and unbalanced nutrition, there may lead to variations in color and grain size characteristic of the variety.

Keywords: *plant nutrition, ecological production, sustainability, quality, grain color.*

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THE INFLUENCE OF FERTILIZER APPLICATION ON COLOR, SIZE AND NUMBER OF GRAINS IN ECOLOGICAL WHEAT PRODUCTION

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The Influence of Fertilizer Application on Color, Size and Number of Grains in Ecological Wheat Production

Besim Salkić ^α, Emina Mešinović ^σ, Adela Mujić ^ρ, Ahmed Salkić ^ω & Ernad Kucalović [¥]

Abstract- Plant nutrition is one of the most important measures for obtaining high yields and quality of products in agricultural production. Unlike conventional production where is possible to directly feed the plant, in ecological production nutrients are primarily introduced into the soil, therefore fertile soil forms the basis of a balanced nutrition of plants. In addition, ecological farming is defined as sustainable management of resources, which should be conserved and aim to use local resources through cycle closing, especially in terms of nutrients and organic matter. It is very important to apply fertilizer in an adequate period, having in mind the characteristics of the soil, the nutrient content in it, as well as the needs of the cultivated plants, so it can therefore be said that the efficiency of the nutrients depends on the type of fertilizer and its time of application. When specifically talking about phosphorus as a biogenic element that forms part of many organic compounds, it has an impact on the processes of growth, development, resistance to low temperatures and grain quality. The grain color, as one of the physical properties is generally a varietal characteristic. However, often under the influence of certain factors, insufficient and unbalanced nutrition, there may lead to variations in color and grain size characteristic of the variety.

Keywords: plant nutrition, ecological production, sustainability, quality, grain color.

1. INTRODUCTION

Fertilization significantly affects the stability of yields and soil fertility, which are very closely related, because higher fertility implies greater availability of nutrients and greater ability of the soil to neutralize some extent adverse seasonal impacts (eg. drought) and the adverse impact of insufficient or redundant nutrition (soil elasticity) and thus contributing to the stability of yields¹. The importance of plant nutrition in agricultural production is recognized at all levels, including in legislation where the differences between conventional, integral and organic agriculture are largely focused on nutrition and crop protection¹. Fertilization affects most of the parameters in the agro ecosystem, including: height, quality and stability of yield, soil fertility, nutrient circulation, sustainability and cost-effectiveness of production. In ecological farming, environmental protection comes first, so a special attention is on the selection and application of fertilizers.

One of the basic assumptions that makes production ecological is the use of organic fertilizers. Other types of fertilizers that can be used in ecological production are natural mineral fertilizers, ingredients of different rocks. Since soil as a resource was created by rock mineralization, the introduction of these fertilizers into the soil naturally mimics the process of land formation². Mineral fertilizers are used primarily for phosphorus, potassium and calcium. Phosphorus is a very important element for all living organisms. It is necessary in the physiological processes and metabolism of energy and matter, in the constitution of vital compounds and in the reproduction. Plants adopt and demand it in large quantities. Phosphorus is one of the essential elements, from an agricultural point of view, extremely important for the growth and development of plants, where it plays a role in energy reactions in the plants, photosynthesis, respiration, and gene and nutrient transfer, but also a key nutrient for optimizing N fixation of Rhizobium bacteria in nodules of leguminous roots, so it is imperative that the P content be maintained above minimum levels to ensure sufficient N₂ fixation³. Some varieties of legumes are adapted to mobilize rarely available sources of phosphorus in the soil and improve the phosphorus provision of the following crop in rotation. In addition to legumes, which have a high proportion of typical crop rotation in organic farming systems, there is also the possibility of using recycled phosphorus fertilizers, including those with higher and lower phosphorus bioavailability³. Due to the limited application of effective mineral fertilizers, the potential need for phosphorous fertilizers in ecological production is greater than in conventional. For sustainable management, it is crucial that the nutrients being removed are returned to the soil. Much of the nutrient demand in ecological farming is covered by the internal circulation system, that is, the application of manure.

However, phosphorus deficiency is caused by the fact that the phosphorous contained in the manure cannot compensate for the needs of the plants in ecological farming. In order to compensate for the needs of the plants, it is possible to apply recycled fertilizers that can balance the nutrition and get high yields without damaging the environment. In addition to high yields, quality is also very important. One of the good and essential features of recycled fertilizers is that

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they release nutrients slowly, which is good for sustainable phosphorus management⁴. Its "recovery" itself is a step in closing the cycle of nutrient cycling and contributes to sustainable management⁵. However, the efficiency of recycled fertilizers depends on the soil type due to differences in solubility and sorption properties of the soil. It is most effective in soils of moderate or low pH, but its efficiency is limited in soils with low fertility and high pH. The solubility of the fertilizer improves under acidic conditions, increasing efficiency. Acidic conditions result in increased P adsorption into the soil and hence its dissolution and availability. The use of recycled fertilizers helps to realize some additional benefits, some of them are loss reduction and encourage the uptake of other nutrients. Depending on the variety, soil type and nutrient, wheat grains can differ in grain size, color and shape, as well as protein composition, carbohydrates, fats, minerals and vitamins. The shape and size of the grain play a large role, especially in grain processing. The grain shape is characteristic for each type of cereals, so the wheat is characterized by an elongated ellipsoidal shape, but preferred grains are closer to the round shape. A grain size is also a very significant indicator. Larger grains generally have a higher endosperm content⁶. Certainly, genetic potential is taken into account when selecting wheat varieties. Each variety of wheat has DNA (deoxyribonucleic acid) that gives it certain genetic traits. In the wheat kernel, the DNA is located in the germ, which is the embryo or sprouting section of the seed. Some varieties of wheat grow better in drought conditions while others are better at resisting certain pests. Some wheat varieties have a higher moisture content or contain higher percentages of protein⁷. This paper focuses on the impact of fertilizers (manure, P-Rock Morocco, Dolophos, Berliner Pflanze) and control samples on color, size and number of wheat grains, variety SW Kadrijin ecological production system.

II. METHODS

The experiment was conducted during the wheat growing season in 2018, at the experimental station of the Institute for Agricultural and Urban Ecological Projects in Berlin. The experiment was set up in Mitscherlich pots in a greenhouse in Berge (Nauen). The vegetation experiment in Mitscherlich pots is based on the cultivation of plants according to a well-defined plan to determine the impact of certain elements of the plant nutrition, canceling out the significant influence of environmental factors. The Mitscherlich cultivation vessel is made of porcelain enamelled steel plate. For the experiment were selected pots which are 20 cm in diameter and with a capacity of 6.2 l. For grain counting was used Contador grain counter which provides fast counting speed and exact results. Wheat grain quality is a complex concept and includes several properties. To

evaluate the quality based on the physical properties of the grain, it is easiest to determine the properties of hectoliter mass and thousand grain mass. Unfortunately, due to the insufficient quantity of samples it was not possible to determine the quality on that way, so visual assessment and comparison of size, shape and grain color was made.

a) *Soil selection, preparation and preculture sowing*

The soil was taken from two different locations, which have been in the ecological / organic production system for years. Both types of soil, light and heavy were used because each type has both advantages and disadvantages, and the aim was to compare yields and changes on plants as well as on grain from that aspect. After collection, soil was sifted in order to remove mechanical and biological impurities. The soil is well mixed with inert quartz sand. The mixing of soil and sand was performed in order to achieve good water-air regime. For the trial, a total of 40 pots were selected, with 4 replications for each treatment with heavy and light soil. For each pot were prepared 6 kilos of soil and 1g of fertilizer. The bottom half of the mixture in the pot is well compacted and the top half is left friable. In 2017, growing season, a broad bean (*Vicia faba*), a one-year-old plant from the legume family, was in the pots as a preculture. Since it is useful plant as a nitrogen fixer, the goal was to keep the soil rich in nitrogen after growing it.

b) *Nutrition*

As noted in the introduction part of this study, for nutrition were used four treatments: manure, P-Rock Morocco, Dolophos and Berliner Pflanze. Manure is considered to be the most important organic fertilizer and generally contains all the nutrients needed for plant nutrition. The manure repairs the physical, chemical and biological properties of the soil¹. A fully composted manure was used for this experiment. As the second treatment was used P-Rock Morocco. It is a crude phosphate of magmatic rock deposits originating in Morocco. P-Rock Morocco contains 25-34% of P_2O_5 and is authorized for use in ecological production under Regulation (EEC) No. 2092/91 and Regulation (EC) No. 834/2007 but it is important that cadmium content (Cd) not exceeding 90 mg / kg P_2O_5 ⁸. Dolophos is a granular fertilizer with different P_2O_5 content (11% or 26%). 26% was used for the experiment. It has the effect of slow release during vegetation, which is an advantage for sustainability. However, the release rate is also regulated by the soil pH. It also contains important secondary nutrients, including CaO, 2% MgO, and manganese, zinc, copper, and molybdenum. It is also approved for use on farms that are in the ecological production system⁹. The last treatment was a recycled, high-quality, slow-release fertilizer under the factory name Berliner Pflanze. It sells itself according to German and European Fertilizer Regulations (VO 2003/2003) as

a compound fertilizer containing 5% N, 23% P and 12% MgO¹⁰.

c) *Main crop (wheat) sowing – variety SW Kadrij*

In spring of the season 2018, 3 g of K₂O was added to each pot, and then the main crop, wheat (*Triticumaestivum*), of the SW Kadrij variety was sown. It is a high-yielding variety, which is very tolerant of bearing. It is medium early variety, characterized by high

and stable yields and good disease resistance, which is an advantage in ecological production¹¹. The seeds of this variety are certified as organic. In each pot was seeded 15 grains of wheat, and after sprouting, the number was reduced to 10. The pots were placed in appropriate places, on tables, below which were the receptacles for accepting drainage water. Wheat characteristics of the Kadrij variety are shown in table 1.

Table 1: The characteristics of wheat – variety SW Kadrij

(adopted from: <https://www.syngenta.de/produkte/saatgut/sommerweizen/sw-kadrij>)

The characteristics of wheat - variety SW Kadrij	
Plant height	Short to medium (4)
Earing	Early to middle (4)
Thousand grain mass	Medium (5)
Inclination to bearing	Low (3)
Disease resistance	Medium to high (6)
Maturity	Medium (5)
Quality	High (7)
Crude protein content	High (7)

d) *Grain counting*

Seed counter – Contador was used for counting wheat grains. This grain counter is suitable for counting and filling of all seeds from 0.3 mm to 15 mm. The Contador is an optical counter with integrated vibration channel. The counting speed is automatically controlled depending on the size of the material to be counted, so that the counting time is minimized and a high degree of counting accuracy is achieved. The feed container is held by a magnet and is easy to change. Both a sample change and a crop type change can therefore be carried out very quickly. The Contador can be controlled using the keyboard on the device or using the serial interface. Particles that are significantly smaller in size are not counted. Thus, for example, rapeseed seeds in a pea sample fall into the pot but do not count. By manually adjusting the seed size, it is possible to control the counting of the material. The Auto Mode screen shows the set quantity and number of grains counted. In manual mode it also displays the selected counting speed and seed size. The keyboard is used to select

different modes. There are 3 types of containers for counting grains according to their size¹². For this experiment, tank number 2, which is adequate for wheat grains, was used.

III. RESULTS AND DISCUSSION

In the framework of the conducted research, the results in this part are given in order to discuss the same and determine the differences in the physical properties of wheat grains in relation to the treatments applied. Wheat grain quality and physical properties are always strongly influenced by the variety, but nutrition also has a major impact on changes in color, grain size and number of the same wheat variety. Nutrition has an impact especially during the grain filling period, and nitrogen, phosphorus, potassium as well as magnesium and zinc are very important. Differences in the color of SW Kadrij wheat grains with respect to the treatment applied are shown in Figures 1 and 2.



Figure 1: Grain color differences (light soil)



Figure 2: Grain color differences (heavy soil)

a) Grain color

Each of used treatments have shown a different color of the Kadrij wheat kernel, which is a clear indicator that, in addition to all the factors that can cause color change, nutrition plays a large role. For light soil types, the darkest grain color was shown by samples where manure was used, so that color of grain is not a variety characteristic. In addition, the grains where this treatment was applied do not, by hardness, shape or size, meet the quality criteria of the physical characteristics of SW Kadrij variety. This was definitely influenced by the nitrogen content of the manure, which led to prolonged vegetation, and a considerable number of wheat ears in pots labeled with this treatment continued to have a color on the transition from green to yellow, which was reflected in the grain filling, and ultimately to the color and quality of the grain. Although

the number of kernels under this treatment was highest, the kernels were shrunken and fractured compared to other treatments. Also, for light soil type, the color is lighter than grain samples obtained on heavier soil using manure. For other samples where used (P-Rock Morocco, Dolophos and Berliner Pflanze) and samples that were in control, the grain color difference was evident in shades, and samples where Dolophos was applied and samples in control showed almost the same color, while the grain samples where P-Rock Morocco was applied showed a lighter color with a distinct golden tone in light soil type, compared to samples in the heavier type, which showed a darker color without gold tone. In addition to the color of the grain, the application of different fertilizers also affected the number of grains, which can be seen in Tables 2. and 3.

Table 2: Overview of the difference in the grains number in relation to the applied treatments (light soil)

Treatment	Soil type (light)	Total number of grains
Control	1	886
Manure	1	2359
P Rock Morocco	1	807
Dolophos	1	893
Berliner Pflanze	1	1502

Table 3: Overview of the difference in the grains number in relation to the applied treatments (heavy soil)

Treatment	Soil type (heavy)	Total number of grains
Control	2	946
Manure	2	2784
P Rock Morocco	2	1024
Dolophos	2	978
Berliner Pflanze	2	1705

As shown in the results, the largest number of grains in light as well as in heavy soil was obtained by applying manure, which is quantitatively excellent, but qualitatively, as previously shown through physical properties very poor. Following samples under manure, the best result in the total number of grains in both soil types was shown by samples where was used Berliner Pflanze fertilizer, which is an additional indication that this recycled fertilizer has a positive effect on yield and quality. Behind it, by the total number of grains obtained on light soil type are samples where a fertilizer called Dolophos was used and for heavier soil types, samples where P-Rock Morocco was used. A better result of applying P-Rock Marrocco to heavier soil types was influenced by its exceptionally favorable impact on that type of soil. The smallest total number of grains was shown by the samples that were in control. These results are indicative of the crucial influence of the nutrition with nitrogen and phosphorus, where the proportion of phosphorus nutrients is significantly increased.

b) Grain size

Certainly, various studies have been done over the years to show on what the nutrition can affect, and

thus its effect on grain size has been proven, especially during the filling grain phase. Certainly, in the last years various studies have shown the influence of fertilization on wheat growth and development, on yields and thus its effect on grain size has been proven, especially during the filling grain phase. The grain size is genetically determined, that is, depends on the variety and the length of the filling period. Immediately after pollination, the embryo and endosperm begin to develop, so that the plant directs all photo synthates and previously stored starch and proteins (in leaves and stems) to these developing grains. The longer this period of grain fill is, the larger wheat grain size is likely to be. Nitrogen management will have the most impact on final wheat grain size and weight. Applications made early will ensure a canopy that is large, containing high levels of stem carbohydrate that is translocated to the developing grain during maturation. It is important to monitor plant nitrogen levels ensuring the canopy does not senesce early and curtail the grain filling period. However, except for nitrogen, phosphate has a major role in the supply of energy for plant processes. Redistribution of stored carbohydrate requires energy making phosphate nutrition important in achieving good wheat grain size¹³. Positive results during this research

were shown by applied fertilizers with an emphasis on phosphorus content, and in particular recycled fertilizer - Berliner Pflanze.

IV. CONCLUSIONS

1. Fertilization is one of the agro-technical measures that is indispensable in wheat production, without which high and stable yields and good grain quality cannot be expected.
2. Comparing all used treatments, the best results in grain quality were shown by the application of recycled fertilizer Berliner Pflanze, while the highest number of grains was obtained by applying manure.
3. The grains obtained from plants using the treatments P-Rock Marroko, Dolophos, and Berliner Pflanze showed good physical properties, unlike grains from plants where the manure was used, which were smaller, darker and shriveled.
4. Phosphorus is an important macronutrient without which plants cannot grow and develop normally, and through this work it is shown that nutrition with phosphorous fertilizers definitely affects a number of processes in plants, and ultimately has an effect on the height and quality of yield, color, size and uniformity of wheat grain.
5. In ecological wheat production where nutrition remains a challenge and where it is very difficult to strike a balance, through this study it has been shown that the color deviations characteristic of a particular variety can be minimized by the use of recycled fertilizers.

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Prospectives of Coffee Production and Marketing (The Value Chain Approach): The Case of Yirgachefe District, Gedeo Zone, Southern Nation Nationalities and Peoples Regional State, Ethiopia

By Tizazu Toma Dilebo

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Abstract- Coffee produced in Yirgachefe is internationally known as the rarest and most prized coffee, especially in America. But farmers in Yirgacheffe district complain that they are not benefited from the existing coffee supply, and half of the coffee supplied to Ethiopian Commodity Exchange(ECX) to be exported does not fulfill the quality criteria of ECX. These might be due to some technical and socio-economic factors. Thus this study was conducted to identify those determinants reducing the quality of Yirgachefe coffee. The general objective of this study was analyzing coffee value chain and Its specifics were to trace the value chain of Yirgachefee coffee AS-IS from input supply to consumption, to identify all the constraints that impede the competitiveness of coffee produced in Yirgachefe in the national & global market and to determine the role of actors in the coffee value chain for the intervention.

Keywords: coffee producers, coffee value chain, ecx, coffee processing industries.

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Abstract- Coffee produced in Yirgachefe is internationally known as the rarest and most prized coffee, especially in America. But farmers in Yirgacheffe district complain that they are not benefited from the existing coffee supply, and half of the coffee supplied to Ethiopian Commodity Exchange(ECX) to be exported does not fulfill the quality criteria of ECX. These might be due to some technical and socio-economic factors. Thus this study was conducted to identify those determinants reducing the quality of Yirgachefe coffee. The general objective of this study was analyzing coffee value chain and Its specifics were to trace the value chain of Yirgachefee coffee AS-IS from input supply to consumption, to identify all the constraints that impede the competitiveness of coffee produced in Yirgachefe in the national & global market and to determine the role of actors in the coffee value chain for the intervention. To achieve these objectives, both primary and secondary data were collected from 130 farm households, 16 traders, three processors and 17 consumers using pre-tested semi-structured questionnaire, and from different literatures such as unpublished organizational documents, books, published journals, and unpublished M.Sc. thesis. Descriptive statistics was employed to analyze the data together with mapping and narrative approach. The study result showed that there is a gap in input supply, land preparation, production, harvesting, processing, and marketing functions. Regarding input supply, Shortage of improved seedlings, reduced productivity due to manual operation, and transmission of coffee disease due to untreated hand tools were constraints on the AS-IS value chain. Absence of plowing practice before holing and Lack of holing machine were identified as constraints related to land preparation. Production problems identified were farm operations such as Slashing, hoeing, pruning, Stumping,& de-suckering using manual tools; use of un-decomposed or sub-standard compost; no mulching practice; intercropping competitive non-leguminous plants and Untimely uprooting the infected coffee tree. Lack of machine support and Picking unripe & over ripped cherries together with the red cherry are out of harvesting problems. Quality problems due to processing non-uniform varieties of coffee, improper use of pulping machines, and operating with maladjusted disk type, which creates

quality problems, manual separation, and shortage of drying materials such as mesh wire sacks made from fibbers are also out of processing problems. Regarding marketing, insufficient storage units, Wastage during sample taking, and extra warehousing costs are constraints in the AS-IS value chain. The study result indicated the need to encourage the entry of TVET, Institute of Technology (IOT), and Coffee, Tea and Spices Authority to fill the gap.

Keywords: coffee producers, coffee value chain, ecx, coffee processing industries.

I. INTRODUCTION

Coffee is being produced in more than fifty developing countries in Latin America, Africa, and Asia, and it is a major source of income for 20-25 million families worldwide (Murphy & Dowding, 2015; Lewin B. et al., 2004; ICO, 2009). Ethiopia, the birthplace of coffee, stands first in coffee production in Africa and is the fifth-largest coffee producer in the world next to Brazil, Vietnam, Colombia, and Indonesia, contributing about 4.2 percent of total world coffee production (Alemayehu, 2014). By 2011/12, the country had produced approximately 500,000 metric tons of coffee (Abu Tefera & Teddy Teffera, 2014).

Out of nine regional states of Ethiopia, coffee is dominantly produced in Oromia and Southern Nation, Nationalities and People regions. As per the coffee, tea and spices authority, south nations, nationalities, and peoples' region contributes around 60 % of the total washed coffee and 40% of the total unwashed coffee being supplied to domestic and international markets. Sidama and Gedeo zones are the first and the second highest producers of coffee in SNNPR.

Yirgachefe District is one of the six district s of the Gedeo zone and is the highest producer of coffee in the Zone. It contributed around 32.1% of the total washed coffee and 26.4 % of the total unwashed coffee produced in the Zone in 2017. The total annual production of coffee in 2016/2017 was 70546 qt, which was 30.1% of the total coffee produced in the zone in 2016/2017, which is 234061qt.

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The district is internationally known for its distinguished flavor coffee. Tehsale (2017) stated that the washed coffee of Yirgacheffe is the most famous Ethiopian coffee, especially in the United States, as a trademark (Teshale, 2017). It has a test of Blueberry overtones and aroma, with a hint of floralness and winey in the finish. But farmers in Yirgacheffe complain that they are not benefited from the existing coffee supply while their coffee had been internationally accepted as the rarest and most prized. The other problem is that although Ethiopia has been taking part in exporting coffee to the World market, half of the total production including the one supplied from Yirgacheffe is being consumed locally (Belay Kinati, 2017), which implies that half of the coffee supplied to ECX to be exported does not fulfill the criteria of ECX and rated as under qualifying.

Therefore, this study addresses factors that contributed to under-qualification of coffee from Yirgacheffe in terms of value chain analysis. In doing this, the study will identify various technical, institutional, and technological gaps that contributed to low quality in the value chain from input supply up to consumption.

a) *Statement of the Problem*

Yirgacheffe is known for its high production of coffee in the Gedeo zone. It is the first in coffee production from 6 districts of the Gedeo zone. Coffee produced in Yirgacheffe had also been internationally known as the rarest and most prized coffee, especially in America. But farmers in Yirgacheffe complain that they are not benefited from the existing coffee supply, and half of the coffee supplied to ECX for export does not fulfill the quality criteria of ECX, implying that half of the coffee produced in Yirgacheffe is being consumed domestically. This low quality might be due to some technical, technological, institutional, managerial, socio-economic, and environmental factors. Thus, this study was conducted to identify those factors that reduced the quality of Yirgacheffe coffee. The study employed a value chain analysis method to investigate the problem.

b) *Objectives of the Study*

i. *General Objective*

The general objective of this study is to analysis the coffee value chain produced in Yirgacheffe district of Gedeo Zone found under southern state of Ethiopia, to identify the constraints within the value chain in pursuit of technological interventions.

ii. *Specific Objectives*

- To identify the value chain of Yirgacheffe coffee AS-IS from input supply to consumption.
- To study international best practices to be used as a benchmark to take a competitive advantage.
- To identify all the constraints that impede the competitiveness of coffee in the study area in the national & global markets.

- To determine the role of actors in the coffee value chain for the intervention.

II. REVIEW OF RELATED LITERATURE

Various literatures define the value chain in different ways. However, the core idea behind all definitions implies similarity. For instance, WBCSD (2011) put value chain as 'the full life cycle of a product or process, including material sourcing, production, consumption, and disposal/recycling processes. It is an integral part of strategic planning for many businesses today'. Kaplinsky & Morris, (2001) also described the value chain as the full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers, and final disposal after use. These definitions imply that value chain refers to the comprehensive process from input supply for production of a given good up to its consumption and waste disposal, which encompasses production process and value-adding activities, actors involved, product flow chains, and support chains in each value addition activities. Likewise, the value chain of coffee implies the full process from its input supply up to consumption.

Porter (1985), cited in Teshale Fekadu (2017), utilized the framework of value chains to assess how a firm should position itself in the market and about suppliers, buyers, and competitors. It is as put follows.

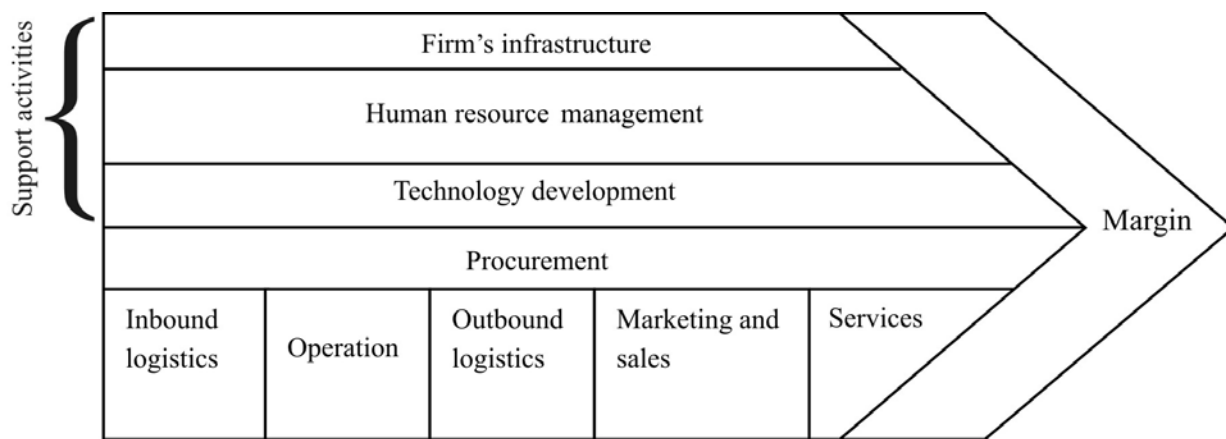


Figure 1: Porter's (1985) representation of a value chain

However, in real-life situations, value chains is more complex, involving several producers, creating various links within the value chain. Therefore it can be said that one value chain may be composed of several smaller value chains (Kaplinsky and Morris 2001).

III. METHODOLOGY

a) Description of the Study Area

Yirgachefe district is one of the six districts of the Gedeo zone, which is located in the east-central part of the Gedeo zone at a distance of 37 km from the capital city of the Zone/Dila and 127 km from the capital of SNNPR, Hawassa. The Zone is located in the coordinates of 6° 06' to 6° 29' North latitude and 38° 09' to 38° 31' East longitudes. The total area of the district was 266 sq.km, and it was bordered on the south by Kochere, on the west by the Oromia region, on the north by Wenago, on the east by Bule, and on the southeast by Gedeb (SNNPR BoFED, 2012).

There were around 246,573 people in the district who live being clustered in 36 *Kebeles*, out of which 50.3% (123997) were females, and the rest 49.7% (122576) were males as per the 2013 projection of Central Statistics Agency (CSA, 2013) for the coming four years from 2014-2017. The total household size was estimated to be 41096. Around 87% (214,439) of the total population is living in rural areas depending on crop production and livestock raising, and the rest 13% (32134) are dwellers in the urban part of the district.

The average population density is estimated to be 933 persons per square kilometer, and the average land holding size of the district is around 0.65 hectare, which is much below the national average of total households' land holding in rural areas (1.77 hectares) (CSA and World Bank, 2013). Agro-ecologically, the district exhibits 93% *Weina Dega* (Midland) and 7% *Dega* (Highland). It has the mean annual temperature ranging from 15.1°C to 20°C, elevation ranging from 1501 to 3000 masl, and average annual rainfall ranging from 1201mm to 1800mm (DistrictBoFED, 2015).

Regarding coffee production, the district was ranked as the highest producer of coffee in the Gedeo zone as out of the total 36 kebeles, 33 were coffee producers. Of this amount, 26 are registered as high producer kebeles. The total annual production for the year 2015/16 was 49464 quintals of washed coffee and 21082 quintals of unwashed coffee according to the reports of the Yirgachefe coffee, tea, and spices production coordination department (CTSPCD, 2017). The figure below shows a map of the Yirgachefe district.

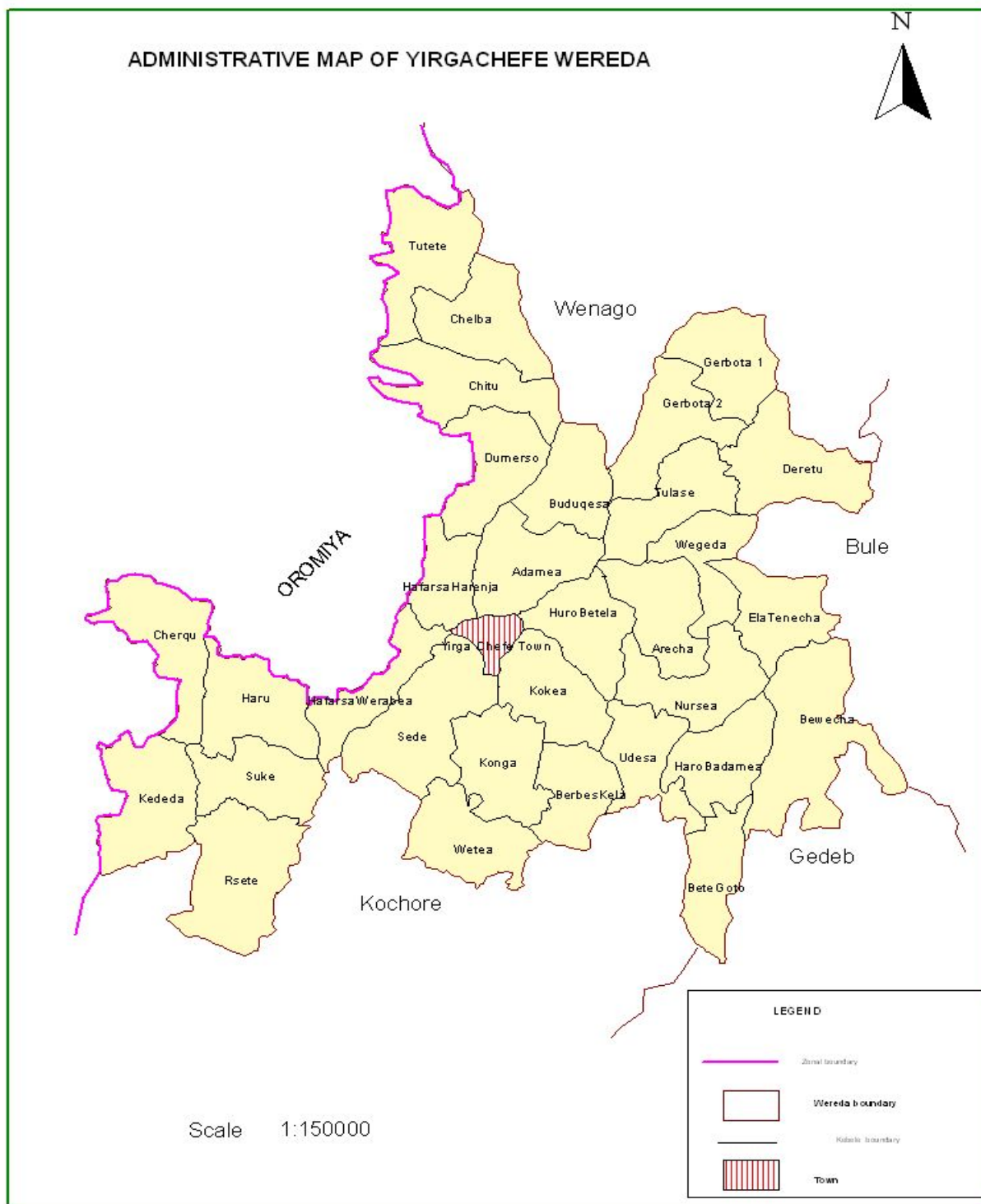


Figure 2: Map of Yirgacheffe district (Source: BOFED, 2016)

b) Selection Criteria of Coffee Value Chain

The coffee value chain is selected for analysis based on the selecting criteria set by Federal TVET agency. First, GTP-2 priority sectors were listed, and among them, the main economic activity in the case area was identified, which is agriculture. In Yirgacheffe district, the livelihood of the society is mainly dependent on crop production in which coffee plays a dominant

role in terms of land coverage, employment, GDP share, market share, the share of export, growth potential, market potential, product diversification, conservation importance & women empowerment. Table 1:1 below shows the growth and transformation plan (GTP) priority sectors from which the study selected coffee value chain.

Table 1: GTP priority sectors

Growth and Transformation Plan (GTP) Priority Sectors			
1	Agriculture Crop production Coffee value chain		
2	Industry development	4.2	Road Transport
		4.3	Shipping Transport
2.1	Textile and Garment	4.4	Air Transport
2.2	Leather Industry	4.5	Energy
2.3	Sugar	4.6	Water and Irrigation
2.4	Cement	4.7	Telecommunication
2.5	Metal Engineering	4.8	Urban Development
2.6	Chemical	5.	Trade
2.7	Agro Processing	6.	Health
3	Mining	7.	Culture, Tourism, & Sport
4	Economy and infrastructure	8.	Social
4.1	Rail Transport		

c) *Data Types, Sources, and Method of Data Collection*

This study required both primary and secondary data to fully conduct it. Various value chain actors, including cooperative unions, traders, exporters, producers, consumers, financial organizations, and ECX were sources of primary data. Secondary data sources were internet, published and unpublished reports. Data have been collected from primary data sources using data collection instruments such as an observation, pre-tested semi-structured questionnaire, and checklists. During an observation, the availability of coffee farms, the farming system, farm tools used, traders' retail shops, and processors processing machines have been observed. Checklists were used to collect data from agricultural experts of the District and from experts of the district Trade and Industry Development Coordination Unit, cooperative unions, financial organization, ECX experts and zonal agricultural experts to have the overall outlook on the flow of coffee throughout the value chain and the different support services delivered by value chain actors. Interview method has been employed to collect data from farmers, traders, processors, and consumers using separate questionnaires.

d) *Sample Size Determination and Sampling method*

Regarding sample size, 30 producers, 16 traders including ECX exporters, three processors (industries), and 17 consumers were arbitrarily determined as samples for this particular study due to time and budgetary constraints. The random sampling method was used to select producer farmers from three kebeles of Yirgacheffe district. All 16 traders, including

ECX exporters, processors, and 17 consumers were randomly selected as samples for this study.

e) *Data Analysis*

Both qualitative & quantitative data collected through various methods were analyzed by using a descriptive method of data analysis. The collected data from both sources were analyzed by using value chain analysis approach. A value chain map was used to depict the coffee value chain in Ethiopia explicitly. After collection of data from interviews and desk studies, the analysis is done by the value chain analysis approach. The stakeholder matrix was used to show the role of chain supporters taking part in the coffee value chain. Chain mapping is used to explain the value chain of coffee in the country. Also, a comparative analysis of the AS-IS value chain and the benchmark value chain of coffee had been undertaken.

IV. RESULTS AND DISCUSSION

a) *Coffee Value Chain Actors and Their Roles*

Actors participating in the coffee value chain include input suppliers, coffee producers, traders (small-scale and large scale traders), unions or cooperatives associations, processors (hullers and wet mills), exporting firms (including Ethiopian Commodity Exchange organization) and local roasting firms.

Input suppliers: These actors include research centers (seedling suppliers), agricultural chemicals suppliers, agro-input dealers, and the likes. Large-scale producers directly buy from international suppliers, whereas the rest get from local agro-dealers.

Coffee producers: these include small-scale coffee producers and farmers' cooperatives, and large-scale commercial private enterprises, which produce coffee for the local and global market as per the standard of coffee quality set by the inspection body.

Traders: Buy coffee from smallholder farmers at their locality and supply to processors. They include local collectors and large scale traders. They have a crucial role in the coffee assembly and transfer to the processors.

Cooperatives: these are farmers groups who collect coffee from member farmers and supply to processors, Unions, and ECX. Members collect coffee together as well as purchase others' coffee in the village town as a group and supply to processors and Unions. Since some cooperatives have their processing machines, they process and sell directly to ECX.

Processors: Processors are actors performing processing activities in stations. They carry out both dry and wet processing. These processing activities include hulling and pulping of coffee and sorting, grading packing and weighing is carried out here in large scale producers & cooperatives all processing work is accomplished by the producers by their processing plants.

Cooperative Union: they link producer farmers' cooperatives to international traders. They Collect coffee from cooperatives and makes some value addition

practices(hulling/processing, clearing, sorting and packaging), and export directly to international buyers. Also, Cooperative Union plays a significant role in the area of market linkages, collateral for cooperatives, and technical support to other cooperative and representing other cooperative members in the marketing process as well.

Wholesalers: There are private enterprises and individuals that have got legal license to participate in a coffee transaction according to the regulation set by the country coffee transaction undertaken at ECX, and they buy processed coffee from collectors and sell the best quality to exporters. They also make sale of under qualified coffee for retailers.

Exporters: Involved in operations such as buying the coffee from wholesalers at ECX and export the finished clean and standardized coffee beans.

Retailers: these are two group. The first are found in Ethiopia. They buy under qualified coffee and sell it domestically. The second are found in coffee importing country. Retailers in Ethiopia purchase coffee from the large-scale producers, exporters and cooperatives for selling for domestic consumers.

Consumers: these are also two group. Those found in Ethiopia and those who are in importing country. The role of both consumers is nearly the same. It is consuming coffee either in the form of hot boiled coffee or in other different forms such as candy.

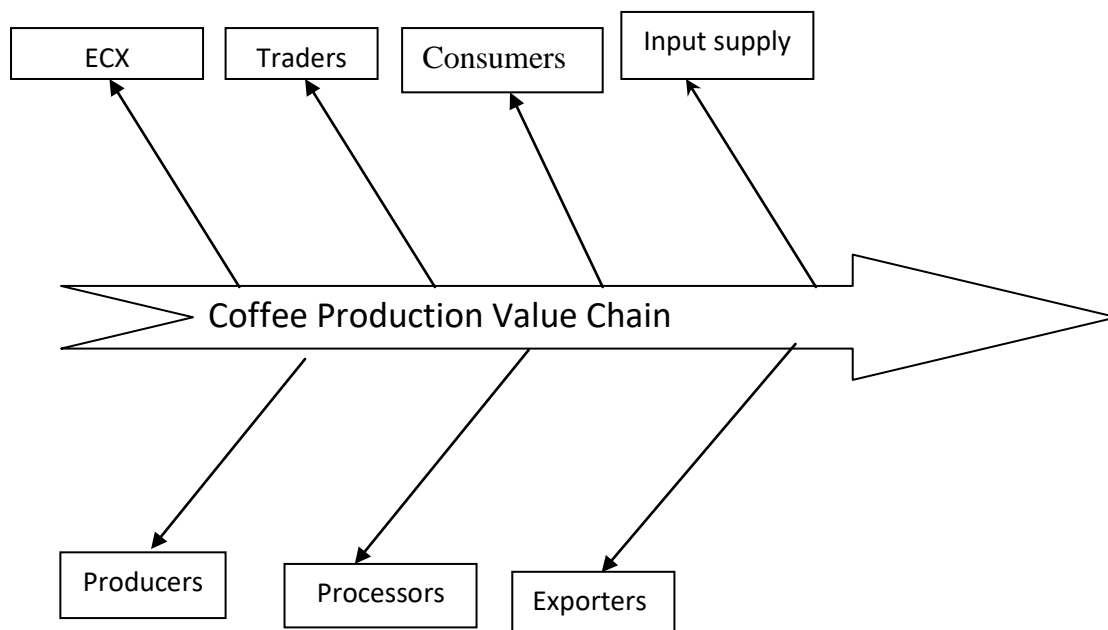


Figure 3: Fish Bone diagram representing actors of the coffee value chain

b) *Bench-marking*

The bench mark was selected based on the total production and productivity history of countries. The following table shows the total production and

productivity of the world top 10 coffee producers including our country Ethiopia.

Table 2: Ten coffee producing countries by year 2017/18 in mil bags of 60kg

Name of country	Yield per hectare per year	Remark
Brazil	61	
Vietnam	30	
Colombia	13	
Indonesia	11	
Honduras	7.5	
Ethiopia	6.5	
India	6	
Mexico	5	
Peru	4.9	
Guatemala	4.1	

The above countries also differ in their productivity rate. The following figure also shows the productivity rate of these coffee-producing countries in quintal per hectare in order of their importance.

Therefore, Brazil is selected as a bench mark for this comparative study to compare with the existing value chain of coffee (AS-IS) in Ethiopia, especially of Yirgachefe.

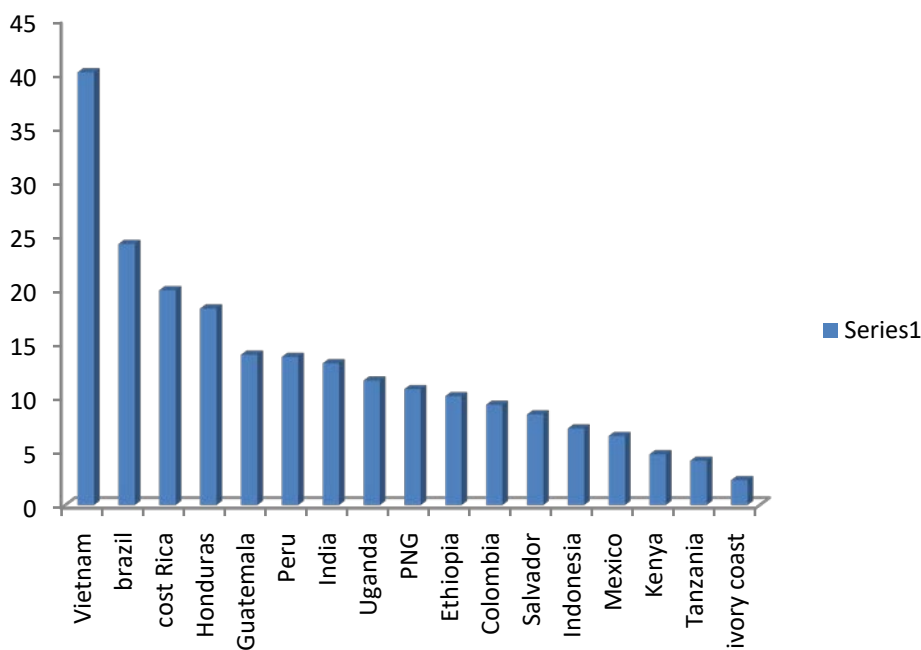


Figure 4: Productivity rate of world coffee-producing countries in quintal per hectare

c) Value Chain Mapping

i. Mapping the AS-IS Coffee Value Chain Starting from Yirgachefe

Figure 3 below shows the AS-IS map of the coffee value chain, which starts from Yirgachefe, where most of the coffee produced in the Gedeo zone comes. It begins from input supply and ends at export. The coffee that flows through either changes its form or its place from where it was produced up to export. In each stage, the different functions undertaken by respective actors have been listed. Each activity in the AS-IS value chain is being compared to figure 4 which is the benchmark (the Brazilian experience), and mapped

under the AS-IS map. The gap between Brazilian experience and the AS-IS condition are also identified and put in figure 5. This map shows what is available there in Brazil but not here in Ethiopia and functions which are available but are not being properly undertaken.

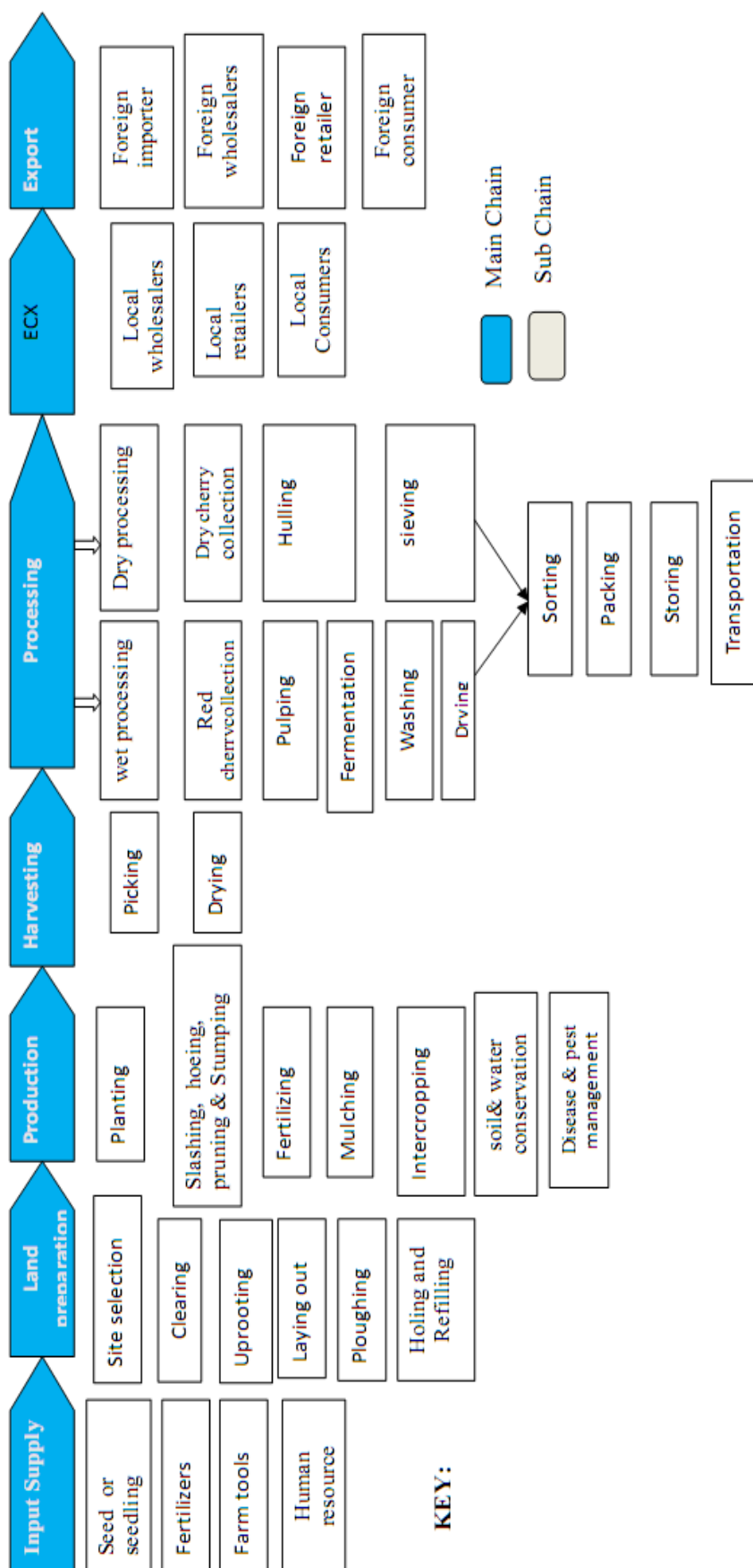


Figure 5: The AS-IS coffee value chain starting from Yirgacheffe

ii. The Benchmark Coffee Value Chain: The Case of Brazil

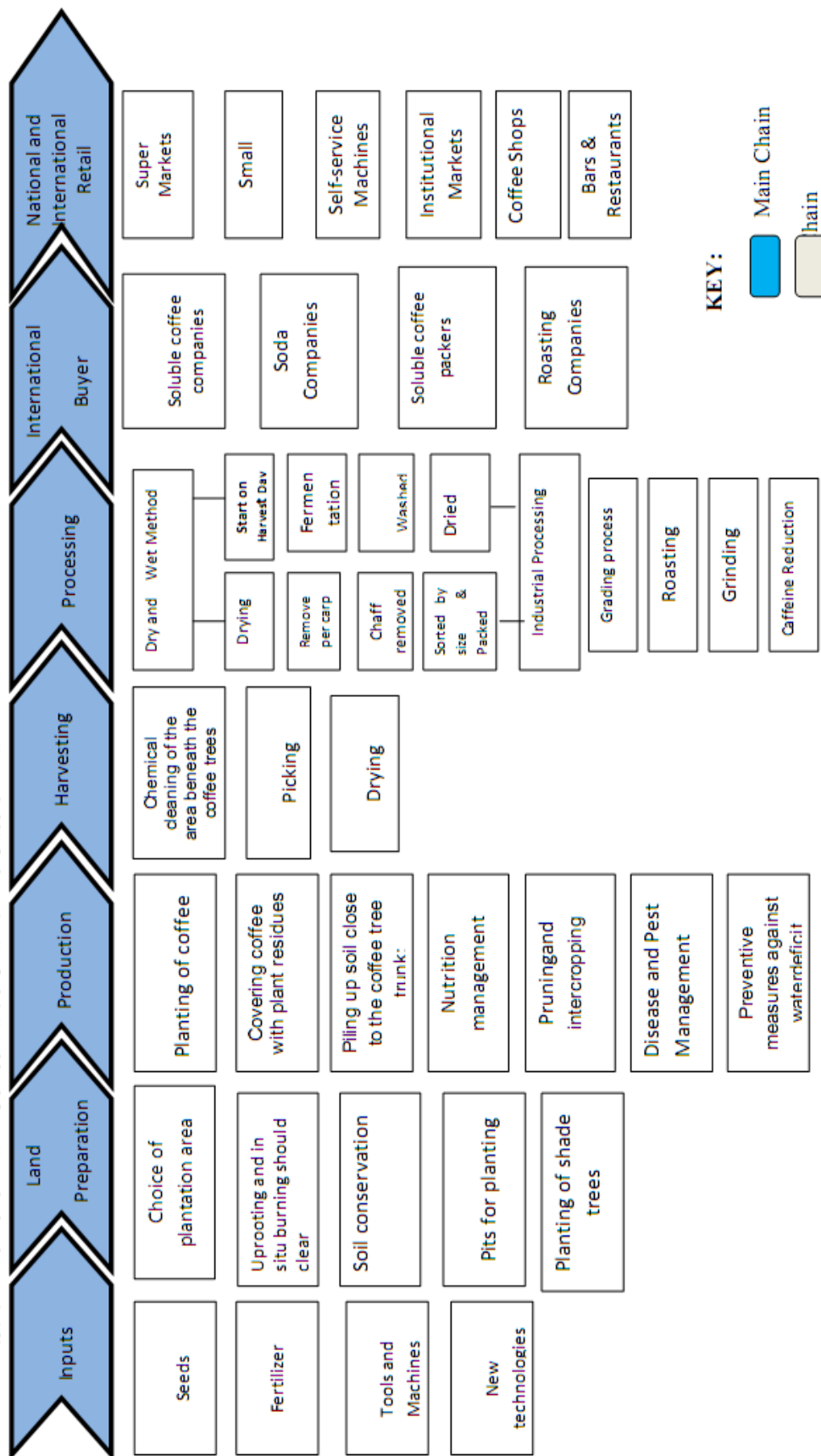


Figure 6: The benchmark coffee value chain: the case of Brazil

iii. The Gap between AS-IS and the Benchmark

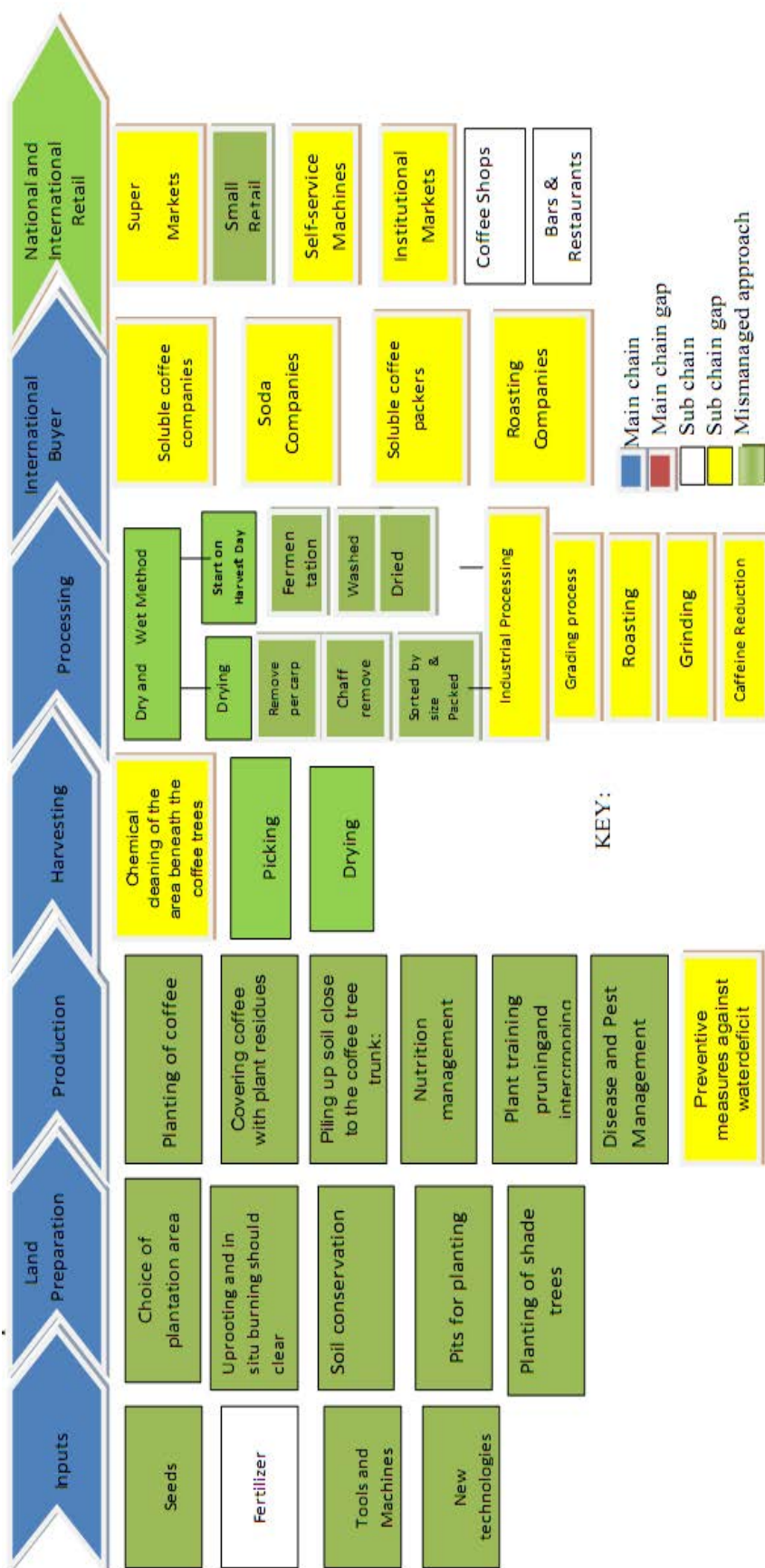


Figure 7: Gap b/n AS-IS & benchmark value chain

d) Description of constraints in the AS-IS value chain relative to the benchmark

i. Constraints in Input supply

Inputs used	Constraints associated with inputs used
1. Seed: - Framers of Yirgachaffee mainly use 74110, 74112, 74,148, 74,158 and 1377 seed varieties - Besides, they use local varieties - coffee seed's moisture content was being tested with knife or tooth	- Shortage of improved seeds - Use of Substandard/unspecified seed varieties - Skill gap in seed preparation - Lack of convenient cold store rooms for seeds to maintain moisture at an appropriate level - Shortage of coffee research institutes regionally and nationally
2. Seedling: - Seedbed preparation - Sowing seeds, watering (manual irrigation), sheltering, weeding - Bare root seedling - seedlings raised in poly bags	- Manual watering - The mortality rate is high in bare root planting - Shortage and expensiveness of plastic (poly bag) supply - The mix of d/t varieties due to insufficient training and follow-up
3. Fertilizer: - Use of organic fertilizer or compost - Use of locally available materials such as animal dung, biomass (coffee husk or parchment), wood ash, forest soil & bamboo & any biodegradable materials can be used for compost preparation.	- An inappropriate ratio of components - An inappropriate layering of ingredients - Lack of transportation facilities to bring parchments from coffee processing industries to farmlands. - Poor integration between farmers & processors - Inadequate storage for compost
4. Farm tools - Use of manual tools (watering cane, slashes, spade type of hoe, three prolonged hoes, pruning shear, hand saw etc)	- Reduced productivity due to manual operation - Transmission of coffee disease due to untreated hand tools - Poor weed control - Tiresome (time-consuming) - Poor quality of farm tools - A poor linkage between farmers & farm tool suppliers - An absence of user manual for farm tools & pieces of equipment - No irrigation scheme
5. Human resource - Farmers - Labourers - Experts - Trainers - Supervisors	- Shortage of trained manpower - The high wage rate for daily laborers - Lack of periodic skill gap training for farmers & labor force - lack of adequate extension service - Provision of inconsistent supervision by subject matter specialists & other others

ii. Constraints associated with Land preparation

Land preparation functions	Problems associated with land preparation
1. Site selection: - a place rich in decomposed plant pieces - having shed trees and windbreaks - sufficient rain distribution	- inappropriate slopes on the selecting areas - poor fertility - deficiency in the required nutrients and minerals - poor treatment of soil - frost action and impacts
2. Clearing - Site clearing by slashing	- Tiresome & time taking manual work - Unsafe operation with hand tools
Uprooting - Uprooting is undertaken by using the hoe, saw, and ax	- Tiresome & time taking manual work - Unsafe operation with hand tools

<p>3. Laying out</p> <ul style="list-style-type: none"> - Laying out is carried out by using hand tools such as tape rule, line level & pegs 	<ul style="list-style-type: none"> - shortage of appropriate hand tools - Lack of surveying materials - Skill gap on laying out & leveling
<p>4. Plowing</p> <ul style="list-style-type: none"> - it involves tilling and turns over outer and inner soil layers for coffee planting 	<ul style="list-style-type: none"> - No ploughing practice or trend before holing among farmers in the study area
<p>5. Holing:</p> <ul style="list-style-type: none"> - Manual holding 3 months before planting - 60 cm* 60 cm area of the hole - Putting top soil & subsoil separately after holing - Refilling the topsoil mixed with 2kg of compost after two months 	<ul style="list-style-type: none"> - Lack of holing machine or equipment - Inconsistency using a standard of holding dimension - Negligence in putting topsoil & subsoil separately - Untimely refilling

iii. Constraints associated with Production

Main production functions	Problem associated with production
<p>1. Planting</p> <ul style="list-style-type: none"> - Opening the refilled hole manually - Planting seedlings by keeping the collar zone - Mulching operation around a radius of 10cm from the planted seedling - Construction of temporary shed in the direction of sunrise & sunset (in the east-west direction) 	<ul style="list-style-type: none"> - Some farmers are unable to plant the seedling by keeping the collar zone - Most of the farmers don't use mulching during planting - Manual operation - insufficient & inconsistent supervision - poor provision of extension services for farmers/producers
<p>2. Slashing, hoeing, pruning, Stumping & de-suckering:</p> <ul style="list-style-type: none"> - perform slashing operation three times in a year - perform hoeing operation twice in a year - main pruning is performed immediately after harvesting (manually operated) - maintenance pruning performed at list twice per year - stamping operation is carried out after harvesting; - they are leaving many suckers beyond the optimum 	<ul style="list-style-type: none"> - use of manual tools for all mentioned operations - inefficient control of perennial weeds - some farmers are unable to perform the hoeing operation periodically - some farmers are not using a temporary shedding - they are not practicing proper de-suckering; it reduces productivity; - some farmers show resistance against stamping(rejuvenation) operation - lack of adequate stamping materials such as sow & saw blades - farmers often don't use disinfectant chemicals or - they do not disinfect their stamping tools using chemicals or fire before and after application
<p>3. Fertilizing application:</p> <ul style="list-style-type: none"> - Use of organic fertilizer or compost twice per year - Use of locally available materials such as green leaf, crop residue, animal manure, biomass (coffee husk or parchment), wood ash, forest soil & bamboo & any biodegradable materials can be used for compost preparation. - applying 5kg or 5spade per coffee tree 	<ul style="list-style-type: none"> - Some farmers don't use fertilizers periodically (twice a year) - Some farmers use un-decomposed or sub-standard compost - Some farmers don't use the recommended amount (3-5kg per plant per round) - Unable to use the fertilizer around the canopy & mixed with soil - application of compost without considering the age of the coffee tree as well as a round of practicing - farmers in the study area are not considering C and N ratio properly

<p>4. Mulching:</p> <ul style="list-style-type: none"> - mulching used as a control of weeds - it conserves soil & moisture content, - it increases soil fertility, - farmers in the study area are using some parts of enset such as leaves, sudo stems 	<ul style="list-style-type: none"> - farmers in the study area have not been using enough mulching materials other than enset by-products; - They are not giving attention regarding the practicing of mulching and its real importance for the growth of a coffee tree
<p>5. Soil and water conservation:</p> <ul style="list-style-type: none"> - it involves a construction of structures such as a trench, micro-basin, pet and tie ridges, etc 	<ul style="list-style-type: none"> - practicing soil & water conservation after planting the coffee seedling rather than before - low-quality structures that may facilitate erosion rather than be conserving soil and water - some farmers do not use such structures at all - having skill gap in designing structures
<p>6. Intercropping:</p> <ul style="list-style-type: none"> - Intercropping with haricot bean (for improving soil fertility & income generation, false banana (for shedding & consumption) & taro (for food) - Helps for weed control 	<ul style="list-style-type: none"> - Taro has a negative effect on soil fertility /competition for nutrient & water/ and other non-leguminous plants
<p>7. Disease & pest management:</p> <ul style="list-style-type: none"> - Uprooting and burning the infected coffee tree on the spot - farmers have been using coffee berry disease(CBD) resistant varieties such as 74110 and 74112 	<ul style="list-style-type: none"> - Untimely uprooting the infected coffee tree - Some farmers are using the infected tree for firewood (not burning at the spot) - Not treating hand tools with chemicals & fire

iv. Constraints associated with Harvesting and postharvest

Harvesting and postharvest Functions	Problems associated with Harvesting and postharvest functions
<ul style="list-style-type: none"> - Preparation of picking materials & drying bed using bamboo basket & other wooden materials - Manual picking of red cherry - Drying or selling red cherries for processors - Supplying red cherries to processors within eight hours after picking 	<ul style="list-style-type: none"> - Tedious & time taking a manual operation - Labour intensive (lack of machine support) - Picking unripe & over ripped cherries together with the red cherry - Some farmers are unable to meet the delivery time; - not practicing proper sorting before processing undergone - Adulteration with foreign materials & soaking in water to uplift weight - Using inappropriate picking materials

v. Processing



Processing Functions	Problem associated with processing
<p>1. Red & dry cherry collection:</p> <ul style="list-style-type: none"> - Red & dry cherry buying & sorting - Transporting 	<ul style="list-style-type: none"> - Lack of transportation facilities & infrastructure - Quality problems due to untimely arrival of red cherry for washed coffee processing - Processing mixed varieties of coffee - Quantity based price setting rather than quality
<p>2. Wet & dry coffee processing:</p> <p>2.1. Wet processing:</p> <ul style="list-style-type: none"> - it involves pulping or separating clean coffee from parchment using the pulping machine with the help of water 	<ul style="list-style-type: none"> - Using pulping machines inappropriately and operating with maladjusted disk type, which creates quality problems - Lack of trained machine operators - Not undertaking pulping or processing washed coffee in the day at which the red cherry-picked or collected; - not applying recirculation effectively so as to save the volume of water needed for wet processing and reducing the number of lagoons required for storing liquid by-products or sewage

	<ul style="list-style-type: none"> - Over & under fermentation - Some parchments are fermented with the coffee bean in the fermentation tank
<p>2.2. Dry processing:</p> <ul style="list-style-type: none"> - it involves milling through which the removal of husk from the sun-dried coffee so as to get clean unwashed coffee (Fisher) - Sieving has been taken place for sundried coffee to separate byproducts from pure one using manually 	<ul style="list-style-type: none"> - Manual separation - Poor standard of hulling machines - Time taking operation - not using color sorter machines to save the effort of manual sorting costs
<p>3. Fermentation:</p> <ul style="list-style-type: none"> - Removal of mucilage by soaking with water in the fermentation tank 	<ul style="list-style-type: none"> - inappropriate application of fermentation time interval in terms of different agro-ecologies - inconsiderate of volume, coffee bean maturity, temperature, altitude and variety during fermentation
<p>4. Drying:</p> <ul style="list-style-type: none"> - Drying bed preparation & cemented drying floor - Reduces moisture content in the coffee bean till it reaches 11.5 to 12% - mostly the stage of drying testing has been practiced using teeth 	<ul style="list-style-type: none"> - Insufficient drying bed & cemented floor preparation - shortage of drying materials such as mesh wire sacks made from fibers, yellow plastic cover sheets, etc - Lack of uniformity in drying - Overdrying & under drying - lack of artificial and solar drying technologies, which are important during a heavy rainy season of coffee processing - lack of moisture testing instrument
<p>5. Sorting</p> <ul style="list-style-type: none"> - Manual Separation of foreign materials, broken bean, beans infected by disease & insect pests, and other defects from coffee bean 	<ul style="list-style-type: none"> - Labor intensive and time taking - tedious manual separating of defects from the clean washed and unwashed coffee
<p>6. Packing</p> <ul style="list-style-type: none"> - Manual Packing sorted coffee in sacks (60kg for washed & 85kg for unwashed) 	<ul style="list-style-type: none"> - Manual operation - Less accurate - shortage of packing materials
<p>7. Storage</p> <ul style="list-style-type: none"> - Storage of sacks of coffee in a separate warehouse - Should free from bad odor 	<ul style="list-style-type: none"> - Using undesirable bags (plastic bags) - Some farmers store in rooms where animals are living - Not well-ventilated storerooms or warehouses - Inappropriate and bottleneck ordering


vi. Constraints associated with Marketing


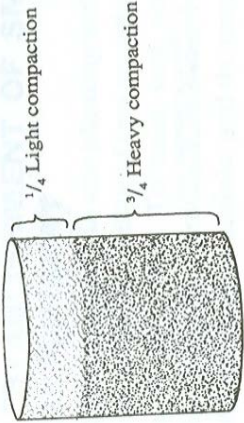

Marketing Functions	Problem associated with marketing
<p>1. ECX</p> <ul style="list-style-type: none"> - Storage services - Taking samples - Testing & Grading - Auction (plays an intermediary role between coffee suppliers & exporters) 	<ul style="list-style-type: none"> - Insufficient storage units - Wastage during sample taking - Extra warehousing costs
<p>2. Exporters</p> <ul style="list-style-type: none"> - Purchasing coffee from suppliers - Selling coffee to foreign importers 	<ul style="list-style-type: none"> - A blending of differing traits - Unfair payment for different quality standards - Poor linkage with a foreign market (farmers)
<p>3. Local wholesalers:</p> <ul style="list-style-type: none"> - Purchasing coffee from ECX - Selling to retailers 	<ul style="list-style-type: none"> - Lack of sustainable provision of coffee the retailers - Always selling UG coffee to retailers
<p>4. Local retailers:</p> <ul style="list-style-type: none"> - Purchasing coffee from ECX - Selling to retailers 	<ul style="list-style-type: none"> - Lack of sustainable provision of coffee to consumers - Always selling UG coffee to consumers

e) Analysis of value addition process in the bench mark value chain (Brazilian Experience)
 i. Input supply


Value addition practice	Function	Existing Technology
1. Input supply	<p>Access to Agricultural Inputs: In Brazil, cooperatives are the main distribution channel for lime, fertilizers, agrochemicals and seeds</p> <ul style="list-style-type: none"> ▶ Variety and Smart use of inputs from research and Technology centre. i.e. ▶ Resilience to climate change, ▶ Resistance to pests and diseases. ▶ Improve more coffee quality. 	
2. Seed		
3. Fertilizer	worm compost, bovine Manure or organic compost.	
4. Tool and Machines		
5. New Technologies	<p>NEW HYBRID COFFEE VARIETIES:</p> <p>New technologies in less time-clones with desirable agronomic features like :-</p> <ul style="list-style-type: none"> ▶ High productivity; ▶ High quality; ▶ High vigor; ▶ Resistance to leaf rust; ▶ -Shorter orthotropic inter node length. 	


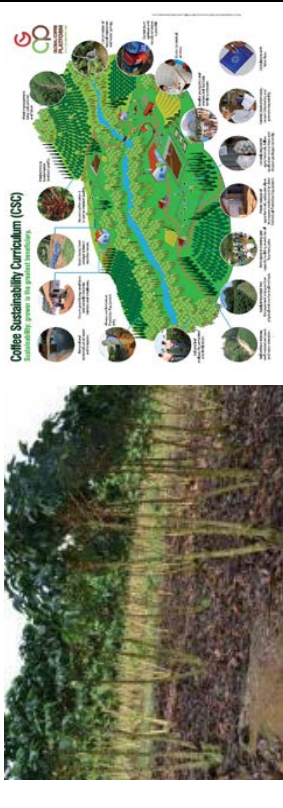
ii. Land preparation

Value addition practices	Function	Existing Technology
1. Choice of plantation area	<p>In the organic management of coffee plantations techniques for covering the soil with litter are frequently used (husks and various residues from plantations or from the agro industry, such as coffee husks, sugar cane fiber, etc); live soil cover (vegetation that is cultivated or grows spontaneously kept covering the soil) and green fertilizers (plants that are cultivated in the local or brought from elsewhere, which are incorporated to the soil with the purpose to preserve the soil fertility, which can be used as a crop rotation, live-fences, wind breakers, surrounding strips and road edges). The use of plant biomass as source of organic matter represents one opportunity for the producer to decrease their dependence in relation to the use of manure. Additionally, the soil cover protects it against erosion and decreases the incidence of spontaneous plant growth.</p>	
2. Uprooting and insist burning should clear		
3. Soil conservation		



<p>4. Pits for planting</p>	<p>Planting</p> <ul style="list-style-type: none"> - Slightly acid (pH 5.2 to 6.3) well drained soil - Beginning of wet season - Vertical position or 30° angle <p>Spacing- need light for fruit ripening</p> <ul style="list-style-type: none"> - Arabica, 1350 trees/ha <p>Time to fruiting</p> <ul style="list-style-type: none"> - Take 3-4 years to obtain mature plant - Fruit on year old wood 	 
<p>5. Planting of shade trees</p>	<ul style="list-style-type: none"> ▶ Grevillea trees should be planted be 10 -14 m apart. ▶ Inside the coffee plantation, the tree distribution should be approx. 70 plants/ha. ▶ Protection against frost should start three years after the trees have been planted. 	

iii. Production process

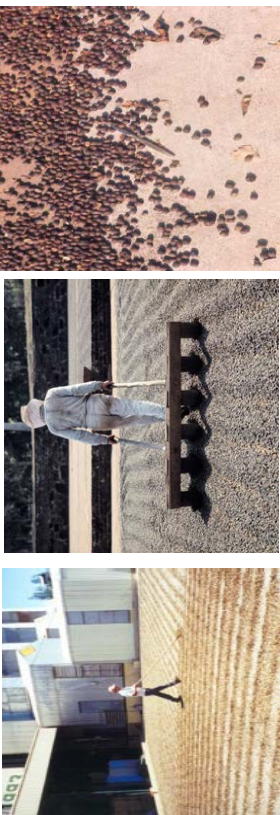
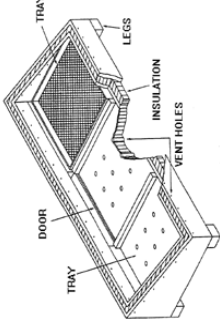
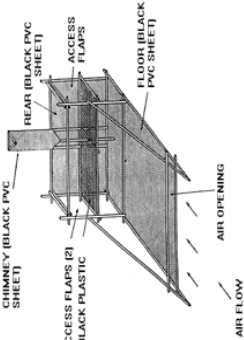
Value addition practices	Function	Existing Technology
<p>1. Planting of coffee</p>	<ul style="list-style-type: none"> ▶ Slightly acid (pH 5.2 to 6.3) well drained soil ▶ Beginning of wet season ▶ Vertical position or 30° angle ▶ Spacing- need light for fruit ripening ▶ Arabica, 1350 trees/ha ▶ Time to fruiting:- ▶ Take 3-4 years to obtain mature plant ▶ Fruit on year old wood 	
<p>2. Covering coffee plant with residues</p>	<p>Another way to prevent frost damage is to cover coffee plants with a thick layer of plant residues the day before suspected frost. After the frost risk is over, this protective layer should be removed. This procedure promotes complete protection against severe frost – it is crucial that there is adequate covering of the coffee plantation for it to be effective.</p>	
<p>3. Piling up soil close to the coffee tree trunk:</p>		


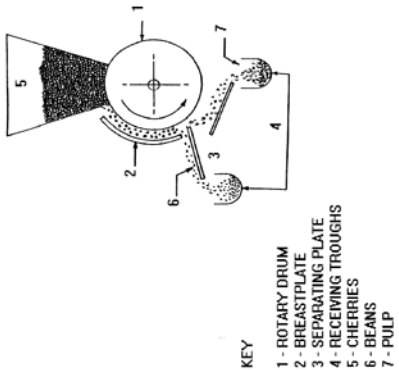


<p>4. Nutrition management</p>	<ul style="list-style-type: none"> ▶ Prominent role of In caper; developing, transferring and assisting farms (especially small ones) to adopt new technologies. ▶ mulching, irrigation, fertilizer and pests management; pruning; etc. 	
<p>5. Plant training pruning and intercropping</p>	<p>CYCLIC PRUNING PROGRAM:-</p> <ul style="list-style-type: none"> ▶ Increased average productivity and reduced labor costs. ▶ Coffee sustainable curriculum implemented 	
<p>6. Disease and Pest management</p> <p>Preventive measures against water deficit</p>		

iv. *Harvesting*

Value	Function	Existing Technology
<p>1. Chemical cleaning of the area beneath the coffee trees</p>	<p>With the purpose of facilitating the harvest and reducing the conditions suitable for the rapid deterioration of the fruits that fall either before or during the harvest.</p>	 
<p>2. Picking</p>	<p>Most done by hand</p> <ul style="list-style-type: none"> ▶ Materials, such as sacks, spreaders and clothes must also be acquired in advance so that the harvest is completed within a maximum period of two to three months for large plantations. ▶ Ripe berries only Pick every 8-10 days 	

v. Processing

Value addition practices	Function	Existing Technology
<p>1. Dry and wet method</p>	<p>Washed (Wet) -Water under pressure -Dried - spread out to dry - Sun - Artificial heat</p> <p>Dry</p> <ul style="list-style-type: none"> ▶ Initial drying done on trees Spread on concrete, tile or matted surface ▶ Immediately after harvesting, coffee is submitted to the 'wagging' operation, with the purpose of removing gross impurities that are mixed with the fruits. ▶ The harvested coffee must be placed immediately in the vehicle, or in sacks, and transported for drying on terraces. 	   <p>The solar cabinet drier</p> <p>The exell solar</p>
<p>2. Grading process</p>	<p>Grinding is a means of adding value to a product. There are basically two types of grinders. -Manual grinders and motorized grinders. Manual grinding mills There are many manual grinders that could be used to grind coffee. An experienced operator can grind about 20kg in an eight hour day. However, this is hard and boring work. A treadle or bicycle could easily be attached to the grinder, which will make the work easier. With this system, one person could grind about 30kg in one day.</p>	

  <p>KEY 1 - ROTARY DRUM 2 - BREASTPLATE 3 - SEPARATING PLATE 4 - RECEIVING TROUGHS 5 - CHERRIES 6 - BEANS 7 - PULP</p>	 
	<p>Roasting (370°F to 540°F)</p> <ul style="list-style-type: none"> ▲ Removes moisture ▲ Light roast lose 3-5% moisture ▲ Dark roast lose 8-14% moisture ▲ Time (up to 30 min) determines flavor ▲ Decreasing the amount of Chlorogenic acid ▲ Trigonelline
<p>3. Industrial Processing</p> <ul style="list-style-type: none"> - Roasting and Caffeine Reduction 	

4. Marketing	<ul style="list-style-type: none">▶ 90 Coffee Cooperatives in Brazil▶ Small farmers have the same market and technology access as the big ones.▶ Integrated Solution: inputs, equipment and services▶ Cooperatives - Facilitate access to: (i) domestic and international markets and (ii) risk management instruments (hedge).▶ Adding Value: Investment in coffee industrialization and Incentive for the production of specialty coffees.
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CHAPTER FIVE

I. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

a) *Summary and Conclusion*

This study was conducted in Yirgacheffe District found in Gedeo Zone, SNNPR, Ethiopia, and had the general objective of analyzing the coffee value chain in the *District*. The specific objectives were to identify were to trace the value chain of Yirgacheffe coffee AS-IS from input supply to consumption, to study international best practice to be used as a benchmark to take competitive advantage, to identify all the constraints that impede the competitiveness of coffee in the case area in the national & global market and to determine the role of actors in the coffee value chain for the intervention.

Coffee is the second most traded commodity in the world after oil (Roldán-Pérez, 2007 cited in Dilebo, 2019). It is one of the main cash crops in Yirgacheffe district. The district has huge potential in coffee production. It was the highest producer of coffee in the Gedeo Zone. The total annual production for the year 2015/16 was 49464 quintals of washed coffee and 21082 quintals of unwashed coffee. The data for this study were generated by individual interviews using questionnaires and by observation using an observation checklist. These data were supplemented by secondary data collected from different published and unpublished literature. The analysis was made by comparing the AS-IS value chain with the bench mark value chain, which is Brazilian experience. A total of 30 coffee producer households (26 male-headed and four female-headed) were randomly selected from three *Kebeles* found in Yirgacheffe. About 16 traders, three processors, and 17 consumers were also interviewed.

The study result indicated that that there is a gap between the bench mark value chain and the existing AS-IS value chain in input supply, land preparation, production, harvesting, processing, and marketing functions. Regarding input supply, Shortage of improved seeds, Bare root seedling, inappropriate composition in compost preparation, Reduced productivity due to manual operation, Transmission of coffee disease due to untreated hand tools and Shortage of trained labour are identified as constraints on the AS-IS value chain. Regarding land preparation, gaps such as inappropriate slopes on the selecting areas, Unsafe operation with hand tools, No ploughing practice or trend before holing among farmers in the study area, Lack of holing machine or equipment, Inconsistency using a standard of holding dimension and Some farmers are unable to plant the seedling by keeping the collar zone. Production problems identified are that Some farmers are unable to plant the seedling by keeping the collar zone, Slashing, hoeing, pruning, Stumping & de-suckering using manual tools; Some

farmers don't use fertilizers periodically (twice a year); Some farmers use un-decomposed or sub-standard compost; farmers in the study area have not been using enough mulching materials; intercropping competitive non-leguminous plants rather than using complementary plants; Untimely uprooting the infected coffee tree. Labour intensive (lack of machine support) and Picking unripe & over ripped cherries together with the red cherry are out of harvesting problems. Quality problems due to untimely arrival of red cherry for washed coffee processing; Processing mixed varieties of coffee; Using pulping machines inappropriately and operating with maladjusted disk type, which creates quality problems, Manual separation, Poor standard of hulling machines; inappropriate application of fermentation time interval in terms of different agro-ecologies; shortage of drying materials such as mesh wire sacks made from fibbers, yellow plastic cover sheets, and Lack of uniformity in drying are also out of processing problems. Regarding marketing, insufficient storage units, Wastage during sample taking, and extra warehousing costs are identified as constraints in the AS-IS value chain.

b) *Recommendations*

The following recommendations are given based on results of the study,

1. The study result indicated that most of the farm tools used to produce coffee are traditional and are operated manually. Therefore, TVET colleges can intervene to imitate the technologies practiced in Brazil(the bench mark).
2. The study indicated that some farmers are using local coffee seedlings due to a shortage of coffee seedlings supply, and there is a knowledge gap in coffee production and marketing. Therefore, coffee, tea, and species authority of Yirgacheffe district, Gedeo zone, and SNNPR region should supply sufficient coffee seedlings and mobilize coffee value chain actors starting from input supply up to consumption.
3. The result also indicated that there is no interdependence among value chain actors. Therefore, industry owners should support producers and develop out-grower scheme in the process of coffee production.
4. Most of the farmers, industries, and coffee traders responded that they are not getting loans to produce and market coffee. Therefore, financial institutions such as credit institutions, commercial bank and development banks should facilitate loans for coffee production and marketing.
5. The observation by transect walk revealed that there is no farm equipment supply center in the district. Therefore, coffee producers' cooperatives should establish farm tools and equipment supply centers.

- The review of literature showed that there were limited resources to refer regarding coffee value chain of Ethiopia in general and Yirgacheffe in particular. Therefore, institutes of technology in universities such as Dilauniversity and Hawassa university should intervene in research and development to identify constraints in the coffee value chain.
- The observation by transect walk has shown that the coffee processing industries in the district are not using the byproducts (coffee parchment, husks and liquid wastes) as alternative energy sources such as ethanol and briquettes. Therefore, the district, zonal, and regional mineral, and energy bureau should work in collaboration with coffee, tea and spices authority on the issue.

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- g) Suitable statistical data should also be given.
- h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

- i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
- j) There should be brief acknowledgments.
- k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.



FORMAT STRUCTURE

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in a research paper?" Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.



Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

PREPARATION OF ELETRONIC FIGURES FOR PUBLICATION

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

TIPS FOR WRITING A GOOD QUALITY SCIENCE FRONTIER RESEARCH PAPER

Techniques for writing a good quality Science Frontier Research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of science frontier then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.



6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.



20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium through which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

INFORMAL GUIDELINES OF RESEARCH PAPER WRITING

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.



Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.



The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.



Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."



Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

THE ADMINISTRATION RULES

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CRITERION FOR GRADING A RESEARCH PAPER (COMPILATION)
BY GLOBAL JOURNALS

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

Topics	Grades		
	A-B	C-D	E-F
<i>Abstract</i>	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
<i>Introduction</i>	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
<i>Methods and Procedures</i>	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
<i>Result</i>	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
<i>Discussion</i>	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
<i>References</i>	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring



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