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1. HAMA PENYAKIT KAKAO

Abstract: Cocoa Swollen Shoot Virus Disease (CSSVD) is one of the major factors limiting cocoa (Theobroma cacao L.) productivity in West Africa. The only cure for CSSVD is to cut out visibly infected trees and the official eradication campaign in Ghana has cut out more than 200 million trees since 1946. 80 years of research on preventive control measures have mainly focused on resistance breeding, mild strain cross-protection (inoculation of cocoa seedlings with a mild strain of the virus to protect against the severe strain) and control of mealybug vectors. Meanwhile, diversification measures such as agroforestry (for shading) or barrier (strip) cropping have received less attention. Despite promising results, CSSVD is more prevalent in the field than ever before. The large body of knowledge on preventive control measures for CSSVD is fragmented and many publications are not easily accessible. Furthermore, the literature has never been systematically evaluated and quantitatively assessed. Hence, we consolidated this knowledge with an extensive literature review followed by meta-analysis to identify the pertinent research gaps. Out of 423 publications on CSSVD-related issues, we selected 34 studies, which contained 52 datasets on seven different preventive control measures. Results showed that resistance breeding and mild strain cross-protection may reduce CSSVD infection by 30 percent, while the potential of diversification measures (shading/agroforestry and barrier (strip) cropping) seems to be considerably higher (40 and 85 percent, respectively). However, there is a lack of evidence because of a low number of studies about diversification measures, indicating that our results have to be interpreted with care and calling for more research in this area. Future testing is needed to evaluate the efficacy of barrier (strip) cropping to reduce CSSVD, and address the effect of shade on CSSVD symptom severity. Furthermore, the practical relevance of different preventive control measures for farmers needs to be assessed, and shade should be considered in current breeding programs for CSSVD resistance.
Keywords: Cocoa swollen shoot virus disease; Meta-analysis; Resistance breeding; Agroforestry system; Strip cropping

Abstract: Pests and diseases threaten cacao production worldwide. Agroforestry systems are traditionally seen by farmers as one of the causes of increased pest and disease incidence, in contrast with full-sun monocultures. Cultural management

practices—e.g. regular tree pruning, frequent pod harvest, regular removal of infested pods, weed management—have been reported to be crucial for pest and disease management. We performed two experiments for the purpose of assessing the effect of (i) different cacao production systems, and (ii) the frequency of harvest and removal of infested pods on the incidence of pests and diseases and on the cacao yield. The first experiment was performed in a long-term system comparison trial in Bolivia, where data on pest and disease incidence were recorded for three years in five production systems: two monocultures and two agroforestry system under organic and conventional farming, and one successional agroforestry system, i.e. a high tree density multi-strata system. Pest and disease management did not differ between systems and relied on cultural management practices. Overall, the incidence of pests and diseases did not differ between production systems, which indicated they were not the driver of yield differences between them. Across production systems, only 14% of the pods were affected by pests and diseases; 70% of these were affected by frosty pod rot. More than 80% of the pods infected by frosty pod rot were removed before the sporulation phase. In the second experiment, the effects of the frequency of harvest and removal of infected pods—every 15 days versus every 25 days—on pest and disease incidence and yield were tested in four farmers' fields. Fortnightly harvest and diseased pod removal significantly decreased disease incidence and increased cacao yield, by 25% and 46% respectively. Our results show that cacao agroforestry systems do not increase pest and disease incidence compared with monocultures when good cultural management practices are implemented, which, in turn, can increase the productivity of the cacao plantations.

Keywords: Labour time; Long-term system comparison; Organic farming; Frosty pod rot; Phytosanitary inspection; Theobroma cacao; Yield; On-farm trial

Abstract: Cacao swollen shoot virus is a member of the family Caulimoviridae, genus Badnavirus and is naturally transmitted to Theobroma cacao (L.) by several mealybug species. CSSV populations in West African countries are highly variable and genetically structured into several different groups based on the diversity in the first part of ORF3 which encodes the movement protein. To unravel the extent of isolate diversity and address the problems of low titer and mixed viral sequences in samples, we used Illumina MiSeq and HiSeq technology. We were able to reconstruct de novo 20 new complete genomes from cacao samples collected in the Cocoa Research Institute of Ghana (CRIG) Museum and from the field samples collected in Côte d'Ivoire or Ghana. Based on the 20% threshold of nucleotide divergence in the reverse transcriptase/ribonuclease H (RT/RNase H) region which denotes species demarcation, we conclude there exist seven new species associated with the cacao swollen shoot disease. These new species along with the three already described leads to ten, the total number of the complex of viral species associated with the disease. A sample from Sri Lanka exhibiting similar leaf symptomology to West African CSSD-affected plants was also included in the study and the corresponding sequence represents the genome of a new virus named cacao bacilliform SriLanka virus (CBSLV).

4. D. Nyadanu, S.T. Lowor, A.Y. Akrofi, B. Adomako, H. Dzahini-Obiatey, R. Akromah, R.T. Awuah, C. Kwoseh, R. Adu-Amoah, A.O. Kwarteng,
Mode of Inheritance and Combining ability studies on Epicuticular wax Production in Resistance to Black pod disease in Cacao (Theobroma cacao L.),
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https://doi.org/10.1016/j.scienta.2018.07.002.
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Abstract: Black pod caused by Phytophthora species is a devastating disease of cacao (Theobroma cacao L.) in production regions worldwide. Breeding for cacao genotypes resistant to black pod disease is crucial for sustainable cocoa production and profitability. Although breeding programmes in the past have made considerable efforts in improving resistance of cocoa genotypes with diverse genetic background, the disease continues to cause unacceptable yield losses in cacao production. To understand the mode of inheritance of epicuticular wax on the surface of cocoa pod known to play a major role in resistance to black pod disease, a 6×6 full diallel and a M x N (6×4) mating designs were used and data was analysed using Griffing's method I model I approach and the North Carolina design –II approach, respectively. The results of the two mating designs were consistent and showed that epicuticular wax on leaf and pod surfaces of cacao were under the control of additive genetic effects. The non-additive effects were generally much smaller compared to the additive genetic effects. The significant association between GCA estimates of parents and their means indicates that parental values could be used as indicators of progeny performance. The best general combiners for epicuticular wax load on leaf and pod surfaces were Pa7/808, T60/887 and Pa 150. The larger additive components and heritability observed in this study, indicates that pedigree selection could be used to develop cacao cultivars with high amount of epicuticular wax on pod surface to enhance resistance to black pod disease.

5. Christian Andres, Wilma J. Blaser, Henry K. Dzahini-Obiatey, George A. Ameyaw, Owusu K. Domfeh, Moses A. Awiagah, Andreas Gattinger, Monika Schneider, Samuel K. Offei, Johan Six,
Agroforestry systems can mitigate the severity of cocoa swollen shoot virus disease,
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https://doi.org/10.1016/j.agee.2017.09.031.
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Abstract: Currently, the only effective treatment for cocoa (Theobroma cacao L.) infected with the cocoa swollen shoot virus disease (CSSVD) is to cut and replant infected trees. Hence, the development of preventive control measures and strategies to mitigate the severity of the disease are of utmost importance. While past research has mainly focused on resistance breeding, mild strain cross protection and vector control, diversification measures such as agroforestry have received relatively less attention, despite their potential to mitigate CSSVD severity. Therefore, we studied the effects of shade on CSSVD symptom severity, capsid damage and cocoa yield along a gradient

of increasing shade tree abundance in smallholder cocoa farms in Ghana. Furthermore, we measured photosynthetic active radiation and assessed soil fertility in order to elaborate on potential causal factors for possible shade effects on CSSVD symptom severity. Both CSSVD symptom severity and cocoa yields followed quadratic curves, and were found to be lowest and highest in plots with 54% and 39% shade, respectively. The simulated optimal shade levels for CSSVD symptom severity and cocoa yield overlapped between 45%–53%, indicating that agroforestry systems with around 50% shade cover may be an optimal coping strategy to balance CSSVD symptom severity versus reduced cocoa yield until diseased cocoa is replaced with more resistant varieties. Furthermore, our results suggest that rather than soil fertility, high-light and possibly also soil moisture stress may have been responsible for the shade effects on CSSVD symptom severity.

Abstract: Cacao swollen shoot virus (CSSV) is a peril exclusive to the West African cacao-growing countries; causing the Cacao swollen shoot virus disease. This study was set out (1) to analyse the feeding behaviour of two West African and one non-West African mealybug species, Planococcus citri (Risso) and Pseudococcus longispinus (Targioni Tozzetti) and Ps. viburni (Signoret) respectively on CSSV-free cacao. and (2) to provide molecular-based information on the ability of these mealybugs to acquire and transmit the 'New Juaben' CSSV strain from CSSV-infected cacao. Electrical penetration graph (EPG) analysis established that these three mealybug species performed both extracellular (C, E1e, F, G and Np waveforms) and intracellular (E1 and E2 waveforms) feeding activities on cacao which were typical of stylet-possessing, phloem-feeding, virus transmitting hemipterans. Waveform F reported in this study is the first for Pl. citri, Ps. longispinus and Ps. viburni feeding on cacao. The competitive feeding efficiency of Ps. viburni on cacao highlights its potential as a 'new' vector of CSSV. PCR-based results show that Pl. citri, Ps. longispinus and Ps. viburni can acquire CSSV after a 72-h access acquisition period (AAP). DNA sequences of CSSV were detected in leaf tissues of the test plants after a 30-day post 72-h inoculation access period (IAP) by the viruliferous mealybug individuals. It is the first report, with molecular evidence, of T. cacao serving as an acceptable host to Ps. viburni.

Abstract: Cacao swollen shoot virus (CSSV) is causing the major viral disease on cacao (Theobroma cacao) and it is naturally transmitted by mealybugs species. CSSV is restricted to West Africa and is a serious constraint to cacao production, particularly in Ghana. From the high molecular variability of the virus, a complex of 8 viral species has been recognized and the geographical repartition of these species has been done in Côte d′Ivoire, Ghana and Togo. Measures to control the disease are discussed.

2. PASCAPANEN KAKAO

Abstract: Antioxidant activity of cocoa beans is often influenced by drying and roasting stages. In this study, 13 naturally-existing yeast strains were isolated and used as a starter culture and the resulted antioxidant properties of cocoa beans were determined by total polyphenols content (TPC), 2, 2-Diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging activity and total flavonoids content (TFC). The isolated yeasts were identified via sequencing using universal primers ITS 1 and 4. Results revealed that the 13 naturally-existing yeast strains were Pichia kudriavzevii (MH979676, MH979680, MH979681, and MH979677), Hanseniaspora thailandica (MH979675), Hanseniaspora species (MH979678), Wickerhamomyces species (MH979679), Saccharomyces cerevisiae (MH979683), Hanseniaspora opuntiae (MH979684) and Candida quercitrusa (MH979685, MH979687, MH979686 and MH979682). Yeasts were selected based on the phylogenetic analysis, where each species of different genus (except Candida genus) was used as a starter culture. Dried cocoa beans inoculated with isolates (Hanseniaspora thailandica, Pichia kudriavzevii, Hanseniaspora opuntiae, Hanseniaspora species, Wickerhamomyces species and Saccharomyces cerevisiae) contained TPC, TFC and DPPH ranging from 21.82 to 69.81 mg/g Gallic acid (GAE), 1.68–6.33 mg/g Catechin and 113.85 to 328 µmol/g Trolox (TE), respectively. It is noted that there was no significant change of the antioxidant activity between isolates at 24-h to 120-h fermentation. Based on the current study, Hanseniaspora thailandica and Pichia kudriavzevii are the potential starter cultures that result in cocoa beans with higher antioxidant content ($p < 0.05$) compared to natural fermentation.
Keywords: Cocoa; Fermentation; Yeast starter culture; Phenolic; Antioxidant activities

Abstract: The quality of Theobroma cacao L. is influenced by different variables both in the crop and in the processes of postharvest, the latter it includes the fermentation and the drying, fundamental for the formation of aroma and flavor precursors, determinants in the characteristics of quality and differentiation of cocoa in the chocolate industry. The objective of the present research was to evaluate the effect of the solar drying process using a plastic roof solar dryer on the sensory and chemical quality of a mixture of cocoa cultivated in a region of Antioquia, Colombia. The content of total polyphenols, anthocyanins, sugars, mannitol, pH, total acidity, humidity, ethereal extract, ash, crude fiber and odor and flavor descriptors were analyzed. For analyzing the data, we used

the methodology of longitudinal data analysis and repeated measurements, a Principal Component Analysis (PCA), and a principal factor analysis. The analyzed sensory characteristics are statistically different over time ($p < 0.05$). There was a decrease in the content of anthocyanins, total polyphenols and sucrose, and an increase in glucose and fructose during fermentation and drying. The analysis of factors allowed to define a series of groupings as indexes of quality according to the chemical and sensory properties analyzed in the drying process. Overall, the mixture of cocoa clones evaluated in the solar drying process presented indicators of sensory and chemical quality associated with descriptions of odor (spicy, dairy, nut, fruity, sweet cane), flavor (floral and spicy), ethereal extract, and pH that indicate a good benefit of cocoa and show the potential that Colombia has as a producer of fine aroma cocoa in high demand in premium markets.

Keywords: Theobroma cacao L; Fermentation; Solar drying; Sensory analysis; Chemical characterization, Multivariate Analysis

3. Ernest Teye, Elliot Anyidoho, Robert Agbemafle, Livingstone K. Sam-Amoah, Chris Elliott,
Cocoa bean and cocoa bean products quality evaluation by NIR spectroscopy and chemometrics: A review,
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Abstract: Cocoa bean is an international commodity largely produced in developing countries and mostly consumed worldwide in several forms. During the last few decades, rapid detection of cocoa beans and cocoa bean products quality has gained centre stage with many kinds of research conducted. However, no reviews about the application of NIR spectroscopy for cocoa beans and cocoa bean products (CACBP) have been reported. Therefore this review presents application of NIR spectroscopy and chemometrics in the field of the postharvest value chain of cocoa: cocoa beans and cocoa bean products, focusing on the prediction of categorization, authentication, chemical composition, and sensory attributes. In addition geographical classification, fraud and safety are also covered. The information presented in this review clearly shows that NIR spectroscopy has its usefulness in the entire postharvest cocoa bean industry. After analyzing the literature, it was found out that, NIR spectroscopy technology could be successful for qualitative and quantitative examination of CACBP. However, more work needs to be done to move this technology from the laboratory applications to real onsite usage especially among cocoa producing countries in the developing world for optimum global benefits in the face of concerns regarding cocoa bean integrity. This requires the use of extensive samples covering a wide range of cocoa beans from West African.
Keywords: Cocoa beans; Cocoa bean products; NIR spectroscopy; Chemometrics; Examination

4. Christelle Kouamé, Gérard Loiseau, Joël Grabulos, Renaud Boulanger, Christian Mestres,
Development of a model for the alcoholic fermentation of cocoa beans by a Saccharomyces cerevisiae strain,
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Abstract: The aromatic quality of chocolate requires the use of cocoa with high aromatic potential, this being acquired during the fermentation of cocoa beans. Traditional fermentation is still often carried out on a small scale with wild strains of yeasts and acetic bacteria and under poorly controlled conditions leading to cocoa quality ranging from best to worst. This study is the first part of a project aiming to control quality of cocoa to produce high aromatic quality chocolate by using a mixed starter of selected strains of yeast and acetic bacteria and by controlling the conditions of fermentation. To achieve this objective, a mathematical model of the alcoholic fermentation of cocoa beans has been developed. The growth, glucose consumption and ethanol production of Saccharomyces cerevisiae LM strain in synthetic broth were modeled for the most important intrinsic (pH, glucose, ethanol, free nitrogen and oxygen levels) and extrinsic (temperature, oxygen level) fermentation parameters. The model was developed by combining the effects of individual conditions in a multiplicative way using the gamma concept. The model was validated in liquid synthetic medium at two different inoculation levels 104 and 106 CFU/mL with an increase in temperature that recorded during spontaneous fermentations. The model clearly shows that the level of inoculation and the speed of the increase in temperature clearly drive yeast growth, while other factors including pH and ethanol, free nitrogen and oxygen levels have no significant impact on yeast growth.
Keywords: Yeast; Starter; Chocolate; Gamma concept; Predictive microbiology

5. Maritza Gil, Yamile Jaramillo, Carolina Bedoya, Sandra M. Llano, Vanessa Gallego, Jairo Quijano, Julian Londono-Londono,
Chemometric approaches for postharvest quality tracing of cocoa: An efficient method to distinguish plant material origin,
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Abstract: The aim of this study was to compare the quality of a mixture of cocoa harvested and fermented in three subregions of Antioquia (Colombia), from the chemometric profile based on multivariate statistical analysis. A mixture of clones CCN-52, ICS-1, FLE-2, and FEC-2 harvested in Bajo Cauca, Uraba and Magdalena Medio were subjected to a spontaneous fermentation. The characterization of raw and well-fermented cocoa was performed through 38 parameters, and results were compared by a Principal Component Analysis (PCA) and a Cluster Analysis (CA), followed by a Principal Factors Analysis (PFA- CA). The CA showed that there are differences among subregions only in raw cocoa from Bajo Cauca. PCA allowed identifying the variability between raw and fermented cocoa in a representative way and these results were consistent with the chemical profile. Besides, the number of parameters to differentiate raw cocoa from different subregions was reduced (11–13 parameters) and it was possible to characterize well fermented cocoa with only 10 parameters of 38. PFA-CA consolidated in three factors a grouping to identify the cocoa quality according to the process or interest of the sensory or functional properties. Factor 1 (cocoa quality indicators with functional properties), Factor 2 (indicators of quality of the beginning of fermentation) and Factor 3 (indicators of quality of well-fermented cocoa) each one with a weight of 39, 35 and 26 respectively.

6. Yasmine Hamdouche, Jean Christophe Meile, Marc Lebrun, Tagro Guehi, Renaud Boulanger, Corinne Teyssier, Didier Montet,

Impact of turning, pod storage and fermentation time on microbial ecology and volatile composition of cocoa beans,

Abstract: Cocoa quality depends on several parameters, such as cocoa variety, environmental growth conditions, cultivation technique, and post-harvest treatments applied to coca beans. In this work, we studied the impact of cocoa post-harvest processing on both microbial communities structure and volatile composition. Cocoa beans samples were fermented in wooden boxes in Ivory Coast at different time intervals with turning and without turning, and derived from pods stored for two different duration times. Cocoa beans were analyzed using a molecular fingerprinting method (PCR-DGGE) in order to detect variations in microbial communities' structure; this global analysis was coupled to SPME-GC–MS for assessing cocoa volatile profiles. The results showed that the main parameter that influenced microbial communities structure was fermentation time, followed by turning, whereas, pods storage duration had a minor impact. Similar results were obtained for aromatic profile, except for pods storage duration that significantly affected volatile compound production. Global statistical analysis using Canonical Correspondence Analysis (CCA), showed the relationship between microbial communities and volatile composition. Furthermore, this study allowed the identification of discriminating microbial and chemical markers of cocoa post-harvest processing.
Keywords: Cocoa beans fermentation; Microbial communities; Volatile compounds; SPME-GC–MS; PCR-DGGE

Abstract: This review examined the factors that influence flavour volatiles of cocoa beans and the volume of work that needs to be done on these factors and their impact on the flavour volatiles of commercial cocoa beans. Cocoa bean flavour is one of the most important quality attributes as flavour is central to acceptability of cocoa beans and cocoa products such as chocolate. The complex composition of cocoa bean flavour depends on bean genotype, postharvest treatments such as pulp pre-conditioning, fermentation and drying, industrial processes such as roasting as well as the type of soil and age of cocoa tree. The bean genotype determines the chemical composition of the bean, specifically the contents of bean storage proteins, polysaccharides, and polyphenols. This determines the quantities and type of precursors formed during fermentation and drying processes leading to flavour formation, hence, influencing both flavour type and intensity. Cocoa bean fermentation and drying result in the breakdown of the storage proteins by endogenous proteases into amino acids and short chain oligopeptides while the polysaccharides are also degraded by invertase to glucose and fructose. The amino acids, oligopeptides, glucose and fructose react with each other during the roasting process to produce the typical cocoa flavour volatiles. Polyphenols are also oxidized by polyphenol oxidase during fermentation and drying which reduce

the astringency and bitterness of the beans, thus, enhancing the flavour of cocoa beans. However, the extent to which other factors such as age of the cocoa tree and soil chemical compositions influence the formation of flavour precursors and their relationships with final flavour quality remains unclear. With increasing demand for sustainable production of high quality cocoa beans, greater understanding of factors contributing to the variations in flavour character would have significant commercial implications.

Abstract: Fructophilic lactic acid bacteria (FLAB) are a recently discovered group whose main characteristic is to prefer D-fructose over D-glucose. In this study, laboratory cocoa beans fermentation was analyzed by Illumina-based amplicon sequencing, indicating the presence of potential FLAB of the genera Fructobacillus and Lactobacillus. Eighty efficient fructose-fermenting isolates, obtained from fermenting cocoa pulp beans mass, were identified by 16S rRNA gene sequencing as Pediococcus acidilactici (n = 52), Lactobacillus plantarum (n = 10), Pediococcus pentosaceus (n = 10), Bacillus subtilis (n = 4), and Leuconostoc pseudomesenteroides (n = 4). The growth characteristics of all the 10 L. plantarum strains classified them as "facultatively" fructophilic bacteria, i.e., they grew on glucose without an external electron acceptor but the growth on fructose was faster. Among them, L. plantarum LPBF 35 was characterized by producing a range of aroma-impacting compounds (acetaldehyde, ethyl acetate, nonanal, and octanoic acid), being introduced into a cocoa fermentation process. Although the process started with approximately equal amounts of glucose and fructose, a concomitant, but faster utilization of fructose, was observed in cocoa fermentation conducted with L. plantarum LPBF 35 (with no residual fructose observed) when compared to control fermentation using a glucophilic strain (8.77 mg/g residual fructose) and a spontaneous process (8.38 mg/g residual fructose). L. plantarum LPBF 35 also showed an ideal profile of organic acid metabolism (citric acid consumption and lactic acid production) associated with cocoa fermentation. These results proved new insights on cocoa microbial activity and brings new perspectives on the use of lactic acid bacteria as starter culture.

Abstract: The aim of this review is to describe the volatile aroma compounds of green coffee beans and evaluate sources of variation in the formation and development of

coffee aroma through postharvest processing. The findings of this survey showed that the volatile constituents of green coffee beans (e.g., alcohols, aldehydes, and alkanes) have no significant influence on the final coffee aroma composition, as only a few such compounds remain in the beans after roasting. On the other hand, microbial-derived, odor-active compounds produced during removal of the fruit mucilage layer, including esters, higher alcohols, aldehydes, and ketones, can be detected in the final coffee product. Many postharvest processing including drying and storage processes could influence the levels of coffee aroma compositions, which remain to be elucidated. Better understanding of the effect of these processes on coffee aroma composition would assist coffee producers in the optimal selection of postharvest parameters that favor the consistent production of flavorful coffee beans.

Abstract: The aim of this work was to determine the effect of temperature on the formation of acrylamide in cocoa beans during drying treatment by an experimental and computational study, in order to assess the presence of this neoformed compound from postharvest stage. The computational study was conducted on the reaction between fructose, glyoxal from glucose, and on asparagine at the M06-2X/6-31+G(d,p) level, under cocoa bean drying conditions at 323.15 to 343.15 K. The proposed reaction for acrylamide formation consisted of seven steps, which required to progress a via cyclic transition state of the four members. In addition, step III (decarboxylation) was considered to be the rate-determining step. Glucose followed an E1-like elimination and fructose exhibited an E1cb-like elimination. Computational model showed that the reaction of acrylamide formation was favored by fructose rather than glucose. The content of reducing sugars, asparagine and acrylamide in fermented and dried cocoa from two subregions of Antioquia-Colombia, as well as roasted cocoa, were evaluated by UHPLC-C-CAD and UHPLC-QqQ. The concentrations of monosaccharides measured at the end of the fermentation and drying process of cocoa nibs showed greater decreases in the levels of fructose as compared to glucose, supporting the main model hypothesis. Acrylamide formation only occurred in Bajo Cauca due to the presence of both precursors and fast drying time (72 h). Finally, it was possible to find the conditions to which acrylamide can be formed from the drying process and not only from roasting, information that can be used for future control strategies.

Pod storage with roasting: A tool to diversifying the flavor profiles of dark chocolates produced from 'bulk' cocoa beans? (Part II: Quality and sensory profiling of chocolates),

Abstract: The impact of pod storage (PS) and roasting temperature (RT) on the quality parameters and the sensory profiles of dark chocolates were evaluated. Dark chocolates (70%) from ten liquors of different PS and RT combinations as well as six liquors of different origins (Ecuador, Ghana, Ivory Coast, Madagascar, Venezuela and Vietnam) with variable genetic groups were produced under identical conditions and compared. To a greater extent, the range of chocolate quality attributes underscored the generally minimal effects of PS, RT and origin of liquor on the processing conditions. Although with a few exceptions, generally, chocolate acidity (pH and TA) decreased with increasing PS and vice versa in the case of RT. Furthermore, results from a balanced incomplete block design (BIBD) involving a 16-member expert panel also revealed the impact of the applied treatments (PS and RT) on the final flavor profiles of the chocolates irrespective of the origin or genetic groups of the cocoa beans. The same was confirmed when instrumental aroma results were correlated with the sensory data using partial least squares (PLS) regression models. Thus, this study demonstrates the possibility of creating diverse flavor profiles (even towards 'fine' flavor) from 'bulk' cocoa beans through an optimized combination of PS and RT. The findings are therefore expected to challenge the status-quo, especially in the way 'bulk' cocoa is currently processed and consequently priced, thereby, possibly fostering a win-win situation between cocoa producers and industries.
Keywords: Cocoa & chocolates; Pod storage; Roasting; Aroma volatiles; Sensory evaluation; Flavor profile

12. Hà V.H. Nguyễn, Hùng M. Lê, Geoffrey P. Savage,
Effects of maturity at harvesting and primary processing of cocoa beans on oxalate contents of cocoa powder,

Abstract: The total, soluble and insoluble oxalate contents of cocoa beans (Theobroma cacao L.) harvested at four different maturity stages: immature, mature, half ripe and fully ripe were extracted and measured using HPLC chromatography. The mean total oxalate content of the four maturity stages was 632 ± 20 mg/100 g dry matter (DM); soluble oxalates were 89% of the total oxalates. Natural fermentation of the whole beans had a small effect on the soluble oxalate content of the raw cocoa powder produced following three to seven days of fermentation. Fermentation of the beans with pectinase had no significant effect on the total oxalate contents of the raw cocoa powder. Soluble oxalates in the cocoa powder were reduced by fermentation with added pectinase (581 vs 613 mg soluble oxalate/100 g DM). For both fermentation treatments, increasing fermentation duration increased the insoluble oxalate content and reduced the proportion of soluble oxalate. There were no differences in the total oxalate contents between samples dried by freeze, oven or sun drying. However oven dried cocoa powder contained the highest level of soluble oxalate (648 ± 11.0 mg/100 g DM) compared to the other two drying methods.

Abstract: Fermented cocoa beans can be described as a complex matrix that integrates the chemical history of beans, their processing, and environmental factors. This study presents an analysis that aims to identify volatile compounds of five varieties of fine-aroma cocoa types. The cocoa types studied were Carmelo, Rojo Samuel, Lagarto, Arcoiris, Regalo de Dios, that grow in the Maya lands of Chiapas, Mexico. Profile of volatile compounds was obtained from each cacao type during fermentation and drying process. This profile of volatile compounds also was compared with beans unfermented, using a statistical analysis of Venn diagram and a multivariate Analysis of Principal Components (PCA). One hundred nine different compounds were identified by SPME-HS GC-MS, these compounds mainly related to desirable aromatic notes generated by esters, aldehydes, ketones, and alcohols. The differences in chemical composition of the volatile compounds were associated mainly with the process and not to cocoa varieties. Fermented dry cocoa beans showed a higher content of esters, aldehydes, pyrazines, alcohols, some acids, and furans where Lagarto (CL), Rojo Samuel (CR), and Regalo de Dios (TRD) cocoas type showed a more interesting aromatic profile. On the other hand, as expected dry unfermented cocoas presented a few numbers of aroma compounds, in the five cacao types, where alcohols, ketones and hydrocarbons predominated.

Abstract: Cocoa fermentation is a crucial step for the development of cocoa aroma and precursors of high quality cocoa and by-products. This bioprocess has been studied for years to understand cocoa chemical changes but some matters concerning changes in fat content remain that are investigated in this work. Changes in the quantity (free and total fat), extractability and composition of cocoa butter were assessed in samples from Madagascar, the Dominican Republic and Ecuador. Increases in free fat content were highlighted in samples from each origin thanks to the use of the 'soxtec' solvent method, which preserves the integrity of the butter. A 4.71% increase in free fat was measured in the Ecuadorian samples fermented for 144 h. Conversely, total fat content remained stable throughout fermentation. Protein and polyphenol contents decreases were linked

to fat content augmentation by a strong negative interaction. Triglyceride and total and linked fatty acid kinetics (0 to 6 days) of the butter remained statistically stable during fermentation, as did unsaponifiable matter. The origin of fermentation had a predominant and significant impact on composition, revealed by PCA. This work underlines and explains the importance of fermentation process in improving yield of fat that can be extracted while preserving the composition of this cocoa butter. This study highlights an interaction in cocoa unfermented or partially fermented beans. This phenomenon causes butter content retention but is slowly broken after 72 h fermentation. Therefore, fermentation appears to be also necessary to enhance the cocoa butter content extracted from the nibs.

3. PEMUPUKAN KAKAO

Abstract: Cocoa (Theobroma cacao L.) is a strategic product for Côte d'Ivoire. This country is the world leader producer with aver 40% of world volume production. This production is obtained on 6% of the country's area by the work of 5 million farmers and the members of their family. Cocoa contributes to 30% of export earnings and 15% of the Gross Domestic Product (GDP). These economic parameters show the importance of cocoa for Côte d'Ivoire. Despite some remarkable performance, in cocoa growing systems, there are many constraints for cocoa productivity and sustainability. Particularly, in acid strongly P-sorbing soils of Côte d'Ivoire, P is among the nutrients that most limits cocoa production. For the success of cocoa planting, application of P to soils is one solution to ensure cacao growth and productivity. However, the current recommendations of fertilization based on the use of the fertilizer 0N. 23 P2O5.19 K2O + 10 CaO + 5MgO is not adapted in a context of deteriorating soil fertility. Improving the productivity of cocoa in Côte d'Ivoire therefore requires to update the fertilizer recommendations. In this context, the National Agronomic Research Center (CNRA, Côte d'Ivoire) conducts research-development in collaboration with the company Mars Inc. and Office Chérifien of Phosphates (OCP, Morocco), in order to test and validate a new fertilizer called Teractiv Cacao (0% N. 15% P2O5. 14% K2O + 28% CaO + 5,5% S + 2,5% MgO + 0,9% Zn + 0,24% B2O3). This new fertilizer includes natural tender phosphate (Reactive Phosphate Rock, RPR) in its composition, which makes it reduces the cost of purchase for cocoa producers and optimizes phosphate fertility of soils in cocoa growing systems. In its implementation, the research-development project adopted a participatory approach. Trials are conducted in three main cocoa regions in Côte d'Ivoire, including CNRA research stations Divo (Central - West) and Abengourou (East), as well as cocoa farmers areas in Soubré (South West). Ultimately, this project will contribute to the updating of fertilizer forms and doses in order to improve cocoa productivity in Côte d'Ivoire.
Keywords: Teractiv cocoa; Reactive Phosphate Rock; Soil fertility; Côte d'Ivoire

Abstract: Increasing demand for cocoa and climate-related yield declines have sparked a multi-stakeholder debate on cocoa production strategies. Agrochemical inputs and pollination enhancement through hand pollination are two strategies to increase yields. Here, we test both strategies with field experiments in Indonesia. We show that even partial hand pollination (13% of easily accessible flowers/tree), and not fertilizers or

insecticides, increases yield/tree by 51%. The more laborious 100% hand pollination of the entire tree increases yield/tree by 161%, and farmer's annual net income from 994 USD/ha up to 1,677 USD/ha, or 69% in the study area, after accounting for farm operational, hand pollination labor, and opportunity costs. Thus, intensifying cocoa pollination appears to be a potential solution for closing cocoa yield gaps and should be considered in the current industry-led discussion of designing farms for mitigation of climate change.

3. Munir P. Hoffmann, James Cock, Marianne Samson, Noel Janetski, Kate Janetski, Reimund P. Rötter, Myles Fisher, Thomas Oberthür,
Fertilizer management in smallholder cocoa farms of Indonesia under variable climate and market prices,
Agricultural Systems,Volume 178,2020,102759,ISSN 0308-521X,
https://doi.org/10.1016/j.agsy.2019.102759.
(http://www.sciencedirect.com/science/article/pii/S0308521X18301665)

Abstract: Cocoa yields on the smallholder farms of Sulawesi are <500 kg/ha, yet, attainable yields are substantially higher. Seventy-three on farm trials were established in Sulawesi, Indonesia, to determine how farmers could optimize their fertilizer management considering both, factors under their control and factors beyond their control, such as the weather. The farmers, who were divided into four groups, had all been trained in Good Agricultural Practices (GAP). Two inorganic fertilizer regimes were compared on the farms that were all supposed to be using GAP. The trials for each group were run for 2 years, with different groups monitored over distinct periods with varying weather conditions, over a 4-year period from 2013 to 2016. Striking variations in farmer yields within groups under similar conditions were attributed to unexpectedly large variations in management. The percentage increase in yield due to fertilizer application was about 34% across all management levels and weather conditions, but the absolute yield increase was greater when weather conditions and management were favorable. Net financial returns to fertilizer applications in years with unfavorable weather and farms with poor management were negative. Rather than giving blanket fertilizer recommendations, applications should be adjusted to the level of management and the expected weather conditions. With current low levels of management, many farmers will only benefit from recommended fertilizer applications rates when weather and prices are favorable. When low prices and adverse weather are expected many farmers would be better off not applying fertilizer.

4. MARKETING KAKAO

Abstract: Abstract:
This chapter covers the history of the physical or actuals market, and its evolution from spot sales to a modern market using standardised contracts with arbitration services and allowing forward sales. The main origin countries' individual methods of marketing their cocoa following liberalisation of Marketing Boards and Caisse de Stabilisation are discussed, together with the role of bulk cocoa and the economics of processing at origin. The changing role of the brokers, dealers, processors and chocolate manufacturers is included.
Keywords: physical market; actuals; spot market; forward sales FCC; CMAA; Marketing Boards; Caisse de Stabilisation; free markets; processing at origin; brokers; dealers; agents; cocoa processors; chocolate manufacturers

Abstract: Although liberalization of the cocoa sector has increased internal competition within the marketing chain it has also led to the emergence of informal market actors within the chain. Therefore, the aim of this paper is to analyse how the cocoa marketing chain operates by measuring and comparing the marketing margins of the formal and informal actors. Qualitative data were used to establish the structure of the marketing chain and quantitative data to estimate the marketing margins. A total sampling size of 76 cocoa market actors was obtained by using a multi-stage sampling technique: 15 for qualitative data and 61 for quantitative data. Descriptive analysis was used to map the marketing chain and economic analysis to compute the costs and margins for both informal and formal market intermediaries from the Centre and South-West regions in Cameroon. The results indicated three market intermediaries (one informal and two formal) and four marketing channels by which cocoa moves from the farmers to the exporters. The calculation of marketing costs indicated that informal actors incurred the highest costs in both regions. The results regarding the marketing margins were twofold: informal actors obtain low net marketing margins when they do not use illicit strategies, but high net marketing margins when illicit strategies are used. Given the significant role of informal actors, we suggest that their actions should be integrated in a suitable manner into those of formal actors to contribute to a better performance of the marketing chain and to the sustainability of the cocoa sector.
Keywords: Cocoa; Marketing channels; Market intermediaries; Marketing costs; Marketing margins

3. E.A. Obeng, B.D. Obiri, K.A. Oduro, S. Pentsil, L.C. Anglaaere, E.G. Foli, D.A. Ofori,
Economic value of non-market ecosystem services derived from trees on cocoa farms,
Current Research in Environmental Sustainability,Volume 2,2020,100019,
ISSN 2666-0490,
https://doi.org/10.1016/j.crsust.2020.100019.
(http://www.sciencedirect.com/science/article/pii/S2666049020300323)
Abstract: Tree-based conservation agriculture is becoming critical for reducing vulnerability of agricultural production systems from climate risks while enhancing forest-agriculture landscapes. On-farm tree integration is being promoted to restore degraded forest in cocoa landscapes. This study assessed farmers' knowledge and attitude towards non-market ecosystem services provided by trees on cocoa farms. Contingent valuation method was used to estimate economic value of these services to farmers. Data from 340 cocoa farmers from 10 cocoa-farming communities in the Western and Western North Regions of Ghana were analyzed. The results show farmers are familiar with non-market ecosystem services provided by on-farm trees. About 83% of respondents had either retained naturally occurring trees or intentionally planted trees on their farms. Cocoa farmers were willing to pay for tree integration on farms to enhance a bundle of essential regulating and supporting non-market ecosystem services such as providing habitat for pollinating insects and nutrient cycling. The estimated economic values for a bundled non-market ecosystem services provided by integrated trees on cocoa farms was GH₵837.59 (USD 164.00) per farmer per hectare per year. This amount is approximately 8.2% of the mean annual household income of respondent and equivalent to approximately 128 kg (2 bags) of marketable cocoa beans. Family size, age, value motivations and favourable attitude towards forest in general statistically predicted willingness to pay. Cocoa farmers hold substantial economic value for non-market ecosystem services provided by trees on cocoa farms and are likely to support on-farm tree integration initiatives that provide these essential non-market ecosystem services for enhanced cocoa productivity.
Keywords: Economic values; Tree integration; On-farm trees; Cocoa farms; Non-market ecosystem services; Ghana

7. Hamish van der Ven, Catherine Rothacker, Benjamin Cashore,
Do eco-labels prevent deforestation? Lessons from non-state market driven governance in the soy, palm oil, and cocoa sectors,
Global Environmental Change,Volume 52,2018,Pages 141-151,
ISSN 0959-3780,
https://doi.org/10.1016/j.gloenvcha.2018.07.002.
(http://www.sciencedirect.com/science/article/pii/S0959378017304545)
Abstract: In countries marked by the growing uptake of non-state market driven (NSMD) governance for agricultural commodities (i.e., eco-labels and certification systems), forested areas are steadily decreasing while crop lands are growing. This deforestation continues despite NSMD rules aimed at prohibiting the conversion of forested land to agriculture. In this paper, we ask why the growing presence of NSMD governance has coincided with ongoing deforestation. While the seeming inability of NSMD governance to halt broader patterns of land use change can be partially explained by a lack of market uptake, there are also a range of other variables that may contribute to this relationship. We probe the plausibility of five hypotheses through comparative case studies of

sustainable soy certification in Brazil, palm oil in Indonesia, and cocoa in Côte d'Ivoire. Our findings indicate that NSMD governance has neither abetted, nor hindered, the conversion of forested land to agricultural production. We find strong evidence that a lack of broad market uptake limits the effectiveness of NSMD governance. However, we also find evidence that regulatory loopholes in NSMD systems may explain the inability of eco-labels and certification systems to halt broader patterns of land use change in countries with comparatively strong market uptake. Our results highlight critical problems related to expanding the reach and stringency of NSMD governance alongside the ongoing fragmentation of global environmental governance. The study contributes to scholarship on the impacts and effectiveness of transnational environmental governance.

Keywords: Non-state market driven governance; Certification; Eco-Labeling; Land use change; Transnational environmental governance

5. PETANI KAKAO

Abstract: Adaptation to climate change is crucial for many farming households around the world. Due to path dependencies, perennial crop farmers often face a confined set of adaptation options. This paper explores the potential for index-based weather insurance for cocoa as an example of a perennial crop. The paper presents empirical findings on determinants of interest in index insurance based on a sample of 313 cocoa farming households in Ghana. Further, results of key informant interviews with representatives relevant for the planning and implementation of index insurance are presented. A key finding on the demand side is that more than 90% of the sampled cocoa farmers are interested in index insurance. The main determinants for interest were ownership of the cocoa farm, access to extension services, and age of the cocoa farm. For the supply side, main findings are that while stakeholders showed a general appreciation of the conceptual benefits of index insurance, a plethora of disadvantages and obstacles relating to insurance implementation were mentioned ranging from insufficient data and infrastructure, over low profitability, to wrong perceptions of insurance among farmers. The paper concludes that structural changes to the cocoa economy are necessary to address these impediments in the long run.
Keywords: Index insurance; Perennial crops; Cocoa farmers; Climate change; Ghana

Abstract: It is a truism that Cameroon's agricultural sector in general and the cocoa sector in particular has been hit by climatic vagaries with telling repercussions. Cocoa (Theobroma cacao Linn.) production remains one of the main cash crops in Cameroon with over 90% of households in the cocoa producing areas depending on it for their income. Cameroon ranks fifth in the world in cocoa production which has a significant contribution to her economy. This important sector is exposed to climate-related shocks requiring mitigation and adaptation strategies. From an economic perspective, climate-insurance has been suggested as one of the solutions to this problem, as an option to reduce farmers' vulnerability. However, there is little or no information on farmers' preparedness and willingness to pay for climate –related insurance. This article therefore seeks to ascertain the level of preparedness of farmers to sue for climate insurance in cocoa producing areas in Cameroon. We randomly selected 10 cocoa farmer cooperatives drawn across the main cocoa producing divisions of the South West Region - a major cocoa producing region in Cameroon. We combine a structured questionnaire survey with focus group discussions to assess cocoa farmers' awareness, knowledge, perception, level of preparedness and challenges to adopting climate

insurance. Furthermore, we interview insurance authorities within the region on existing insurance policies. This information is complemented through field observations and review of relevant literature. We employ descriptive and correlation analysis to assess cocoa farmers' perceptions and level of preparedness for climate insurance. We observe that there is a direct statistically significant relationship between farm sizes, level of diversification and awareness, and farmers' preparedness ($P \leq 0.05$). Income levels showed a significant but indirect relationship with level of preparedness. Poverty, uncertainty, and weak institutions operating with policies that do not consider farmers' realities were key challenges to climate-insurance preparedness. Based on the results we recommend that (i)insurance bodies should undertake feasibility study on the possibilities of instituting friendlier policy for farmers, (ii) farmers should sensitized on the relevance of insurance policies to support cocoa farming in the face of climate vagaries, (iii) farmer groups should strengthen cooperative spirit to ease access to pro-poor insurance policies; and (iv) government should work in partnership with insurance bodies to support farmers through more climate-friendly insurance policies which can be accessed by farmers irrespective of their levels of diversification, income and farm sizes.

Keywords: cocoa farmers; awareness; climate insurance; perception; preparedness; Cameroon

Abstract: The study was conducted to explore actual manifestations of climate change in smallholder cocoa farms to aid extension response to climate impacts, and to understand the reasons for a renewed interest in cocoa production in the forest-savanna agro ecological landscape in Ghana, in spite of unfavorable climatic conditions. Two hundred cocoa farmers were interviewed in nine cocoa farming communities. Selected farms were also visited to document on-farm manifestation of climate impacts as well as innovations and strategies farmers are employing to respond to the adverse impacts of climate change on their cocoa systems. The results revealed various manifestations of climate impacts on cocoa farms which included, increased incidence of pests and diseases, wilting of cocoa leaves, high mortality of cocoa seedlings which affected expansion and farm rehabilitation, and wilting of cherelles resulting in low yield. The farmers maintained that their response to the immediate impacts of climate on cocoa was a shift to cereals due to the unpredictable climatic patterns and the shortened duration of rainfall. However, a combination of storage and supply chain challenges and low returns from cereal production, coupled with land scarcity in the Western Region, where most of them are migrant farmers accounted for their decision to return to cocoa production lately. It was observed, among other adaptive responses, that some farmers plant about three times the plantain suckers they usually plant, to provide a dense temporary shade over cocoa seedlings, and resort to planting more cocoa seedlings randomly per unit area on new farms, contrary to recommended planting approach, as a form of insurance against seedling mortality. More importantly, a community-based fire response system was identified to be a major safeguard mechanism to the threat of fire. Clearly, the farmers are not replanting cocoa in the forest-savanna agro ecological

landscape because it is more productive than cereals, but they believe that a low yielding cocoa is far better than a productive cereal cropping systems that offer low returns when compared to cocoa. The study brings out the sustainable livelihood challenges of the rural farmer within the context of a changing climate for appropriate policy response.

Keywords: Agro-ecological zone; Theobroma cacao; Landuse; Adaptation; Livelihood; Smallholder

Abstract: The simultaneous adoption of pesticides management practices has the potential of boosting productivity and improving the welfare of smallholder cocoa farmers in Ghana. This study identified the factors influencing farmers' choice of the combination options of pesticides management practices using cross-sectional data randomly collected from 838 cocoa farm households. The results from the multinomial logit model revealed that farmers' decision to adopt insecticides only, fungicides only or a combination of the two is influenced by different socio-economic, farm-specific and institutional factors as well as farmers' perception about incidence of pests and diseases on their farms. Using both multinomial endogenous switching regression (MESR) framework and the inverse-probability-weighted regression adjustment (IPWRA) estimator, the adoption of pesticides management practices improves households' welfare. However, the highest payoff was achieved when insecticides and fungicides were adopted simultaneously. The results of the study implies that farm-level cocoa-specific programmes such as Cocoa Disease and Pest Control Programme (CODAPEC) promoting the use of pesticides to improve productivity in Ghana's cocoa industry should be strengthened to enhance the simultaneous adoption of both insecticides and fungicides.

Keywords: Average treatment effects; Multinomial endogenous switching regression; Ghana's cocoa industry; Inverse-probability-weighted regression adjustment; Pesticides management practices

Abstract: Climate change poses a serious threat to many farmers' yield and income. Previous studies often applied a general approach to examine climate change mitigation strategies implemented by farmers. Our study focuses on income diversification of cocoa farmers in Ghana as a strategy to cope with climate change. We compiled data from 400 cocoa farmers, and applied a Heckman two-step regression to investigate the probability and extent of cocoa farm income diversification. Further, we used beta regression to determine the share of annual farm income generated by diversification. Most cocoa farmers in our study region diversify farm income as a strategy to reduce climate change

impacts. These strategies comprise crop and livestock diversification, intercropping of cocoa farms, provision of labour for other farmers, and agricultural-related economic off-farm activities. Factors that influence income diversification include the age of the farm, access to credits, extension contacts, the information sources on climate change, and government support. The study provides recommendations for policy- and decision-makers to enhance diversification strategies in the country's cocoa sector. These include the provision of financial credits, farm input subsidies, and farmers' training on farm management.

Keywords: Climate change; Coping and adaptation strategies; Farm income diversification; Cocoa; Heckman two-step regression; Beta regression

Abstract: Background
Bougainville, an autonomous region of Papua New Guinea (PNG) is slowly improving services and infrastructure destroyed 20 years ago during the ten year civil war. However, the region still faces significant constraints to economic growth and human development and remains under-developed compared to PNG and close Pacific neighbours. PNG's 2017 Human Development Category (HDC) was one of the lowest at 0.544. The Bougainville Strategic Development Plan 2018–2022 noted significant gaps in health services and infrastructure, had inadequate water and waste disposal and experienced weak markets and cocoa quality. This research examines domestic conditions and the extent to which they impact on livelihoods.
Method
A cross-sectional livelihood survey was administered to cocoa growing households in 33 Village Assemblies (VAs) with 11 VAs in each of the three regions.
Results
Data was collected from 5172 individuals. A significant majority of households reported multiple health issues, rudimentary housing, unimproved sanitation and unimproved water. Over two-thirds of cocoa growers did not sell any cocoa bags in 2014–2016 resulting in low incomes and greater food insecurity compared to families selling cocoa. Families that produced no saleable cocoa were more likely to have rudimentary housing, unimproved toilet facilities and unsafe water, factors that increase the likelihood of chronic disease and exacerbate malnutrition and poor labour productivity.
Conclusion
This study provides key information about the health and livelihood status of cocoa growers in Bougainville. If productivity is to increase, farmer health needs to improve including improving water and sanitation practices and diets. Building a responsive health system for the community is a challenge when a majority of the population live in small villages with difficult access to health centres. Establishing and integrating outreach village health clinics will enable health care to be more accessible to these remote communities.

Keywords: Livelihood; Health; Water; Sanitation; Bougainville; Cocoa; Productivity; Poverty; Farmer

7. Sugeng Raharto,
Institutional Development Model Cocoa Farmers in East Java Province District Blitar,
Agriculture and Agricultural Science Procedia,Volume 9,2016,Pages 95-102,
ISSN 2210-7843,
https://doi.org/10.1016/j.aaspro.2016.02.131.
(http://www.sciencedirect.com/science/article/pii/S2210784316301310)
Abstract: The agricultural sector especially the plantation sub-sector are required to play a role in the national economy, among others through the Gross Domestic Product (GDP), the creation of foreign exchange, the food supply. Cocoa absorb labor at the same time create jobs for farmers, contribute to a positive foreign exchange, and encourages the growth of agribusiness and agro-industries in the area. The quality of exported cocoa is generally not good, because about 90% of Indonesian cocoa exports which are not fermented. The purpose of this study was (1) to analyze the driving factor inhibiting the fermentation of cocoa farmers, (2) determine the root cause of the problem reluctance of farmers ferment, (3) institutional strengthening to formulate models that could encourage farmers to ferment. The method used in this research, descriptive methods, and action research in Blitar of East Java Province Sampling method using Simple Random Sampling with the number of samples in each region sebanyak45 farmers. Including data analysis methods or the force field analysis Force Field Analysis (FFA), analysis or Fish Bone Fishbone Analysis, to analyze the root of the problem is less reluctance of farmers to ferment cocoa. In addition to data collection is done through the collection of primary data was also conducted Focus Group Discussion (FGD). This research is expected to encourage farmers to utilize fermented cocoa and cocoa-products in order to increase their family income. The wider benefits that cocoa exports of Indonesia has a good quality so that no rebates (automatic detention) in the world market. The results showed that farmers ferment inhibiting factor is the difference between the price of cocoa beans fermented and not fermented very small. The root problem reluctance cocoa farmers ferment cocoa beans market cluster is a cluster focus issues and knowledge of farmers are at the root problem of the factors that affect farmers in the fermentation of cocoa beans. While the model of institutional empowerment of farmers through the strengthening of institutional synergy among stakeholders.
Keywords: farmers; farmer groups; farmer knowledge; market

8. James S. Kaba, Alexander Otu-Nyanteh, Akwasi A. Abunyewa,
The role of shade trees in influencing farmers' adoption of cocoa agroforestry systems: Insight from semi-deciduous rain forest agroecological zone of Ghana,
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ISSN 1573-5214,
https://doi.org/10.1016/j.njas.2020.100332.
(http://www.sciencedirect.com/science/article/pii/S1573521420300336)
Abstract: Farmers growing desire for no shade cocoa system has reiterated the scepticism about the impact of research on farmers' adoption of cocoa Agroforestry. In this study, we assess farmers' perception about shade trees and how that influences their adoption of cocoa Agroforestry. Five cocoa growing communities in the Eastern Region of Ghana and 91 cocoa farmers were purposively sampled and interviewed. The result showed that the most desirable shade trees among the farmers were Spathodea campanulata, Terminalia superba, and Terminalia ivorensis while Alstonei boonei was the least desirable. About 87 % of farmers introduced shade trees at different stages of cocoa farm establishment while 13 % of farmers had existing trees at establishment.

Farmers with less than 11 years farming experience and those with Senior High education kept the recommended number (15–18) of shade trees ha−1. Most farmers related the importance of shade trees to the good growth of cocoa associated crops (37 %) and as source of fodder (31 %), while higher cocoa yield and low education on the importance of shade trees were major reasons farmers removed shade trees. In conclusion, collaboration between farmers and other stakeholders in the cocoa sector is essential in reversing the growing hunger for no shaded cocoa system. This collaboration must focus on educating farmers on the importance of shade trees, and by providing money and agro-inputs support to farmers as impetus for the adoption of cocoa Agroforestry in Ghana.

Keywords: Unshaded cocoa system; Sustainable; Ecological; Cocoa agroforestry system

Abstract: Much literature has been devoted to understanding farmers' adaptation decisions in annual cropping systems, but comparatively little is known on adaptation in perennial systems. This paper presents empirical findings on Ghanaian cocoa farmers' experiences of climate change, the coping strategies they have used and the factors that influenced their adaptation decisions. Primary data were collected through a structured survey of 313 households in 20 communities in Dormaa West and Bia East districts of Ghana. The econometric analysis of the data shows that more than 90% of cocoa farmers have been exposed to negative impacts of climate change. This resulted in severe and very severe effects on their cocoa production and livelihood. Yet a fourth of the respondents have not implemented any adaptation strategy. We argue that this is due to the economic superiority of cocoa as a perennial crop vis-à-vis other agricultural (annual) crops. We conclude that there is need for the development of adaptation technologies for current cocoa farmers but also need for more transformational adaptation policies that generate jobs and income generating activities outside cocoa cultivation.

Keywords: Adaptation; Perennial crops; Cocoa farmers; Ghana

Abstract: The study aims at examining the sustainability of cocoa farmer livelihood. Emphasis was laid on investigation of factors that increase or derail the sustainability of cocoa farmer livelihood. Quantitative and qualitative data were sourced from relevant state institutions and 264 farmers drawn from 774. The results indicate that cocoa farmer livelihood provides larger secondary livelihoods for labour-sellers, petty traders and staff of cocoa marketing companies. The cocoa farmer livelihood is facing threats from the newly oil found, service and industry. The initial capital assets invested in cocoa farming

were poor. The study concludes that farmers are made vulnerable by land degradation, corruption in the internal cocoa marketing and inflation. Consequently, incomes (savings) and capital assets are not able to increase as spelt out in the Sustainable Livelihood Framework analysis.

6. HAMA DAN PENYAKIT TANAMAN KOPI

Abstract: Summary
Superoxide dismutases (SOD; EC 1.15.1.1) in coffee leaves (Coffea arabica L.) from cultivars susceptible and resistant to infection by Hemileta vastatrix (Berk and Br.) were characterized by non-denaturing polyacrylamide gel electrophoresis. The 3 molecular forms of SOD were distinguished from each other by their different sensitivities to cyanide and H_2O_2. In leaves of the susceptible cultivar (cv. Caturra), one Mn-SOD, one Fe-SOD, and one Cu,Zn-SOD were found, and Fe-SOD was the most abundant isozyme (about 50% of the total SOD activity). In coffee leaves from the resistant cultivar (cv. Colombia), two additional Cu, Zn-SODs were present. The appearance of new Cu,Zn-SOD isoenzymes could be related to the manifestation of resistance against fungal infection. The identification of Fe-SOD in a species belonging to the plant family Rubiaceae extends the small number of higher plants where the presence of these Fe-containing metalloenzymes has been demonstrated. Results obtained may be useful from an evolutionary viewpoint and also in oxy-radical studies in plants dealing with defence mechanisms against fungal infection.
Keywords: Coffea arabica; Hemileia vastatrix; Cu; Zn-superoxide dismutase; Fe-superoxide dismutase; Mn-superoxide dismutase; rust infection; SOD pattern

Abstract: The emergence of viruses in Coffee (Coffea arabica and Coffea canephora), the most widely traded agricultural commodity in the world, is of critical concern. The RNA1 (6552nt) of Coffee ringspot virus is organized into five open reading frames (ORFs) capable of encoding the viral nucleocapsid (ORF1p), phosphoprotein (ORF2p), putative cell-to-cell movement protein (ORF3p), matrix protein (ORF4p) and glycoprotein (ORF5p). Each ORF is separated by a conserved intergenic junction. RNA2 (5945nt), which completes the bipartite genome, encodes a single protein (ORF6p) with homology to RNA-dependent RNA polymerases. Phylogenetic analysis of L protein sequences firmly establishes CoRSV as a member of the recently proposed Dichorhavirus genus. Predictive algorithms, in planta protein expression, and a yeast-based nuclear import assay were used to determine the nucleophillic character of five CoRSV proteins. Finally, the temperature-dependent ability of CoRSV to establish systemic infections in an initially local lesion host was quantified.
Keywords: Dichorhavirus; Rhabdovirus; Protein localization; Climate change; Negative-strand RNA virus; Brazil; Virus emergence

Abstract: Early intercellular signaling in Coffea arabica L.–Hemileia vastatrix host–pathogen interaction was studied, using inside-out plasma membrane from two varieties of coffee leaf and a fungal fraction to determine the plant's biochemical responses. Microsomal pellets (100,000 × g) from the susceptible (Caturra) and resistant (Colombia) coffee leaf varieties were purified by partitioning in two-polymer DEX (6.3% w/w) and PEG (6.3% w/w) system aqueous phase. Fungal material was obtained from orange rust Hemileia vastatrix Berk and Br. race II urediospore germ tubes. Plasma membrane vesicles were preferentially localized to PEG phase, as indicated by its enzyme marker distribution. Both H+-ATPase activities displayed similar kinetic and biochemical characteristics, comparable to those described for P-type ATPases. Several enzymes may play pivotal roles in plants regarding early interaction with fungal elicitors. Studies of fungal fractions' effects on H+-ATPase and both varieties' proton pumping activities were thus carried out. Concentration as low as 0.1 Gluc eq. ml–1 fungal fraction induced specific inhibition of H+-ATPase and the resistant variety's proton pumping activities. The present work describes characterizing the H+-ATPase plasma membrane from two Coffea arabica L. varieties (Caturra and Colombia) for the first time and the race specific inhibitory effect of a crude fungal fraction on both H+-ATPase and the resistant variety's proton pumping activities.
Keywords: H+-ATPase; Coffea arabica L; Plasma membrane; Two-phase system; Host–pathogen interaction; Signal transduction; Hemileia vastatrix Berk and Br

7. PEMROSESAN COFFEA ARABICA

Abstract: There are relatively few studies concerning the use of coffee leaves for medicinal purposes and the composition of secondary plant substances. Therefore, we identified and quantitated polyphenolic compounds along with caffeine present in methanol extracts of Coffea arabica leaves from three different regions of Brazil (Ceará, Minas Gerais and São Paulo) by HPLC-ESI-MS. In addition, correlations between polyphenolic content of the coffee leaves and antioxidant assays DPPH, FRAP and ORAC were evaluated. Fifteen compounds belonging to three classes of polyphenols (xanthones, chlorogenic acids and flavonoids) along with the alkaloid caffeine were detected. The mean concentration of total polyphenolic compounds in the leaves of C. arabica, harvested from three different regions of Brazil was quite variable. The highest values were detected in the coffee leaves harvested in Minas Gerais (n = 4) at 40.80(13.00) g/kg (SD), followed by coffee leaves harvested in São Paulo (n = 20) at 24.79(20.19) g/kg, and the lowest in coffee leaves harvested in Ceará (n = 11) in the Northeast of Brazil at 10.30(5.61) g/kg. The three classes of polyphenols, all showed excellent correlations in the antioxidant assays. Coffee leaf tea, appears to be an excellent functional beverage, with its high content of polyphenolic compounds, which may render positive biologic effects, when inbibed as part of the normal human diet.
Keywords: Polyphenolic compounds; Mangiferins; Chlorogenic acids; Flavonoids; Caffeine

Abstract: In this study, a geometric model of Coffea arabica var. Colombia fruits is reviewed to represent computationally the fruit topology in any development stage. A finite element analysis was carried out to estimate Young's moduli for different ripeness stages. Analytical equations were adjusted to experimental data of size, volume and Young's moduli (semi-experimental) with the aim to analyze its behavior in the ripening process. Further, a volume equation is also developed in dependence on the orthogonal variations of the fruit. These variations show that the fruit keeps a growth constant ratio. To simulate the fruit growth, a finite element analysis was performed on an unripe fruit with displacement boundary conditions that enforce the geometric changes. To verify that the volume changes were simulated correctly in each ripeness stage, a strain index

was defined to compare the growth evolution with experimental data. Results show that the simulated fruit growths properly since dimensions and volume were predicted in a reasonable level of approximation. Additionally, the internal pressure was computed for all ripening stages and the results are consistent with the comparisons done from the strain energy of the fruit.

Keywords: Coffee growth; Coffea arabica; Ripening process; Finite element analysis; Fruit growth simulation

3. Luís Roberto Batista, Sara Maria Chalfoun, Cristina Ferreira Silva, Marcelo Cirillo, Eugênia Azevedo Varga, Rosane Freitas Schwan,
Ochratoxin A in coffee beans (Coffea arabica L.) processed by dry and wet methods,
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https://doi.org/10.1016/j.foodcont.2008.10.003.
(http://www.sciencedirect.com/science/article/pii/S0956713508002818)

Abstract: The incidence of ochratoxin A was studied in different coffee (Coffea arabica L.) samples. A higher incidence of filamentous fungi was observed in the coffee swept from ground and floating coffee samples. The species Aspergillus ochraceus, Aspergillus sulphureus and Aspergillus sclerotiorum were ochratoxin A producing. In 128 (44%) samples ochratoxin A was not detected; however, in 89 samples (31%), ochratoxin A was detected at 0.1–5.0μg/Kg levels. Other 25% samples presented contamination above 5.0μg/Kg. This study showed that the fractions coffee swept from ground and floating coffee represents a serious risk of ochratoxin A contamination.

Keywords: Ochratoxin A; Coffee; Aspergillus

4. Deusélio Bassini Fioresi, Lucas Louzada Pereira, Emanuele Catarina da Silva Oliveira, Taís Rizzo Moreira, Alessandro Coutinho Ramos,
Mid infrared spectroscopy for comparative analysis of fermented arabica and robusta coffee,
*Food Control,*Volume 121,2021,107625,ISSN 0956-7135,
https://doi.org/10.1016/j.foodcont.2020.107625.
(http://www.sciencedirect.com/science/article/pii/S0956713520305417)

Abstract: Coffee is one of the most widely consumed beverages in the world. When compared to the arabica variety, robusta coffee has a lower market value due to several factors, especially those related to sensory analysis. Thus, this study examined fermentation processing techniques for Arabica and Robusta coffees using medium infrared analyzes to identify differences in their chemical compositions, which suggested specific fermentation routines for each variety. The samples of both varieties, collected in proper regions of the Brazilian state of Espírito Santo, were subjected to different wet-processing methods (Washed, Yeast fermentation, Dry fermentation, and Dry fermentation with yeast). The obtained spectra were divided into spectral regions, which were compared by specific statistical tests that revealed differences between them for the varieties and processing methods. Yeast Fermentation demonstrated to be the most recommendable processing technique for the robusta variety, considering the obtained secondary compounds associated with final coffee quality.

Keywords: Coffee; Fermentation; Infrared; Statistic

6. Lorenzo Del Terra, Valentina Lonzarich, Elisa Asquini, Luciano Navarini, Giorgio Graziosi, Furio Suggi Liverani, Alberto Pallavicini,

Functional characterization of three Coffea arabica L. monoterpene synthases: Insights into the enzymatic machinery of coffee aroma,

Abstract: The chemical composition of the coffee beverage is extremely complex, being made up of hundreds of volatile and non-volatile compounds, many of which are generated in the thermal reactions that occur during the roasting process. However, in the raw coffee bean there are also compounds that survive roasting and are therefore extracted into the beverage. Monoterpenes are an example of this category, as their presence has been reported in the coffee flower, fruit, seed, roasted bean and in the beverage aroma. The present work describes the isolation, heterologous expression and functional characterization of three Coffea arabica cDNAs coding for monoterpene synthases. RNA was purified from C. arabica (cv. Catuai Red) flowers, seeds and fruits at 4 successive ripening stages. Degenerate primers were designed on the most conserved regions of the monoterpene synthase gene family, and then used to isolate monoterpene synthase-like sequences from the cDNA libraries. After 5′- and 3′-RACE, the complete transcripts of 4 putative C. arabica monoterpene synthases (CofarTPS) were obtained. Gene expression in different tissues and developmental stages was analysed. After heterologous expression in Escherichia coli, enzyme activity and substrate specificity were evaluated in vitro by incubation of the recombinant proteins with geranyl pyrophosphate (GPP), geranylgeranyl pyrophosphate (GGPP) and farnesyl pyrophosphate (FPP), precursors respectively of mono-, di- and sesquiterpenes. The reaction products were characterized by HS-SPME GC–MS. CofarTPS1 was classified as a limonene synthase gene, while CofarTPS2 and 3 showed lower activity with the production of linalool and β-myrcene.

7. Cíntia Sorane Good Kitzberger, Maria Brígida dos Santos Scholz, Marta de Toledo Benassi,
Bioactive compounds content in roasted coffee from traditional and modern Coffea arabica cultivars grown under the same edapho-climatic conditions,

Abstract: Genetic improvement of coffee is aimed at transferring disease resistance genes from Coffea canephora to Coffea arabica cultivars, but the composition of arabica coffee could be affected by the introgression of genetic material from canephora. The objective of the this work was to compare traditional Brazilian arabica coffee cultivars (Bourbon, Catuaí, and Icatu) with modern arabica cultivars (IAPAR 59, IPR 98, IPR 99, and IPR 103) produced in the same edapho-climatic conditions. The cultivation, harvesting, post-harvesting and roasting processes were standardized to evaluate the influence of genetic diversity on the composition of bioactive compounds (5-caffeoylquinic acid, trigonelline, nicotinic acid, caffeine, cafestol, kahweol, and melanoidins) and antioxidant activity (AA) of the roasted coffees. Compositional variability among the coffee cultivars studied was observed, mainly with regard to contents of 5-caffeoylquinic acid (5-CQA) (from 936 to 1695mg 100g−1), cafestol (from 414 to 742mg 100g−1), and kahweol (from 439 to 1068mg 100g−1). In general, arabica

cultivars with the introgression of C. canephora genes showed high antioxidant activity and differed from coffees of traditional arabica genotypes mainly in terms of their diterpenes profiles. A high correlation was observed among the AA (assessed by different methods) and some of the bioactive compounds (melanoidins, caffeine, and 5-CQA). Variability in the levels of the bioactive compounds was higher than that the observed for AA (from 4.2 to 4.7g gallic acid 100g−1 by Folin–Ciocalteau reducing capacity, from 3.75 to 5. 42g Trolox 100g−1 coffee by ABTS radical scavenging activity, and from 80.1 to 83.0 percentage of inhibition of autoxidation of linoleic acid).
Keywords: Caffeoylquinic acid; Kahweol; Cafestol; Antioxidant activity

Abstract: Turkish coffee is a popular hot beverage owing to its delicious taste and pleasant aroma in Turkey. In the present study, key odorants of medium (MRC) and dark roasted Turkish coffee (DRC) brews were studied using GC-MS-Olfactometry. A total of 26 and 28 key odorants were detected in the MRC and DRC samples, respectively, with flavour dilution (FD) factors varying between 4 and 2048. The highest FD factor (2048) was found for 2-ethyl-3,5-dimethylpyrazine and 2-ethyl-3-methyl pyrazine in the MRC and DRC brew samples, respectively. One of the main differences between the two brew samples was the guaiacol with phenolic-burnt odour. A higher amount of chlorogenic acids (CGAs) was determined in the MRC as compared to the DRC using LC-DAD-ESI-MS/MS. According to the sensory analysis, the Turkish coffee sample brewed from the MRC beans had a higher score of general impression and pleasant coffee sensory descriptors as compared to the DRC.
Keywords: Turkish coffee; Key odorants; Olfactometry; SAFE; Phenolics

8. PEMROSESAN COFFEA CANEPHORA

Abstract: Between 15 and 20% of Brazilian coffee production corresponds to defective beans (PVA), which decreases the quality of the coffee brew. Steam treatment has been reported as an alternative to improve the volatile profile and cup quality of coffee. The aim of this study was to propose a steam treatment of defective Coffea canephora beans to improve the volatile profile of the roasted coffee. The sensory impacts of adding steamed coffee (SC) in Coffea arabica blends were evaluated. The steam treatments studied modified the volatile profile of roasted SCs, increasing the contents of acetoin, benzyl alcohol, maltol, 2,6-dimethylpyrazine, 2-furfurylthiol, and 5-methylfurfural and decreasing the contents of 4-ethylguaiacol, isovaleric acid, methional, 2,3-diethyl-5-methylpyrazine, and 3-methoxy-3-methylpyrazine. Among the evaluated parameters, the best condition to maximized the content of the volatiles with a potential positive impact and minimize those with a potential negative impact was 5bar/16min (SC 5). The thresholds of consumer rejection and of detection indicate that up to 30% SC 5 can be added to a high cup quality Coffea arabica coffee without perception or rejection of the coffee brew. A blend of 30% of SC 5 and 70% of Coffea arabica was well accepted.
Keywords: Roasted and ground coffee; Coffee brew; PVA beans; Black; Immature; Sour

Abstract: Commercial coffee is available as a mixture of two varieties of coffee beans, namely Arabica, which is more expensive, and Canephora (Robusta), less expensive. To assess the correspondence between the composition indicated on the label and the real composition of commercially available coffee, it would be desirable to be able to differentiate between the two varieties. This would also help to avoid any possible commercial frauds. This work identifies parameters based on the fatty acid composition to differentiate between Arabica and Canephora coffee in a mixture. Total monounsaturated fatty acids (ΣMUFA), linolenic acid (cis18:3n–3) concentration, the 18:0/cis18:1n–9 ratio, and the ΣMUFA/ΣSFA ratio could be used to determine the relative amounts of Arabica and Canephora in a coffee blend.
Keywords: Coffee; Coffee variety Arabica; Coffee variety Canephora; Roasted coffee; Fatty acids methyl esters; Gas chromatography; HRGC/FID; Food analysis; Food composition

3. Vivien Chia Yen Tang, Jingcan Sun, Maurin Cornuz, Bin Yu, Benjamin Lassabliere,
Effect of solid-state fungal fermentation on the non-volatiles content and volatiles composition of Coffea canephora (Robusta) coffee beans,
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https://doi.org/10.1016/j.foodchem.2020.128023.
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Abstract: In this study, the effects of fungal fermentation on green canephora coffee beans were evaluated by observing the changes to selected non-volatile parameters before roasting, and subsequently the volatile profile after roasting. Solid-state fermentation (SSF) by Aspergillus spp. and Mucor spp. on green canephora coffee beans was shown to modulate the contents of free sugars, free amino acids and polyphenolic compounds such as caffeoylquinic acids (CQAs). Significant strain-specific differences were observed in the contents of aroma compounds after roasting. A significant increase in pyrazines was observed in the Aspergillus oryzae-fermented samples, while higher levels of furans were detected in the Mucor plumbeus-fermented samples. The present work shows that fungal fermentation of green canephora coffee beans is a potentially promising method for the modulation and improvement of coffee flavour and aroma.
Keywords: Green coffee beans; Fermentation; Aspergillus spp.; Mucor spp.; Flavour; Aroma modulation

4. Irène Ahou Kouadio, Louis Ban Koffi, Jean Gnopo Nemlin, Mireille Bretin Dosso,
Effect of Robusta (Coffea canephora P.) coffee cherries quantity put out for sun drying on contamination by fungi and Ochratoxin A (OTA) under tropical humid zone (Côte d'Ivoire),
*Food and Chemical Toxicology,*Volume 50, Issue 6,2012,Pages 1969-1979,
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https://doi.org/10.1016/j.fct.2012.03.042.
(http://www.sciencedirect.com/science/article/pii/S0278691512002268)

Abstract: The effect of coffee cherries quantity put out for sun drying on the kinetics of the drying, chemical components variation, fungal growth and ochratoxin A production was evaluated. The results showed that the more coffee cherries quantity on the drying area was important, the slower they dried. Indeed, the drying durations were 12, 17, 21, 26, 31 and 32days respectively for the lots of 10kg, 20kg, 30kg, 40kg, 50kg and 60kg of cherries by square meter of drying area. The slowness of the drying led to the increasing of fungal development and ochratoxin A production in the cherries. Indeed, samples more contaminated were those from the lots of 50kg and 60kg of cherries by square meter of drying area with between 10% and 100% of infected beans and with levels of ochratoxin A ranging from 0.92 to 118.47 and 1.4 to 131.33µgkg−1 respectively. The slowness of the drying led also to the acidification of the cherries (pH=5.55–4.54) and the degradation of their chlorogenic acids content (13.03–11.69) while for their caffeine content (2.52–2.54), any significant difference was observed whatever the drying duration.
Keywords: Coffee cherries; Fungi; Aspergillus; Toxigenic; Ochratoxin A

5. Thy Minh Kieu Tran, Timothy Kirkman, Minh Nguyen, Quan Van Vuong,

Effects of drying on physical properties, phenolic compounds and antioxidant capacity of Robusta wet coffee pulp (Coffea canephora),

Abstract: Wet coffee pulp (WCP), produced as waste from coffee production, is a rich source of bioactive compounds, especially caffeine and chlorogenic acid. However, it contains high moisture content, thus it is challenging for further utilization due to degradation and microbial deterioration. Dehydration is, therefore, necessary to minimize degradation and ease storage and transportation. As a waste, the common drying methods should be prioritized to be feasible for industrial application. This study aimed to determine the impact of different drying conditions of the three common drying methods including low temperature and pressure, vacuum and hot air drying on physical, phytochemical and antioxidant properties of WCP to identify the most suitable drying conditions. Browning index, moisture content, total phenolic content (TPC), flavonoids (TFC), proanthocyanidins, and chlorogenic acid as well as the antioxidant properties of the dried coffee pulp were significantly influenced by different tested conditions. Vacuum drying was found to be more suitable for drying the wet coffee pulp as compared to low temperature and pressure and hot air drying methods. Vacuum drying at 110 °C retained the highest TPC (14.4 mg gallic acid equivalents (GAE)/g dry weight (DW)), proanthocyanidins (6.8 mg catechin equivalents (CE)/g DW), TFC (13.2 CE/g DW), caffeine (2.9 mg/g DW) and antioxidant capacity. Chlorogenic acid (3.4 mg/g DW) was 13% lower, but energy consumption was 37% less than vacuum drying at 90 °C. Therefore, vacuum drying (3.75 mmHg) at 110 °C for 4h 05 min was suggested for dehydration of the wet coffee pulp for subsequent recovery and processing.
Keywords: Food science; Food analysis; Coffee pulp; Coffee by-products; Coffea canephora; Robusta; Bioactive compounds; Antioxidant capacity

9. PENGOLAHAN TEH HITAM

Abstract: Fermentation process directly determines the product quality of black tea. This work aimed to develop a rapid method for detecting the degree of fermentation of black tea based on electrical properties of tea leaves. An LCR meter employed to identify 11 electrical parameters of tea leaves during the fermentation process, and the content of catechins and tea pigments in tea leaves were measured by using HPLC and UV-Vis spectrometer, respectively. Principal component analysis and hierarchical clustering analysis applied to divide samples into different groups in the degree of fermentation. Correlation analysis used to characterize the responding strength of electrical parameters on the variation of catechins and pigments. Finally, multilayer perceptron, random forest, and support vector machine algorithm used to build discrimination models of fermentation degree, and the average accuracy rate on the testing set reached to 88.90%, 100%, and 76.92%, respectively.
Keywords: Black tea; Fermentation; Electrical properties; Quality components; Random forest; Machine learning algorithms

Abstract: This study selected common processing methods for orthodox black tea and investigated changes in the levels of Nε-(carboxymethyl)lysine (CML), Nε-(carboxyethyl)lysine (CEL), lysine, and polyphenols during each processing stage and using different parameters of each processing step. The effects of epicatechin gallate, epigallocatechin, epigallocatechin gallate, and gallic acid on the levels of CML, CEL, fructoselysine, glyoxal, and methylglyoxal were investigated by chemical model systems study under black tea processing conditions. In tea samples, CML and CEL levels significantly increased during drying (could reach 51.8 and 8.7 µg/g tea, respectively), while natural withering and extensive rolling and fermentation times facilitated the formation of CML and CEL by altering the substrate concentrations and the cellular structure of tea leaves to be dried. The results of model systems (containing lysine, glucose, and fructose) indicated that polyphenols were able to enhance the production of CML and CEL, and the levels of CML and CEL increased 1.2–3.2- and 1.6–3.5-fold, respectively. Furthermore, the main pathways responsible for CML and CEL formation during black tea processing likely involve fructoselysine and others but not glyoxal or methylglyoxal.

3. Junfeng Tan, Weidong Dai, Meiling Lu, Haipeng Lv, Li Guo, Yue Zhang, Yin Zhu, Qunhua Peng, Zhi Lin,
Study of the dynamic changes in the non-volatile chemical constituents of black tea during fermentation processing by a non-targeted metabolomics approach,
Abstract: Fermentation is a critical manufacturing process to produce black tea, in which the chemical compositions are greatly changed. However, the dynamic changes of this sophisticated process are far from clear, and were often characterized by determining a small number of compounds. In this study, we applied a non-targeted metabolomics approach based on ultra-high performance liquid chromatography coupled with quadrupole time-of-flight mass spectrometry to comprehensively profile the variations of metabolites in tea samples with various fermentation durations of 0, 1, 2, 4, 6, 8, 10, 12 and 14h. Principal component analysis indicated obvious stepwise alterations of tea metabolome during the fermentation. Relative quantitation of 61 identified metabolites including catechins, dimeric catechins, flavonol glycosides, amino acids, phenolic acids, alkaloids, and nucleosides revealed distinct changes of phenol pathway. Dynamic changes of a part of these compounds were mapped for the first time. To the best of our knowledge, this study offered the most comprehensive profiles of metabolite changes during the tea fermentation process.

4. Yang Zhang, Weihua Xiao, Guanya Ji, Chongfeng Gao, Xueli Chen, Yaoyao Cao, Lujia Han,
Effects of multiscale-mechanical grinding process on physicochemical properties of black tea particles and their water extracts,
Abstract: Mechanical grinding of tea is a crucial step in tea processing which can influence the quality and utilization of tea products. To investigate the effects of different grinding scale on black tea, particles at organ (~mm), tissue (500–100µm), and cell (50–10µm) scales, were produced to compare their microstructural, compositional, molecular, antioxidant and dynamic extraction properties. The results proved organ and tissue-scale particles had similar properties, whereas cell-scale particles were significantly altered. In detail, for particles, the decrease in particle size resulted in an increase in cell wall breakage ratio, specific surface area, exposure of inner pores and depolymerized cell wall components on particle surfaces. According to the results of dynamic extraction, extraction equilibrium of the components could be obtained within 45min. For water extracts at extraction equilibrium, microstructural changes at cell scale affected the diffusion process of phytochemicals, leading to more extractable macromolecules (protein and polysaccharide) and homogeneous particles, which enhanced antioxidant activity. However, the infusion yields of cytoplasmic

micromolecules (tea polyphenols, caffeine, and free sugars) were not influenced by different grinding process. In conclusion, organ-scale grinding can meet the need for micromolecule-aimed products, while cell-scale grinding is essential for structure, macromolecule and antioxidation-enhanced products.

Abstract: In black tea manufacturing, the fermentation process plays a significant role to determine the quality of finished tea. During this process, complex chain of biochemical reactions takes place and green tea leaves transform from grassy to sweet floral aroma. Monitoring and detection of optimum fermentation time are necessary, as both under and over fermented tea produce inferior grades of tea. This paper presents a method of real-time monitoring to detect the optimum fermentation time of black tea using an electronic nose consisting of eight quartz crystal microbalance (QCM) sensors. The sensor is coated with glucose derivative coating materials viz. maltose (MAL), maltodextrin (MDEX), β-cyclodextrin (β-CD), d-glucose (d-GLU) and polyethylene glycols (PEG) with different molecular weights, 200, 1500, 4000, and 6000. Optimum fermentation times were determined for twelve black tea samples, and the results show good agreement with the estimations of the ultra-violet-visible (UV) spectrophotometer based reference method.

Abstract: This study was to examine the formation of advanced glycation end-products (AGEs) in black tea during drying process at 90, 120, and 150 °C for 1 h. Nine AGEs including Nϵ-(carboxyethyl)-l-lysine (CEL), Nϵ-(carboxymethyl)-l-lysine (CML), three isomers of methylglyoxal-hydroimidazolones (MG-Hs), three isomers of glyoxal-hydroimidazolones (GO-Hs), and argpyrimidine were quantified by using HPLC-MS/MS with isotope-labelled internal standard. Results showed that each AGE during the drying process of 150 °C was significantly higher ($p < 0.05$) than at 90 and 120 °C, and argpyrimidine was only found in the treatment of 150 °C. MG-H1/3 was first quantified as the major AGE during drying at 120–150 °C, the content respectively reached to (39.66 ± 2.61) µg/g and (58.88 ± 1.76) µg/g after 1 h drying, where CML content only

had (19.86 ± 1.02) µg/g and (23.71 ± 1.40) µg/g. This study indicated that arginine derived-AGEs are the key components of black tea AGEs.

Abstract: The theaflavin-to-thearubigin ratio (TF/TR) is an important parameter for evaluating the degree of fermentation and quality characteristics of Congou black tea. Near infrared (NIR) spectroscopy, one of the most promising techniques for evaluating large-scale tea processing quality, in association with chemometrics, can be used as a selection tool when a fast determination of the requested parameters is required. The aim of this work is to develop a unique model for the determination of TF/TR. First, 11 key wavelength variables were screened by synergy interval partial least-squares regression (SI-PLS) and competitive adaptive reweighted sampling (CARS). Based on these characteristic variables, a new extreme learning machine (ELM) combined with an adaptive boosting (ADABOOST) algorithm (ELM-ADABOOST) was applied to construct the nonlinear prediction model for TF/TR, and an independent external set was used for the validation. A determinate coefficient (R_p^2) of 0.893, root mean square error of prediction (RMSEP) of 0.0044, RSD below 10%, and RPD above 3 were acquired in the prediction model. These results demonstrate that NIR can be used to rapidly determine the TF/TR value during fermentation, and it effectively simplify the model and improve the prediction accuracy when combined with the SI-CARS variable.

Abstract: Our previous study reported that different tea processing methods along with the age of coffee leaves affected antioxidant and anti-inflammatory bioactivities; however, identification of phytochemical components or associated mixtures that contribute to the anti-/pro-inflammatory activities was not determined. Herein, we report results of additional experiments designed to characterize the phytochemical composition of fractionated coffee leaf extract, derived from Japanese-style-green-tea-process-young (JGTP-Y) and black-tea-process-mature (BTP-M) leaves and related these data to anti-/pro-inflammatory activities. The aqueous fraction of BTP-M coffee leaves induced nitric oxide (NO), iNOS, COX-2, IL-6 and IL-10 production in Raw 264.7 cells. A 40% methanol fraction possessed greatest anti-inflammatory activities in IFN-γ and LPS treated Raw 264.7 cells (P < 0.05). The anti-inflammatory activities of coffee

leaf fractions could not only be attributed to chlorogenic acids, mangiferin, rutin, and caffeine content, but possibly subtle interactions of mixtures of bioactive molecules.

9. K.R. Jolvis Pou, Sanjib K. Paul, Santanu Malakar,
4 - Industrial Processing of CTC Black Tea,
Editor(s): Alexandru Mihai Grumezescu, Alina Maria Holban,
Caffeinated and Cocoa Based Beverages,Woodhead Publishing,2019,
Pages 131-162,ISBN 9780128158647,
https://doi.org/10.1016/B978-0-12-815864-7.00004-0.
(http://www.sciencedirect.com/science/article/pii/B9780128158647000040)

Abstract: Tea made from leaves of Camellia sinensis is considered to be one of the inexpensive and most habitually consumed aromatic beverages covering two-thirds of the world population. There are two main approaches for processing tea: orthodox method, and crush, tear, and curl (CTC) method. The different types of teas, namely, black, green, white, and oolong, are produced from the same tea plant and the differences between them result from the different processing procedures followed while manufacturing the tea. Among these, black tea is most commonly manufactured worldwide. The generally followed steps in the industrial manufacturing of tea consist of plucking, withering, rolling/macerating, oxidizing/fermenting, and drying. The freshly plucked leaves are taken for withering operation where they are chemically and/or physical conditioned. During this period, tea leaves partially loose moisture by about 10%–15%, the turgid leave becomes flaccid, and biochemical changes occur. The fully withered leaves undergo rolling or maceration process to rupture the cells which lead to the exposure of cell sap. During fermentation of the ruptured leaves, the chemical reaction occurs between the enzymes and chemical constituents of tea leaves in the presence of atmospheric oxygen and form oxidized polyphenolic compounds such as thearubigins (TRs) and theaflavins (TFs). The green color of ruptured leaves turn into coppery brown. Research indicates the optimum ratio 1:10 of TF and TR need to be maintained to get a quality cup of tea. Once the fermentation reaches its optimum level the drying or firing starts to halt the oxidation and other enzymatic activities. The tea particles are dried to an appropriate moisture level (3%–4%, wb) to obtain a stable quality product and also to facilitate in handling and transportation. The dried tea particles undergo grading and sorting operation and finally to the packaging unit. Tea is rich in antioxidants and it is reported to have a great potential for the treatment of oral health problems, various types of cancers, heart diseases, and diabetes and it also improves urine and blood flow, improves the immune system, and have the ability to detoxify, and stimulate. To maintain quality in terms of inherent color, aroma, taste, appearance, and health benefits tea must be processed under controlled condition. Thus, it is essential to understand and maintain standardized parameters for various processing steps.

10. Cemile Yılmaz, Feramuz Özdemir, Vural Gökmen,
Investigation of free amino acids, bioactive and neuroactive compounds in different types of tea and effect of black tea processing,
*LWT,*Volume 117,2020,108655,ISSN 0023-6438,
https://doi.org/10.1016/j.lwt.2019.108655.

Abstract: This study aimed to investigate free amino acids, bioactive amines, and tryptophan derivatives in kynurenine pathway in white, green, oolong, black and pu-erh tea samples. Effects of black tea processing stages (withering, rolling, fermentation and drying) on these compounds were also investigated. Analyses of free amino acids, bioactive and neuroactive compounds were performed by using tandem mass spectrometry. Total free amino acid content of tea increased in withering stage while decreased in drying stage. Although all tea samples were found to contain gamma-aminobutyric acid (GABA) and kynurenic acid, only pu-erh tea contained tyramine and histamine. Furthermore, dopamine was detected in some white (0.8 mg/kg) green (0.3–0.6 mg/kg) and oolong (0.3–0.6 mg/kg) teas. Serotonin, kynurenine and tryptamine were not found in any tea samples. Concentrations of kynurenic acid in white, oolong, green, black and pu-erh tea were found to be within the range of 1.1 ± 0.3 and 13.0 ± 0.9 mg/kg. GABA and kynurenic acid concentration of tea increased 33% and 53% after withering, respectively. Dried tea contained lower GABA and kynurenic acid than withered tea. Tea could have health-promoting effects due to containing neuroactive compounds such as GABA, kynurenic acid and dopamine and, processing stages of tea affects the level of these compounds.

11. Yanqin Yang, Jinjie Hua, Yuliang Deng, Yongwen Jiang, Michael C. Qian, Jinjin Wang, Jia Li, Mingming Zhang, Chunwang Dong, Haibo Yuan,
Aroma dynamic characteristics during the process of variable-temperature final firing of Congou black tea by electronic nose and comprehensive two-dimensional gas chromatography coupled to time-of-flight mass spectrometry,
Food Research International,Volume 137,2020,109656,
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https://doi.org/10.1016/j.foodres.2020.109656.
(http://www.sciencedirect.com/science/article/pii/S0963996920306815)

Abstract: The drying technology is crucial to the quality of Congou black tea. In this study, the aroma dynamic characteristics during the variable-temperature final firing of Congou black tea was investigated by electronic nose (e-nose) and comprehensive two-dimensional gas chromatography coupled to time-of-flight mass spectrometry (GC × GC-TOFMS). Varying drying temperatures and time obtained distinctly different types of aroma characteristics such as faint scent, floral aroma, and sweet fragrance. GC × GC-TOFMS identified a total of 243 volatile compounds. Clear discrimination among different variable-temperature final firing samples was achieved by using partial least squares discriminant analysis (R2Y = 0.95, Q2 = 0.727). Based on a dual criterion of variable importance in the projection value (VIP > 1.0) and one-way ANOVA (p < 0.05), ninety-one specific volatile biomarkers were identified, including 2,6-dimethyl-2,6-octadiene and 2,5-diethylpyrazine with VIP > 1.5. In addition, for the overall odor perception, e-nose was able to distinguish the subtle difference during the variable-temperature final firing process.

12. Tuty Anggraini, Neswati, Ririn Fatma Nanda, Daimon Syukri,
Identification of 9,10-anthraquinone contamination during black and green tea processing in Indonesia,
Food Chemistry,Volume 327,2020,127092,ISSN 0308-8146,

Abstract: Black and green tea are popular owing to their unique flavors and health benefits. However, these teas can be contaminated with anthraquinones, which are associated with health risks in humans. Levels of 9,10-anthraquinone were determined at each step of the manufacturing process for green and black tea using gas chromatography–tandem mass spectrometry. For green tea, anthraquinone was present beginning at the withering process and increased in concentration until the first drying step. Additionally, for black tea, the first drying step resulted in a significant increase in anthraquinone content, whereas the concentration decreased during the final drying step. For black tea, anthraquinone was also detected during withering, although the concentration continued to increase throughout the entire procedure, particularly during drying. Therefore, it can be suggested that the presence of anthraquinone in these teas was influenced by the smoke emitted by the wood fires used to drive the processing machinery.
Keywords: Anthraquinone; Black tea; Green tea; Mass spectrometry; Processing

13. Hualing Wu, Wenjie Huang, Zhongjian Chen, Zhuang Chen, Jingfang Shi, Qian Kong, Shili Sun, Xiaohui Jiang, Dong Chen, Shijuan Yan,
GC–MS-based metabolomic study reveals dynamic changes of chemical compositions during black tea processing,
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ISSN 0963-9969,
https://doi.org/10.1016/j.foodres.2019.02.039.
(http://www.sciencedirect.com/science/article/pii/S0963996919301243)
Abstract: The chemical composition of black tea during tea processing is in a state of flux. However, the dynamic changes of this sophisticated metabolic process are far from clear. GC–MS-based metabolomic analyses were performed to examine changes in volatile and non-volatile compounds throughout the five stages of tea processing. The results showed that the most striking differences were observed at the withering and rolling stages, during which 62 non-volatile and 47 volatile compounds were significantly changed. The levels of most monosaccharides decreased at the withering stage and increased in subsequent stages while di-saccharides decreased as the process progressed. Free amino acids increased sharply at the withering stage, and most kept increasing or remained stable afterwards. However, levels of catechin, epicatechin, epigallocatechin, and epigallocatechin gallate decreased after withering and remained at low levels afterwards. Among the 47 volatile compounds with altered levels, phenylpropanoids/benzenoids and carotenoid-derived volatiles, which contribute to the honey-like and rose-like fragrances and quality of Danxia2 tea, kept increasing during the processing, among them eight were newly produced. Furthermore, 19 volatiles with a grassy odor decreased during processing. This study provides a comprehensive profile of metabolic changes during black tea processing, which is potentially important for both quality control and improvement of the flavor of black teas.
Keywords: Black tea processing; Metabolic profiling; Amino acids; Sugars; Organic acids; Volatile compounds; GC–MS

14. Rafael Vargas, Aldo Vecchietti,
Influence of raw material moisture on the synthesis of black tea production process,
*Journal of Food Engineering,*Volume 173,2016,Pages 76-84,

Abstract: Tea industry is one of the main activities in the northeast of Argentina. It presents some particularities respect of tea production in other regions of the world, mainly in the high level of automation in tea shoots harvesting. Besides, the factory configurations in terms of the equipment used in tea production are different and it is not clear if they are efficient or not. The objective of this work is to study the effects of the moisture in the raw material (tea shoots) in the optimal design of a tea manufacturing plant not only in the investment but also in the operation costs. A superstructure that includes all the equipment involved in black tea manufacturing is proposed and a Generalized Disjunctive Programming model (GDP) is formulated to find the optimal flow sheet to produce black tea minimizing investment and operation cost, considering different wet contents in the tea shoots. A comparison was also made among the optimal plant and typical factories configurations to analyze their performance. From the results obtained can be observed that if the moisture of raw material is below of 4.5 kg of water per kg of dry matter the optimal plant configuration does not change; above this value more investment is needed to extract the extra water content. A similar conclusion can be obtained from the analysis of the operation costs. The optimal configuration is formed by conventional preservation chambers, continuous withering belts, Rotorvane crusher, continuous fermenting machines and fluid bed dryers. Comparing other typical configurations against the optimal one, the operative unit cost is about 20%–60% greater.
Keywords: Black tea production; Raw material moisture; Process system optimization; Disjunctive Programming

Abstract: Instant tea powder is the fully soluble solid of tea that has emerged as a new and fast growing product in every country. The various processes involved in the commercial production of instant tea includeblending of tea leaves, hot water extraction, aroma recovery, soluble solids concentration, aroma restoration and dehydration. An envisaged process has been developed for the production of instant/soluble tea from the expressed juice of fermented tea leaves. Green tea leaves are subjected to withering, maceration, and fermentation process, which are similar to that of existing black tea production process. The fermented leaf is pressed to expel a part of juice containing soluble solids. The juice is then heated, centrifuged and vacuum dried to get soluble/instant tea powder. The pressed leaf residue is subjected to vacuum/hot air drying to obtain low grade conventional tea granules. About 20±2g of soluble tea and 220±20g of pressed cake tea are obtained from 1kg of green tea leaves. The TF:TR ratio for soluble tea is 0.084 and that for pressed cake tea is 0.140.
Industrial relevance
The technology can be easily adopted by existing black tea manufacturers for simultaneous production of instant tea and black tea. The process is economical as both extracted juice and pressed cake are converted into value added products.

Keywords: Soluble tea; Instant tea; Fermented tea; Vacuum drying; Pressed cake tea

Abstract: Plucked tea leaves can be processed into black tea (Camellia sinensis), which is rich in health-promoting molecules, including flavonoid antioxidants. During black tea processing, theaflavins (TFs) and thearubigins (TRs) are generated via the successive oxidation of catechins by endogenous polyphenol oxidase (PPO)- or peroxidase (POD)-mediated reactions. This process must be well controlled to achieve the proper TF/TR ratio, which is an important quality parameter of the tea beverage. However, little is known about the POD/PPO catalyzed TF formation process at the molecular genetic level. Here, we identified and characterized the POD genes responsible for TF production in tea. Genome-wide analysis of POD/PPO family genes, metabolite profiling, and expression analysis of PPO/POD genes in tea leaves enabled us to select several PPO/POD genes potentially involved in TF production. Differential gene expression in plant tissues and enzyme activity in several tea varieties traditionally used for processing of various beverage types indicate that black tea processing primarily depends on PPO/POD activity. Among these POD/PPO genes, the POD CsGPX3 is involved in the generation of TFs during black tea processing. The capacity of PPO/POD-catalysed TF production is potentially used for controlling catechin oxidation during black tea processing and could be used to create molecular markers for breeding of tea plant varieties suitable for the production of high-quality black tea beverages.
Keywords: Antioxidant; Catechin; Phytochemical; Polyphenol; Tea processing

10. PENGOLAHAN TEH HIJAU

Abstract: Green tea catechins can undergo degradation, oxidation, epimerization and polymerization during food processing. Many factors could contribute to the chemical changes of green tea catechins, such as temperature, pH of the system, oxygen availability, the presence of metal ions as well as the ingredients added. Several detection methods have been developed for tea catechin analysis, which are largely based on liquid chromatography (LC) and capillary electrophoresis (CE) methods for getting a good separation, identification and quantification of the catechins. Stability of green tea catechins is also influenced by storage conditions such as temperature and relative humidity. The stability of each catechin varies in different food systems and products. Pseudo first-order kinetic model has been developed and validated for the epimerization and degradation of tea catechins in several food systems, whereas the rate constant of reaction kinetics followed Arrhenius equation.
Keywords: Stability; Green tea catechins; Detection method; Food processing; Epimerization; Thermal degradation; Kinetic model

Abstract: Green tea samples were produced from different roasting temperatures (200 and 300 °C) and drying temperature (80, 120 and 160 °C). Individual catechins, total catechins, caffeine, and chlorophylls content were all evaluated in dried green tea leaves and green tea infusions. The color of dried tea leaves and tea infusions were also evaluated. Results showed variation of individual catechins, total catechins, caffeine, and chlorophylls content among both the dried tea leaves and of the tea infusions. Epimerization and thermal degradation were reported to be the main cause of change in tea catechins during processing. A correlation analysis indicated that total catechins content in dried tea leaves had significant effect with the content in tea infusions. Chlorophyll was considered an important compound for determining the greenness of dried tea leaves, but it had no impact on the color of the tea infusions. Results from this study suggest that strict temperature control is important for maintaining chemical constituents in green tea.
Keywords: Drying; Roasting; Caffeine; Catechins; Chlorophylls

Abstract: This paper presents data related to an article entitled "Green tea flavor determinants and their changes over manufacturing processes" (Han et al., 2016) [1]. Green tea samples were prepared with steaming and pan firing treatments from the tender leaves of tea cultivars 'Bai-Sang Cha' ('BAS') and 'Fuding-Dabai Cha' ('FUD'). Aroma compounds from the tea infusions were detected and quantified using HS-SPME coupled with GC/MS. Sensory evaluation was also made for characteristic tea flavor. The data shows the abundances of the detected aroma compounds, their threshold values and odor characteristics in the two differently processed tea samples as well as two different cultivars.

4. Xiumin Chen, Kaiwen Mu, David D. Kitts,
Characterization of phytochemical mixtures with inflammatory modulation potential from coffee leaves processed by green and black tea processing methods,

Abstract: Our previous study reported that different tea processing methods along with the age of coffee leaves affected antioxidant and anti-inflammatory bioactivities; however, identification of phytochemical components or associated mixtures that contribute to the anti-/pro-inflammatory activities was not determined. Herein, we report results of additional experiments designed to characterize the phytochemical composition of fractionated coffee leaf extract, derived from Japanese-style-green-tea-process-young (JGTP-Y) and black-tea-process-mature (BTP-M) leaves and related these data to anti-/pro-inflammatory activities. The aqueous fraction of BTP-M coffee leaves induced nitric oxide (NO), iNOS, COX-2, IL-6 and IL-10 production in Raw 264.7 cells. A 40% methanol fraction possessed greatest anti-inflammatory activities in IFN-γ and LPS treated Raw 264.7 cells (P < 0.05). The anti-inflammatory activities of coffee leaf fractions could not only be attributed to chlorogenic acids, mangiferin, rutin, and caffeine content, but possibly subtle interactions of mixtures of bioactive molecules.
Keywords: Coffee leaf; Inflammation; Nitric oxide; iNOS; COX-2; Cytokine; Chlorogenic acid; Mangiferin

5. Larissa dos Santos Sousa, Bruna Vieira Cabral, Grasiele Scaramal Madrona, Vicelma Luiz Cardoso, Miria Hespanhol Miranda Reis,
Purification of polyphenols from green tea leaves by ultrasound assisted ultrafiltration process,

Abstract: Application of ultrafiltration membranes is a promising alternative to recovery target components from natural substrates, but some drawbacks should be considered such as the membrane fouling. Here we propose the application of the ultrasound assisted ultrafiltration process for the purification of phenolic compounds from green tea extract. Comparison between the processes with and without ultrasound showed that the state steady flux through the membrane of 5kDa was 4 times greater in the ultrasound assisted process than in the process without ultrasound. This flux

improvement is associated with the decrease in cake formation and in the total resistance (from 17.8 to 10.2×1013m−1). The flux decay profiles were better described by pore blockage models than by the cake formation model, since the cake was formed in the first minutes of filtration and, after that, the particles of relative small size entered in the membrane pores. Moreover, the ultrasound facilitated the permeation of phenolic compounds through the membrane. Comparison between ultrafiltration membranes of different MWCO suggests that the membrane of 20kDa presented high purity of catechin components in the permeate (49% of EGCG related to the total polyphenol content). Turbidity values of ultrafiltration permeates remained lower than 5NTU after 30days of storage under refrigeration and any tea cream formation was observed, which suggests great permeate stability. Thus, the ultrasound assisted ultrafiltration process with the membrane of 20kDa is suggested for the purification of phenolic compounds from green tea extract in order to ensure great permeate flux, purity of phenolic compounds and extract stability.

Abstract: This study aimed to develop green tea paste using a new micro wet milling (MWM) system. The influence of milling conditions on the particle size, morphology, solubility, and antioxidant properties of Matcha, shaded Yabukita, unshaded Yabukita, and Hojicha pastes were studied. MWM green tea paste retained smaller particles, better color, higher solubility, and antioxidant properties than the dry milled Matcha paste. Storage temperature and time affected the stability of ascorbic acid and visual green color at 20, 4, −18, and −60 °C for four weeks. Kinetic analysis demonstrated that first-order kinetic models could predict the degradation of ascorbic acid and the reduction in visual green color of green tea pastes during storage. Temperature-dependent rate constants of ascorbic acid and color of green tea pastes obeyed the Arrhenius relationship. The total viable count revealed that green tea paste could be stored for 7 days at 20 °C and 21 days at 4 °C within the permissible limit.

Abstract: Background
Green tea and its decaffeinated products are foodstuffs which involve a great commercial market due to their interesting healthy properties. Catechins are the main phenolic compounds in tea leaves and these are receiving considerable interest due to

their potential benefits on human health. In this sense, many studies have been performed with the aim of removing the caffeine and obtaining either decaffeinated green tea leaves preserving the catechins or decaffeinated catechins-rich extracts.

Scope and approach

In this review, different methods and solvents described in the literature for green tea decaffeination and recovery of high valued catechins are revised. Particular attention is given to ethyl lactate, an agrochemical green solvent studied by the authors for the extraction of caffeine.

Key findings and conclusions

A diversity of results has been reported for the different green solvents and extraction techniques studied to remove caffeine from green tea leaves and extracts in the last years. Nevertheless, despite the solvent used, the loss of catechins is unavoidable to some extent. In this sense, ethyl lactate has demonstrated higher selectivity and efficiency with respect to commercial and other agrochemical solvents currently used to that end. Additionally, combining ethyl lactate with Supercritical CO2 Anti-Solvent technique, a decaffeinated green tea precipitate could be obtained, overcoming limitations of presently studied procedures to obtain decaffeinated extracts and demonstrating to be a selective and effective alternative for catechins purification.

Keywords: Ethyl lactate; Green tea; Caffeine; Catechins; Decaffeination

Abstract: Flavour determinants in tea infusions and their changes during manufacturing processes were studied using Camellia sinensis cultivars 'Bai-Sang Cha' ('BAS') possessing significant floral scents and 'Fuding-Dabai Cha' ('FUD') with common green tea odour. Metabolite profiling based on odour activity threshold revealed that 'BAS' contained higher levels of the active odorants β-ionone, linalool and its two oxides, geraniol, epoxylinalool, decanal and taste determinant catechins than 'FUD' ($p<0.05$). Enhanced transcription of some terpenoid and catechin biosynthetic genes in 'BAS' suggested genetically enhanced production of those flavour compounds. Due to manufacturing processes, the levels of linalool and geraniol decreased whereas those of β-ionone, linalool oxides, indole and cis-jasmone increased. Compared with pan-fire treatment, steam treatment reduced the levels of catechins and proportion of geraniol, linalool and its derivatives, consequently, reducing catechin-related astringency and monoterpenol-related floral scent. Our study suggests that flavour determinant targeted modulation could be made through genotype and manufacturing improvements.
Keywords: Camellia sinensis; Volatile profiles; Catechins; Caffeine; Manufacturing process; Gene expression; Tea flavour

Abstract: In this study, we constructed prediction models by metabolic fingerprinting of fresh green tea leaves using Fourier transform near-infrared (FT-NIR) spectroscopy and partial least squares (PLS) regression analysis to objectively optimize of the steaming process conditions in green tea manufacture. The steaming process is the most important step for manufacturing high quality green tea products. However, the parameter setting of the steamer is currently determined subjectively by the manufacturer. Therefore, a simple and robust system that can be used to objectively set the steaming process parameters is necessary. We focused on FT-NIR spectroscopy because of its simple operation, quick measurement, and low running costs. After removal of noise in the spectral data by principal component analysis (PCA), PLS regression analysis was performed using spectral information as independent variables, and the steaming parameters set by experienced manufacturers as dependent variables. The prediction models were successfully constructed with satisfactory accuracy. Moreover, the results of the demonstrated experiment suggested that the green tea steaming process parameters could be predicted on a larger manufacturing scale. This technique will contribute to improvement of the quality and productivity of green tea because it can objectively optimize the complicated green tea steaming process and will be suitable for practical use in green tea manufacture.

Keywords: Metabolic fingerprinting; Fourier transform near-infrared (FT-NIR) spectroscopy; green tea; steaming process; principal component analysis; Partial least squares (PLS)

10. Tsuyoshi Katsuno, Hisae Kasuga, Yumi Kusano, Yoshihiro Yaguchi, Miho Tomomura, Jilai Cui, Ziyin Yang, Susanne Baldermann, Yoriyuki Nakamura, Toshiyuki Ohnishi, Nobuyuki Mase, Naoharu Watanabe,
Characterisation of odorant compounds and their biochemical formation in green tea with a low temperature storage process,
*Food Chemistry,*Volume 148,2014,Pages 388-395,
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https://doi.org/10.1016/j.foodchem.2013.10.069.
(http://www.sciencedirect.com/science/article/pii/S0308814613015148)

Abstract: We produced low temperature (15°C) processed green tea (LTPGT) with higher aroma contents than normal green tea (Sencha). Normal temperature processed green tea (NTPGT), involved storing at 25°C, and Sencha had no storing process. Sensory evaluation showed LTPGT had higher levels of floral and sweet odorants than NTPGT and Sencha. Aroma extract dilution analysis and gas chromatography–mass spectrometry–olfactometry indicated LTPGT had 12 aroma compounds with high factor dilution values (FD). Amongst LTPGT's 12 compounds, indole, jasmine lactone, cis-jasmone, coumarin, and methyl epijasmonate contributed to floral, fruity and sweet characters. In particular, indole increased initially, peaking at 16h, then gradually decreased. Feeding experiments suggested [15N]indole and [15N]oxygenated indoles (OX-indoles) were produced from [15N]anthranilic acid. We proposed the increase in indole was due to transformation of anthranilic acid during the 16h storage and the subsequent decline in indole level was due to its conversion to OX-indoles.

Keywords: Odorant compounds; Camellia sinensis; Tea leaves; Indole; [15N]Indole; [15N]Anthranilic acid; Metabolome analysis

11, Tuty Anggraini, Neswati, Ririn Fatma Nanda, Daimon Syukri,

Abstract: Black and green tea are popular owing to their unique flavors and health benefits. However, these teas can be contaminated with anthraquinones, which are associated with health risks in humans. Levels of 9,10-anthraquinone were determined at each step of the manufacturing process for green and black tea using gas chromatography–tandem mass spectrometry. For green tea, anthraquinone was present beginning at the withering process and increased in concentration until the first drying step. Additionally, for black tea, the first drying step resulted in a significant increase in anthraquinone content, whereas the concentration decreased during the final drying step. For black tea, anthraquinone was also detected during withering, although the concentration continued to increase throughout the entire procedure, particularly during drying. Therefore, it can be suggested that the presence of anthraquinone in these teas was influenced by the smoke emitted by the wood fires used to drive the processing machinery.

Abstract: As the processing control and sensory evaluation of green tea are highly subjective and the tea industry is highly professionalized, it is desirable that to find a more objective way of evaluating the quality of tea is found. In this paper, two models were set up using the BP-MLP and RBF neural networks, a sensory quality prediction model, using eleven parameters measured during processing as variables, such as leaf temperature, moisture content, etc., and a sensory quality evaluation model using fourteen parameters related to green tea as variables, such as image information were set up. The overall results suggested that leaf temperature, moisture content measured during production could effectively predict the sensory quality of green tea, with parameters as image information of green tea able to effectively evaluate its sensory quality. Compared with the BP-MLP neural network, the RBF model displayed much greater accuracy as a prediction model, reducing the relative error from 0.204 to 0.006.

11. PEMUPUKAN TANAMAN TEH

1. P.O. Owuor, R.M. Munavu, J.W. Muritu,
Changes in fatty acid levels of young shoots of tea (Camellia sinensis L.) due to nitrogenous fertilizers,
Food Chemistry,Volume 38, Issue 3,1990,Pages 211-219,ISSN 0308-8146,
https://doi.org/10.1016/0308-8146(90)90195-A.
(http://www.sciencedirect.com/science/article/pii/030881469090195A)

Abstract: The unsaturated fatty acids (FA), linolenic acid (C18:3) and linoleic acid (C18:2), responsible for the production of undesirable volatile flavour compounds in black tea, dominate FA composition of young shoots of clonal tea. These FA levels increase with increase in nitrogeneous fertilizer rates whether NPKS 25:5:5:5 or NPK 20:10:10 fertilizer is used. Results explain the general flavour quality deterioration with increase in nitrogenous fertilizer rates.

2. Yuko Ishibashi, Hiroshi Matsuo, Yoshiteru Baba, Yoshitaka Nagafuchi, Toshihiko Imato, Tatemasa Hirata,
Association of manganese effluent with the application of fertilizer and manure on tea field,
Water Research,Volume 38, Issue 12,2004,Pages 2821-2826,ISSN 0043-1354,
https://doi.org/10.1016/j.watres.2004.04.006.
(http://www.sciencedirect.com/science/article/pii/S0043135404001782)

Abstract: Manganese (Mn) concentrations in the tea field effluent were 1.1–3.5mg/l over a 2 year period from June 1997 to May 1998 (first water year) and June 1998 to May 1999 (second water year). The annual Mn loads were 38,000g/ha in the first water year and 19,000g/ha in the second. The highest Mn loads were observed, respectively, in July 1997 (10,000g/ha) in the first water year and in June 1998 (4100g/ha) in the second. The water-soluble Mn content of soil of the tea field increased abruptly with decreasing soil pH in the pH region below 4.5. The large Mn load from the tea field during the rainy season is likely due to application of excess fertilizer and manure before the rainy season, which may lead to acidification of the soil.
Keywords: Manganese load; Fertilizer; Manure; Tea field; Soil; Acidification; Water-soluble manganese

3. P.L.K. Tennakoon, R.M.C.P. Rajapaksha, L.S.K. Hettiarachchi,
Tea yield maintained in PGPR inoculated field plants despite significant reduction in fertilizer application,
Rhizosphere,Volume 10,2019,100146,ISSN 2452-2198,
https://doi.org/10.1016/j.rhisph.2019.100146.
(http://www.sciencedirect.com/science/article/pii/S245221981830140X)

Abstract: A study was conducted to formulate dual plant growth promoting rhizobacteria (PGPR) inoculants, indigenous to each soil series where fields were located, to enhance growth and yield of tea (Camellia sinensis (L.) O. Kuntze), managed with low fertilizers inputs. Field experiments were conducted in five different locations with both early and later stages of mature tea fields representing three soil series i.e Kandy, Matale and Ukuwela. Soil series specific dual inoculants (i.e., Azospirillum sp. + Rhodococcus sp. for Kandy, Azospirillum sp. + Microbacterium sp. for Matale and Azospirillum sp. + Bacillus cereus for Ukuwela soil series) were tested in fields having respective soil series. In addition, a common consortium (Azospirillum sp. + Bacillus cereus) was tested across all the three soil series. They were tested along with a modified VP/UM 910

fertilizer mixture composed of 2/3 N and ½ P of the recommended application, and compared with three non-inoculated controls: an untreated control, a non-inoculated modified VP/UM 910 fertilizer control, and the VP/UM 910 recommended dose of fertilizer control, each with three replicates. Yield records were maintained and soils and leaf N and P contents were assessed after one year. The made tea yield of each soil series, with its soil series specific dual inoculants, conducted in four locations representing Kandy and Matale soil series, varied from 2521 to 2681 kg ha−1 yr−1 and remained comparable to fields with the recommended fertilizer treatment (2491– 2697 kg ha−1 yr−1). Comparable yields to recommended fertilizer treatment due to series specific dual inoculant could also be observed in the location representing Ukuwela soil series. Results indicated that a 1/3 reduction of N and 1/2 reduction of P from the recommended fertilizer dosage VP/UM 910 are possible with application of dual PGPR inoculants formulated with soil series specific strains.

4. Ziteng Wang, Yuanbo Geng, Tao Liang,
Optimization of reduced chemical fertilizer use in tea gardens based on the assessment of related environmental and economic benefits,

Abstract: Chemical fertilizer application is the primary method used to maintain tea yield and quality, but has a negative environmental impact owing to its excessive use. This study sought to assess the environmental and economic benefits of three different chemical fertilizer reduction modes: Single reduction of chemical fertilizer (SRCF), combined application of organic and chemical fertilizer (CAOF), and controlled-release fertilizer substitute (CRFS). Differences in soil nutrient content, NP (NH4+-N, NO3—N and total P) runoff loss, tea yield and quality, and the revenue of tea planting across different fertilizer reduction treatments were then discussed. We also analyzed the coupling effects of these different fertilization modes, fertilization rate and time on soil NP runoff loss, which allowed us to determine the optimum fertilization method based on differences in their respective environmental and economic benefits. Our results revealed differences in soil nutrient content, tea yield and quality, NP runoff loss, and revenue owing to tea planting across the different fertilization treatments. Soil pH after fertilization was significantly lower than before fertilization. CAOF was beneficial and improved soil nutrients as well as tea yield and quality. Of the tested methods, 50% combined application of organic and chemical fertilizer (CAOF2) was the best, as it resulted in the best tea quality and yield. CAOF2 also had the highest revenue. In addition, it was beneficial in reducing NP runoff loss. CRFS was advantageous in its persistent fertilizer efficiency and reduction in NP runoff loss. With CAOF, NP runoff loss was primarily caused by quick-acting chemical fertilizer. With extended time, NP runoff loss caused by fertilization was gradually decreased. Given our analysis of the environmental and economic benefits of different fertilizer reduction methods, CAOF2 emerged in this study as the best fertilizer reduction treatment option.

5. Shaowen Xie, Fen Yang, Hanxiao Feng, Zhenzhen Yu, Chengshuai Liu, Chaoyang Wei, Tao Liang,

Organic fertilizer reduced carbon and nitrogen in runoff and buffered soil acidification in tea plantations: Evidence in nutrient contents and isotope fractionations,

Abstract: Carbon (C) and nitrogen (N) inputs to farmland via fertilizer application are potential sources of C and N that influence soil acidification and water eutrophication. A pilot study was conducted to compare the effects of compound fertilizer and rapeseed cake organic fertilizer on C and N preservation in the soils and runoff of a tea plantation as well as the C and N isotopic fractionation in soils over the three annual cycles of fertilization and tea-leaf harvest. Overall, rapeseed cake organic fertilization effectively increased the pH, total organic matter, NH4-N and NO3-N in soils by 2.19–4.29%, 8.04–21.14%, 53.65–100.32% and 5.74–54.08%, respectively, but decreased NH4-N inputs in runoff by 10.36–25.12% and NO3-N inputs in runoff by 8.94–24.10% relative to the same rate of pure N in compound fertilizer. Before fertilization in February, the average $\delta13C$ and $\delta15N$ were −25.15‰ and 1.88‰, while after a full year of fertilization and tea-leaf harvesting in October, the average soil $\delta13C$ and $\delta15N$ contents were −23.83‰ and −0.33‰ after compound fertilization and −26.22‰ and 1.64‰ after rapeseed cake organic fertilization, respectively, indicating the evident effects of fertilization on the isotopic fractionation in soil. In addition, the fractionation extent was positively associated with the fertilization rates under both fertilizers. However, the two fertilization types had different effects on the C and N isotope fractionations, with rapeseed cake organic fertilization contributing more to $\delta13C$ (21.07–81.80%) but less to $\delta15N$ (18.20–78.93%) and compound fertilization presenting the opposite results (1.88–46.18% and 53.82–98.12%, respectively). This study demonstrates that rapeseed cake organic fertilization can better preserve soil C and N pools while reducing their runoff in tea plantations, which may greatly hinder the regional soil acidification and water eutrophication trends.
Keywords: Tea plantation; Compound fertilizer; Rapeseed cake organic fertilizer; Runoff water; Carbon and nitrogen isotopes

6. Songsong Gu, Qiulong Hu, Yuqi Cheng, Lianyang Bai, Zhonghua Liu, Wenjun Xiao, Zhihua Gong, Yueni Wu, Kai Feng, Ye Deng, Lin Tan,
Application of organic fertilizer improves microbial community diversity and alters microbial network structure in tea (Camellia sinensis) plantation soils,

Abstract: Soil microbiomes contribute to plant growth, health and agricultural production. However, the influence of long-term application of different fertilizers on soil microbial diversity and community structure of tea (Camellia sinensis) plantations remains unclear. Here it was hypothesized that organic fertilizer treatment (OF) would significantly improve the microbial diversity and alter the microbial community structure, leading to the support of more soil ecosystem functions in tea plantation. To test this, we investigated microbial communities of tea plantation soils under different long-term fertilization treatments using both high-throughput 16S rRNA gene Illumina sequencing and molecular ecological network analysis. Soil samples (Red soils, classified as Haplic Acrisol) were collected from 5 large experimental tea plantations under different long-term fertilization treatments (organic fertilizer (OF), chemical fertilizer (CF) and non-

fertilizer (NF)) in central south of China in August 2017. Soils under OF treatment had higher microbial diversity compared with soils under other treatment regimes. Unweighted principal coordinate analysis (PCoA) results revealed a clear separation among the groups of tea plantation soils under the three treatment regimes. Relationship analysis between soil properties and microbial communities showed that pH and nitrate nitrogen (NO_3-N) concentration were key physicochemical factors that significantly influenced microbial diversity and community structure. Furthermore, network analysis indicated that the network of OF treatment soils contained more functionally interrelated microbial modules than soils with CF treatment and that the topological roles of characteristic microorganisms and key microbial organisms were significantly different between CF and OF treatments. Relative to CF treatment, the relative abundances of organisms belonging to chemoheterotrophy, fermentation, nitrogen fixation, and aerobic nitrite oxidation functional groups in tea plantation soils under OF treatment were significantly increased by 28.74%, 110.10%, 41.16% and 556.64%, respectively ($p < 0.05$). It was concluded that OF treatment could improve microbial diversity, alter microbial network structure and enhance potential ecosystem function in tea plantation soils.

7. Philip O. Owuor, Francis O. Gone, David B. Onchiri, Isaac O. Jumba,
Levels of aluminium in green leaf of clonal teas, black tea and black tea liquors, and effects of rates of nitrogen fertilizers on the aluminium black tea contents,
Food Chemistry,Volume 35, Issue 1,1990,Pages 59-68,
ISSN 0308-8146,
https://doi.org/10.1016/0308-8146(90)90131-M.
(http://www.sciencedirect.com/science/article/pii/030881469090131M)
Abstract: Clonal teas have different aluminium content increasing with age of leaf. Although aluminium and fertilizer nitrogen enhance tea growth and tea yields, respectively, field trials have shown no relationship between total aluminium content in the leaf and clonal tea yields. Higher aluminium concentrations were found in the dust grades of black tea than in the large size grades. However, aluminium levels decreased in the tea liquor from dust grades compared to the large size grades. Only up to 40% of the total aluminium in tea was infused into tea liquors; the amounts infused varied with clones and grading (sorting). Aluminium content of black tea was lowered by increasing rates of nitrogenous fertilizers, more frequent fertilizer application, and application of NPK 20:10:10 as opposed to NPKS 25:5:5:5.

8. Lingfei Ji, Zhidan Wu, Zhiming You, Xiaoyun Yi, Kang Ni, Shiwei Guo, Jianyun Ruan,
Effects of organic substitution for synthetic N fertilizer on soil bacterial diversity and community composition: A 10-year field trial in a tea plantation,
Agriculture, Ecosystems & Environment,Volume 268,2018,Pages 124-132,
ISSN 0167-8809,
https://doi.org/10.1016/j.agee.2018.09.008.
(http://www.sciencedirect.com/science/article/pii/S016788091830389X)
Abstract: Substitution of chemical nitrogen (N) with organic fertilizers in agricultural ecosystems has been promoted to sustain crop yield and soil quality. Soil microbes play key roles in soil nutrient cycling after organic matter addition. However, there is limited information about the effect of the organic substitution ratio (OSR) on soil bacterial

communities, which are considered as a good indicator of soil quality in a tea plantation. In this study, a long-term field experiment with six treatments was established to study the effect of different OSRs of N, from pure synthetic fertilization (NPK) to 100% N substituted with organic fertilizer (OM100), on tea yield and soil bacterial communities. The soil bacterial community composition was measured using a high-throughput sequencing technique. The results showed that as the OSR increased, the soil bacterial diversity increased and the community structure shifted significantly. However, 25% N substituted with organic fertilizer (OM25) produced the highest yield. Additionally, the soil pH and organic carbon (SOC) were the predominant soil characteristics that accounted for the soil bacterial community structural change. With more chemical N being substituted with organic fertilizer, the soil pH, available potassium, SOC, total N, and microbial biomass C and N, were elevated; however, the yield of fresh tea leaves decreased. These results indicated the trade-off effect between tea yield and soil bacterial diversity under different OSRs, which could also alter the soil bacterial communities by changing soil characteristics.

Keywords: Long-term fertilization; Tea plantation soil; Organic substitution ratio; Bacterial diversity; Community composition

Abstract: Soil potassium (K) spatial heterogeneity was general in tea gardens. Yet, rhizosphere processes of tea plants under soil K spatial heterogeneity is unclear. K heterogeneity was simulated by multi-layer split-root system as follows: both sides had K fertilizer (K+/K+), both sides had no K fertilizer (K0/K0), one side had K fertilizer (K+/K0–K+) and the other side had no K fertilizer (K+/K0–K0). Under K spatial heterogeneity, the differences in rhizosphere processes between the two tea plants (low-K tolerant genotype "1511" and low-K sensitive genotype "1601") were compared. "1511" could maintain relatively stable fine root proportions under different treatments. For "1511" and "1601", the strongest soil K activation abilities of root exudates appeared in K+/K0–K0 and K+/K0–K+, respectively. The available K and slowly available K of the rhizosphere soils in K+/K0–K+ was 14% and 8% less than those in K+/K+ for "1511", but the above form K of the rhizosphere soils in K+/K0–K+ was 8% and 10% higher than those in K+/K+ for "1601". In conclusion, under the spatial K heterogeneity, low-K tolerant tea plant could achieve high K efficiency mainly through the following ways: (1) maintaining good fine root developments; (2) improving the soil K activation in K+/K0–K0 through the secretion of organic acids; (3) promoting the utilization of soil K in K+/K0–K+. Our findings may contribute to the improvement of tea planting patterns and quality in low K tea gardens, and that to understand the interactions between roots and soil of the low K-tolerant genotype tea plants under the condition of K spatial heterogeneity.
Keywords: K spatial heterogeneity; Organic acids; Root development; K transformation

Abstract: Tea (Camellia sinensis L.) plants have an optimal pH range of 4.5–6.0, and prefer ammonium (NH4+) over nitrate (NO3−); strong soil acidification and nitrification are thus detrimental to their growth. Application of NH4+-based fertilizers can enhance nitrification and produce H+ that can inhibit nitrification. However, how soil acidification and nitrification are interactively affected by different NH4+-based fertilizers in tea plantations remains unclear. The objective of this research was to evaluate the effect of the application of different forms and rates of NH4+-based fertilizers on pH, net nitrification rates, and N2O and NO emissions in an acidic tea plantation soil. We conducted a 35-day aerobic incubation experiment using ammonium sulphate, urea and ammonium bicarbonate applied at 0, 100 or 200 mg N kg−1 soil. Urea and ammonium bicarbonate significantly increased both soil pH and net nitrification rates, while ammonium sulphate did not affect soil pH but reduced net nitrification rates mainly due to the acidic nature of the fertilizer. We found that the effect of different NH4+-based nitrogen on soil nitrification depended on the impact of the fertilizers on soil pH, and nitrification played an important role in NO emissions, but not in N2O emissions. Overall, urea and ammonium bicarbonate application decoupled crop N preference and the form of N available in spite of increasing soil pH. We thus recommend the co-application of urease and nitrification inhibitors when urea is used as a fertilizer and nitrification inhibitors when ammonium bicarbonate is used as a fertilizer in tea plantations.
Keywords: N2O emission; Net nitrification rate; NH4+-N availability; Nitrification inhibitor; Soil acidification

Abstract: A field experiment was conducted to assess N2O emissions in response to different fertilizer types and amounts in a heavily fertilized tea field in Japan. Four treatments were implemented: CONT: no fertilizer, CONV: conventional fertilization, 1/2CONV, and CHEM: chemical fertilization. Gas samples were collected 5–8 times after every fertilizer application using the closed chamber method. The results revealed high seasonal variation in N2O emissions driven by soil temperature rather than the fertilizer application time. The soil temperature at a depth of 0–10cm was significantly correlated with N2O emission (P<0.01). The highest cumulative N2O emission (73.2kgNha−1yr−1) was observed in the CHEM treatment, followed by the CONV treatment (65.0kgNha−1yr−1), the 1/2CONV treatment (18.6kgNha−1yr−1) and the CONT treatment (1.8kgNha−1yr−1). The highest N2O emission factor (7.9%) was found in the CHEM treatment, followed by the CONV treatment (7.0%) and the 1/2CONV treatment (3.7%). There were spatial differences in the soil characteristics across the tea field. Accurate estimates of the ratios of N2O emitted from the four treatments during the two

crop seasons were 47.9% and 52.1% from the soil on the rows (108.6kgNha−1) and under the canopies (118.3kgNha−1), respectively.

12.   PENGAIRAN PADA TANAMAN TEH

Abstract: The effects of drip irrigation on the yield and crop water productivity responses of four tea (Camellia sinensis (L.) O. Kuntze) clones were studied four consecutive years (2003/2004–2006/2007), in a large (9ha) field experiment comprising of six drip irrigation treatments (labelled: I1–I6) and four clones (TRFCA PC81, AHP S15/10, BBK35 and BBT207) planted at a spacing of 1.20m×0.60m at Kibena Tea Limited (KTL), Njombe in the Southern Tanzania in a situation of limited water availability. Each clone×drip irrigation treatment combination was replicated six times in a completely randomized design with 144 net plots each with an area of 72m2. Clone TRFCA PC81 gave the highest yields (range: 5920–6850kg dried tea ha−1) followed by clones BBT207 (5010–5940kg dried tea ha−1), AHP S15/10 (4230–5450kg dried tea ha−1) and BBK35 (3410–4390kg dried tea ha−1) and drip irrigation treatment I2 gave the highest yields, ranging from 4954 to 6072kg dried tea ha−1) compared with those from other treatments (4113–5868kg dried tea ha−1). Most of these yields exceeded those (4200kg dried tea ha−1) obtained from overhead sprinkler irrigation system in Mufindi also Southern Tanzania, and Kibena Estate itself. Results showed that drip irrigation of tea not only increased yields but also gave water saving benefits of up to 50% from application of 50% less water to remove the cumulative soil water deficit (treatment I2), and with labour saving of 85% for irrigation. The yield of dried tea per mm depth of water applied, i.e., "the crop water productivity" for drip irrigation of clones TRFCA PC81, BBT207 and BBK35, in 2003/2004 for instance, were 9.3, 8.5 and 7.1kg dried tea [hamm]−1, respectively. The corresponding values in 2004/2005 were 2.7, 4.5 and 2.0kg dried tea [ha mm]−1 while the yield responses from clone AHP S15/10 were linear decreasing by 1 and 1.6kg dried tea [hamm]−1 in 2003/2004 and 2004/2005, respectively. In 2005/2006 the crop water productivity from clones TRFCA PC81, AHP S15/10, BBK35 and BBT207 were 4.5, 0.4, 5.2 and 6.9kg dried tea [hamm]−1, respectively with quadratic yield response functions to drip irrigation depth of water application. The results are presented and recommendations and implications made for technology-transfer scaling-up for increased use by large and smallholder tea growers.
Keywords: Crop water productivity; Drip irrigation; Irrigation; Limited availability of water; Tea clones; Tanzania; Yield of dried tea

Abstract: Tieguanyin Oolong tea (Camellia sinensis (L.) O. Kuntze) is a name brand important commodity for Anxi county, Fujian province in China. Four-year-old tea plants at a tea plantation in Anxi were subjected to six different irrigation treatments (i.e. 5, 10,

15, 20, and 25d irrigation intervals for T1 to T5 with a rate of 3.5kg water per plant, plus a non-irrigated control). After 50d of irrigation treatments, leaf water potential was −1.70, −2.34, −2.48, −2.89, −3.55, and −4.92MPa for treatment T1, T2, T3, T4, T5, and control, respectively. Leaf biomass yield increased by 32.8%, 21.9%, and 21.3% for T1, T2, and T3, respectively, compared to control. The net photosynthesis (Pn), stomatal conductance (gs) and transpiration (E) decreased with irrigation interval increasing. Tea polyphenol (TP) and free amino acid (AA) decreased when the irrigation intervals were increased, but caffeine (CA) content apparently increased as the irrigation intervals were increased. To balance irrigation water demand and tea yield and quality, it is recommended that the irrigation interval should be set at 10d with a rate of 3.5kg water per plant for the optimal production in Anxi, Fujian province of China.

Keywords: Tieguanyin tea; Irrigation treatment; Photosynthesis; Chemical composition

Abstract: In this study, we measured the morphological, biochemical, and chemical responses to soil drying in nine tea clones [Camellia sinensis (L.) O. Kuntze] grown in a field. Thirteen-year-old tea plants at Shahid Eftekhari Fashalam Experimental Station, Tea Research Center of Iran, were subject to drought stress by withholding water for 40 days. The control group of the clones was regularly watered. The soil moisture content of the non-irrigated and irrigated plants was monitored throughout the experiment. The effects of drought stress were measured by studying physiological (Relative Water Content), biochemical (Proline and Total Sugar Content), and antioxidant activities (Catalase and Peroxidase) after 20 days and 40 days of drought imposition. Green leaf yield and chemical parameters included total polyphenol, caffeine, water extract, and total ash were measured after 40 days of drought stress. Drought stress resulted in a decrease in total polyphenol, water extract, and total ash and an increase in proline, total sugar concentration and, in CAT and POD activities, as a consequence of reduced RWC of the leaves. Thus, drought stress caused a range of biochemical, physiological, and chemical variations, resulting in membrane damage and loss in the functions of the cell and finally a decrease in the tea growth as one of the most important economic crops. The results of grouping the clones under irrigation and drought stress conditions and comparing them with the results of mean comparison of the traits showed that in all cases, clones 276, 100, 285, and 277 were in the group that can be identified as the drought-tolerant group. Also, the results showed that in most cases, clones 278 and 74 were placed in a group that had low values for all the traits and could be considered as a group that is susceptible to drought stress. Overall, these findings provide new insight into the mechanisms of tolerance to drought in tea plants.

Keywords: Catalase; Chemical composition; Drought; Proline; Peroxidase; Relative water content

Abstract: Tieguanyin tea plants (Camellia sinensis (L.) O. Kuntze) are commonly grown at high elevation for good quality of tea product. Scarce water supplies in this area require optimization of irrigation management to improve water use efficiency. Greenhouse and field experiments were conducted to investigate the responses of Tieguanyin tea plants to deficit (DI) and severe deficit irrigation (SDI) by physiological methods, while full (FI) and non-irrigation (NI) were used as control. Tea plants in DI field maintained moderate water stress at −2.0 to −2.5MPa leaf water potential, while water stress in SDI became increasingly severe. DI showed similar effect on tea leaf fresh and dry weight production with FI but increased the content of theanine. SDI and NI, however, caused a higher level of reducing sugar in tea leaves over time, sucrose and fructose content at the last stage, which was associated with an inhibition in net photosynthesis (Pn). Compared to DI, the expressing abundances of RuBisCo and GAPDH were inhibited in SDI plants at last stage, providing a molecular basis for the biochemical changes in reduced Pn due to severe water stress. Meanwhile, SDI enhanced the expressing abundance of ELIP, in turns increased leaf chlorophyll a/b (chl a/b) ratio, which showed a significantly negative relationship with photochemical quenching (qP) (r2=0.62) and significantly positive relationship with non-photochemical quenching (qN) (r2=0.78). This implied that leaf chl a/b ratio might serve as an indicator of water stress in Tieguanyin tea plants. In conclusion, a well-designed DI regime caused minimum stress to tea plant, but achieved the tea products with improved quality by saving water.
Keywords: Tea (Camellia sinensis L.); Deficit irrigation; Yield; Quality

13.   HAMA PENYAKIT TANAMAN TEH

Abstract: Basilepta melanopus is a serious insect pest of tea plantations in southern China. This tea pest poses a great threat to the tea industry in China. No effective and environmentally friendly methods have been established to control this pest at present. Olfactory genes play key roles in insect behaviour, and can potentially be used as targets for developing environmentally-friendly approaches for pest control. In this study, we produced a transcriptome derived from dissected antennae from B. melanopus using high-throughput sequencing. We identified gene families that are potentially involved in odorant reception and detection, including unigenes encoding 63 odorant receptors (ORs), 16 gustatory receptors (GRs), 18 ionotropic receptors (IRs), four sensory neuron membrane proteins (SNMPs), 46 odorant binding proteins (OBPs), and 19 chemosensory proteins (CSPs). Analyses of tissue expression profiles revealed that all 63 OR transcripts, 14 antennal IRs, one SNMP and six OBPs were predominately expressed in antennae. Real-time quantitative PCR assays were also adapted to examine sex-biased expression of selected antenna-predominant genes. Our results provide valuable information for further functional studies of olfactory genes in B. melanopus and potential novel targets for developing new pest control measures.
Keywords: Basilepta melanopus; Olfactory genes; Transcriptome

Abstract: Tea is one of the most economically important crops in China. To secure its production and quality, biological control measures within the context of integrated pest management (IPM) has been widely popularized in China. IMP programs also provide better control of arthropod pests on tea with less chemical insecticide usage and minimal impact on the environment. More than 1100 species of natural enemies including about 80 species of viruses, 40 species of fungi, 240 species of parasitoids and 600 species of predators, as well as several species of bacteria have been recorded in tea ecosystems in China. Biological and ecological characteristics of some dominant natural enemies have been well documented. Several viral, bacterial, and fungal insecticides have been commercially utilized at large scale in China. Progress in biological control methods in conjunction with other pest control approaches for tea insect pest management is reviewed in this article. Knowledge gaps and future directions for tea pest management are also discussed.
Keywords: Tea ecosystem; Biological control; Natural enemies

3. Hamady Dieng, Ruzieyana Bt Mohd Zawawi, Nur Intan Saidaah Bt Mohamed Yusof, Abu Hassan Ahmad, Fatimah Abang, Idris Abd Ghani, Tomomitsu Satho, Hamdan Ahmad, Wan Fatma Zuharah, Abdul Hafiz Ab Majid, Nur Shilawati Abd. Latip, Cirilo Nolasco-Hipolito, Gabriel Tonga Noweg,
Green tea and its waste attract workers of formicine ants and kill their workers—implications for pest management,
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(http://www.sciencedirect.com/science/article/pii/S0926669016303363)
Abstract: Daily, 3 billion cups of tea consumed worldwide and this consumption is accompanied by the discarding of huge waste amounts into the environment. Tea leaf contains a diverse array of toxic molecules. Despite evidence that its waste is almost as rich in toxicants as green leaves; no research has been done to turn this source of pollution into a benefit for ant pest management, where new chemistries are highly needed as a result on insecticide resistance. The present study was performed to explore the behavioral and lethal effects of tea and its leftovers on the black crazy ant (BCA), Paratrechina longicornis Latreille, yellow crazy ant (YCA), Anoplolepis gracilipes Smith, and weaver ant (WA), Oecophylla smaragdina Fabricius. Both fresh tea extract (FTE) and used tea extract (UTE) were detrimental to the survival of BCA, YCA, and WA. FTE was the most toxic solution and BCA was the most vulnerable species. The presence of tea extracts in meals did not prevent workers of all three species from visiting and feeding in the presence their preferred foods. The results presented here suggest that diets containing tea extracts are attractive to BCA, YCA, and WA when in competition with their preferred foods. These extracts were also insecticidal to the worker ants. These properties demonstrate the potential of tea and its waste products for developing novel environmentally friendly and low-cost ant control strategies, which could also be a practical solution to the growing environmental problem it causes.
Keywords: Ants; Tea; Tea waste; Behavioral effects; Toxicity

4. Somnath Roy, Anoop Kumar Barooah, Kamruza Z. Ahmed, Rupanjali Deb Baruah, Anjali Km. Prasad, Ananda Mukhopadhyay,
Impact of climate change on tea pest status in northeast India and effective plans for mitigation,
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(http://www.sciencedirect.com/science/article/pii/S1872203218302701)
Abstract: The impact of climate change has already been observed across various tea growing regions in the form of vulnerability and unpredictability of precipitation, increasing trends in temperature and reduced rainfall events. In the agriculture sector, these impacts of climate change are visibly affecting plant growth and productivity, and tea is no exception to these impacts. In north-eastern India, changes in the weather pattern has been witnessed in terms of decrease of around 200 mm rainfall over the years, increase in average temperature of around 1.3 °C over the last 93 years, increase in number of days with more than 35 °C, specially in last thirty years. The decline in annual rainfall is matched with a prominent shift in distribution of monthly rainfall pattern. The monthly rainfall is more in the late monsoon and winter months. Another important aspect is the rising carbon dioxide concentration in atmosphere. In recent years it has increased to 398 ppm in the state of Assam which is many fold higher than the level of carbon dioxide in the last decade which was quantified to be around 364 ppm in the year

2008. As a consequence of these climatic changes, there has been already a paradigm shift in overall pest scenario associated with tea in the recent years. At present, tea pests cause more damage to the crop through increased reproductive potential, feeding rate, distribution pattern, shorter duration of development stages and consequently with more number of annual generations, migration etc. along with some of the secondary pest outbreaks. A number of areas for future research on the effect of climatic changes on insect pests of tea need to be identified on priority basis. An in-depth investigation on the influence of the changed climatic factors on the variability, load, population dynamics, behavior and migration of the tea pests vis à vis the crop can be helpful in proper pest monitoring and management. Some real time strategies adopted to combat and manage tea production by mitigating the effect of the climate change are discussed in this paper.

Keywords: Climate change; Tea; Northeast India; New insect pest; Emergence seasonal occurrence; Behavioural change mitigation strategy

Abstract: A granulosis virus (GV) was isolated from the diseased caterpillars of Arctornis submarginata (Walker) (Lymantriidae), a defoliating pest of tea from Darjeeling foothill region. The phase contrast and transmission electron microscopic studies identified the virus as granulosis virus. SDS–PAGE analysis of major protein of the occlusion bodies was found to be 31kDa, characteristic for granulin. The total genomic DNA was isolated. The major band found was of molecular weight 16kDa. Bioassay conducted with the occlusion bodies (OBs) of the virus showed LC50 value of 4.46×10^4OBs/ml for the second instar caterpillars. Median lethal time (LT50) were 6.6 days for 1×10^4OBs/ml, 5.09 days for 1×10^5OBs/ml, 4.45 days for 1×10^6OBs/ml and 3.87 days for 1×10^7OBs/ml concentrations. The results indicated the potential of the virus for its future application as microbial pesticide against A. submarginata in future.
Keywords: Pest; Arctornis submarginata; Camellia sinensis; Granulosis virus; Darjeeling

Abstract: This study reports on the biocontrol role birds play in caterpillar pest control of tea plantations of Northeast India. In this area large tracts of tea plantations have been extensively defoliated by the recent invasion of two forest-dwelling geometrid looper caterpillars, Hyposidra spp. and a lymantriid hairy caterpillar, Arctornis submarginata. This exacerbated tea herbivory by two resident pest caterpillars, Biston suppressaria and Eterusia magnifera. Currently there are no identified resident insect predators for any life stage of Hyposidra spp. and A. submarginata. Larvae of these pests drop from

tea bushes using salivary thread, allowing caterpillars to escape from insect predators. The study identified 38 native insectivorous bird species in tea plantations, of which four species (Asian-pied starling, Chestnut-tailed starling, Jungle Myna, Red-vented Bulbul) could be potential control agents of looper and hairy caterpillar pests. These species had high population densities. Their cumulative abundances represented a major proportion of the total bird community during both the infested (86.44%) and non-infested phase (75.34%). They foraged in mixed-species flocks in both tea foliage and on the ground. This behavior is suited to capture foliage-living and dropped caterpillars that were flushed from tea bushes by foraging birds. Abundance and species richness of overall tea layer-foraging birds were higher in infested phase when compared to non-infested phase. The predation rate of four bird species of the foraging flock varied significantly. These results suggest that birds should be considered as important biological control agent of caterpillar pests of tea and considered in pest management plans.

Abstract: Sex pheromone-based pest management technology has been widely used to monitor and control insect pests in the agricultural, forestry, and public health sectors. Scopula subpunctaria is a widespread tea pest in China with Type II sex pheromone components. However, limited information is available on the biosynthesis and transportation of Type II sex pheromone components. In this study, we constructed an S. subpunctaria sex pheromone gland (PG) transcriptome and obtained 85,246 transcripts. Cytochrome P450 monooxygenases (CYPs) thought to epoxidize dienes and trienes to epoxides in the PG and odorant-binding proteins (OBPs) and chemosensory genes (CSPs) thought to be responsible for the binding and transportation of sex pheromone components. In present study, a total of 79 CYPs, 29 OBPs and 17 CSPs were identified. We found that SsubCYP341A and SsubCYP341B_ortholog1 belonged to the CYP341 family and were more highly expressed in the PG than in the female body. Of these, SsubCYP341A was the seventh-most PG-enriched CYP in the PG transcriptome. Two CYP4 members, CYP340BD_ortholog2 and CYP4G, were the top two most PG-enriched CYPs. Tissue expression and phylogenetic tree analysis showed that SsubOBP25, 27, and 28 belonged to the moth pheromone-binding protein family; they were distinctly expressed in the antennae and were more abundant in male antennae than in female antennae. SsubCSP16 was distributed into the same clade as CSPs from other moths that showed high binding affinities to sex pheromone components. It indicated that all the above-mentioned genes could be involved in sex pheromone biosynthesis or transportation. Our study provides large-scale PG sequence information that can be used to identify potential targets for the biological control of S. subpunctaria by disrupting its sex pheromone biosynthesis and transportation pathways.

Abstract: Tea, Camellia sinensis (L.) O'Kuntz is a cash crop, cultivated in tropical and subtropical climatic countries throughout the globe. The tea ecosystem hosts several species of arthropods, of them many species attack different parts of tea plants during their growth phases resulting in huge economical loses. Buzura suppressaria (Bs), Hyposidra talaca (HT), Hyposidra infixaria (HI) are members of order Lepidoptera, which are the most notorious tea pests, found in North-East India and make huge destruction of tea plantation due to their voracious eating habit and short life span. A potent indigenous strain of Bacillus thuringiensis (Bt) against the tea looper (TL) was isolated from Danguajhar Tea Garden, Goodricke Group Ltd. India, and characterized based on morphological, biochemical and genetic traits (16S rRNA gene NCBI GenBank Accession. No. JF966358). Virulence assay, to itemize the entomopathogenic nature of Bt against TL, was determined in laboratory and field conditions to enumerate its LC50 $(1.11 \times 107$ spores/mL) and LT50 (54.64 h) values with a TL mortality rate of 99.43% in field. For large scale production, Bt was screened with four different mediums (based on barley, wheat, rice flour and nutrient broth) and was found to produce a maximum of 4.6×107 spores/mL, when barley was considered as a sole source of carbon. Highly expressive sporulation associated toxins was identified as an immune inhibitor A of Bt (NCBI Accession No.gi|9858110|AAG00998.1) by MALDI-TOF mass spectrometry which is an extracellular bacterial protein known for putrefaction of host tissue proteins with a wide-range of substrate specificity. The results were quite encouraging which can be adapted as a greener way of pest control.

Abstract: We studied the effects of partial spraying, targeting tea [Camellia sinensis (L.) O. Kuntze] plants' plucking surfaces, on the annual number of major pests and damage to new shoots. The prevention of feeding damage to shoots caused by Empoasca onukii Matsuda (Hemiptera: Cicadellidae) was more stable when spraying at high volumes. However, the annual number of E. onukii with conventional spraying (200 L/1000 m2) was similar to the control (No pesticide). On the other hand, the prevention effect on shoots and the annual number of Scirtothrips dorsalis Hood (Thysanoptera: Thripidae) in partial spraying (40 L/1000 m2) was similar to conventional spraying. Moreover, although high volumes of spraying (1000 L/1000 m2) are usually needed to control

Pseudaulacaspis pentagona (Targioni-Tozetti) (Hemiptera: Diaspididae), the male adult population of P. pentagona in the control and partially sprayed field tended to be lower than that in the conventional spraying. When using pesticides harmful to P. pentagona's natural enemies, partial spraying seems beneficial. Enough pesticide spraying to widely cover the leaf layer was thought necessary to protect the tea plants' new shoots. However, the spraying method targeting only the tea plants' plucking surfaces protects the new shoots with similar efficacy. Besides, partial spraying protects pests' natural enemies, allowing additional pest population control.

14. PETANI TEH

Abstract: Climate change is threatening the livelihood of tea farmers in Nepal. Simultaneously, the production of tea is becoming an increasingly important economic sector for the country. This study aimed to reveal the adaptation behavior towards climate change among smallholder tea farmers, particularly which demographic, institutional, and information source factors are likely to influence the degree of adaptation. We collected quantitative data in the district of Ilam via 91 farmers through a questionnaire survey and applied descriptive statistics, multiple regression, and binary logistic regression models to analyze the collected data. Findings revealed that information sources (peer exchange, internet, and training attendance), as well as institutional factors (cooperative membership and credit access), positively influenced the degree of climate change adaptation among the respondents. Easier credit access and joining cooperatives could enhance the adaptive capacity of smallholder tea farmers. Improving the interaction between the Nepalese government and stakeholders involved in the domestic tea value chain could also increase economic success.
Keywords: Climate Change; Adaptation Strategies; Smallholder farmers; Tea Production; Nepal

Abstract: Plantation sector such as tea has been playing an important role to rural economic. This sector is labor intensive and has been providing an aid program to involve farmers in surrounding area to plant the same crops and buy the yield. However due to lower productivity of farmers, problem in quality and price selling arose and prolonged to other problems. Several policies has been proposed to overcome the problem, and including a policy to establish a tea farmer cooperative. Here, this study is aimed to determine factors that able to strengthen the tea farmer cooperative in commercializing tea farmer products. Some factors that are concerned to influence the performance of cooperative are analyzed using the analytical network process (ANP). The results show that factor of cooperation with other related institutions and environment played an important for the farmer cooperatives in order to increase commercialization aspect of their products. Effort to create added value, market and finance information access, and shareholding are among elements that are most prioritized by farmers groups.
Keywords: tea farmer cooperative; commercialization; ANP; priority

3. Yaxuan Chang, Zhiyuan Zhang, Kunihiko Yoshino, Shungui Zhou,

Farmers' tea and nation's trees: A framework for eco-compensation assessment based on a subjective-objective combination analysis,

Abstract: The effectiveness and sustainability of eco-compensation policy implementation are essential to ecosystem service protection. However, a purely subjective standpoint causes deviations from the compensation benchmark, while decision-making based solely on an objective standpoint fails to offer a profound understanding of local stakeholder conflicts. Therefore, local authorities find it difficult to set reasonable and effective eco-compensation implementation standards. An assessment framework for eco-compensation, defined as the subjective-objective combination analysis (SOCA), which considers both the subjective and objective positions of stakeholders is proposed. Focusing on a typical eco-compensation case, "Returning Tea to Forest", a compensation range is finally quantified from $443/ha to $2114/ha per year using the SOCA framework. SOCA quantification from multiple perspectives optimized the eco-compensation benchmark determinations and the eco-protection decision-making process.

Keywords: Eco-compensation; Stakeholder conflicts; SOCA framework; Forest ecosystem services

4. Duc Tran, Daisaku Goto,
Impacts of sustainability certification on farm income: Evidence from small-scale specialty green tea farmers in Vietnam,

Abstract: Sustainability certification for small-scale farms has gained considerable momentum in developing countries. However, evidence on the economic benefits of certification schemes in the context of domestically consumed foods and beverages is scarce. This paper addresses this gap by evaluating the impacts of sustainability standards on the selling prices, sales, costs and net income of small-scale specialty green tea farming in Vietnam. We analyze original survey data on 401 smallholder green tea farmers and employ propensity score matching to mitigate self-selection bias. Our estimates reveal that certified green tea producers are able to obtain a higher average selling price and sales value. In addition, although certification leads to a dramatic increase in the costs of hired labor, net farm income is still significantly improved.

Keywords: Sustainability certification; Small-scale farmers; Specialty green tea; Vietnam; Propensity score matching

5. Ha Thu Vu, Duc Tran, Daisaku Goto, Keisuke Kawata,
Does experience sharing affect farmers' pro-environmental behavior? A randomized controlled trial in Vietnam,

Abstract: Encouraging farmers to adopt pro-environmental production is vital to the promotion of sustainable agriculture. Previous observational studies emphasize the importance of economic incentives and information access to farmers' decision-making

processes; however, due to endogeneity issues, little strong causal evidence is available. This study makes an original contribution by experimentally examining the impacts of the 50% price subsidy and information treatments on farmers' adoption of organic fertilizer. A short video sharing the experience of farmers who have applied organic fertilizer is selected as our information treatment. We analyze data from a randomized controlled trial (RCT) conducted with 1287 small-scale tea farmers in Vietnam. We find significant impacts of both the information and 50% price subsidy treatments. Moreover, the effect of the former is approximately one-third that of the latter. Subgroup treatment analysis also reveals that the information treatment performs well for members of certification groups. Thus, to induce farmers to adopt pro-environmental production behaviors, information treatment can partially substitute for subsidies to reduce the burden on the public budget.