□ 公開
■ 密件、不公開

執行機關(計畫)識別碼：0107010100

農業部苗栗區農業改良場114年度科技計畫研究報告

計畫名稱：廢棄果渣增進蜂蜜酒風味技術之開發
(第1年/全程2年)

(英文名稱) Development of a technology for enhancing mead flavor by using fruit wastes.

計畫編號：114農科-1.7.1-苗-01

全程計畫期間：自 114年1月1日 至 115年12月31日
本年計畫期間：自 114年1月1日 至 114年12月31日

計畫主持人：陳本翰
研究人員：吳姿嫻
執行機關：農業部苗栗區農業改良場

1140996

一、執行成果中文摘要：

本研究篩選出合製備蜂蜜酒高產與風味接受度高的耐高溫酵母(*Saccharomyces cerevisiae*, Fermentis Lesaffre 42150)，接種烏桕蜂蜜(*Sapium sebiferum (L.)* Roxb.)發酵製酒酒精度達8.5%(alc./vol)，添加檸檬皮、鳳梨皮與百香果等水果副產物共同發酵製酒，發酵產生酒精範圍為8.4-10.8%(alc./vol)。本研究製備蜂蜜釀造酒與蒸餾酒並分別進行色澤、香氣、風味與整體4項品評，43受試者品評結果顯示，本研究製備之烏桕蜂蜜釀造酒在風味(p=0.274)與整體(p=0.11)品評項與荔枝蜂蜜對照商品酒無顯著差異，在另一組38位受試者品評蒸餾酒顯示，本研究製備之檸檬烏桕蜂蜜蒸餾酒在香氣(p=0.027)項顯著優於對照商品，其餘品評項無顯著差異(p>0.05)，進一部以但性別分析，我們發現19位女性受試者品評指出檸檬烏桕蜂蜜蒸餾酒香氣與整體項顯著優於對照商品(p=0.009)。我們又分析受試者感官描述辭彙，受試者能認為蜂蜜釀造酒與蒸餾酒樣品均感受到蜜香、果香與醇和口感，顯示本研究發酵製程能保有蜂蜜與水果風味特色，研究成果具有提升蜂蜜釀造酒加工產值潛力。

二、執行成果英文摘要：

This study successfully screened a thermo-tolerant yeast strain (*Saccharomyces cerevisiae*, Fermentis Lesaffre 42150) that exhibited high alcohol yield and acceptable flavor for mead production. When inoculated with Chinese tallow (*Sapium sebiferum (L.)* Roxb.) honey, the resulting mead achieved an alcohol content of 8.5% (alc./vol.). Co-fermentation with fruit by-products (lemon peel, pineapple peel, and passion fruit respectively) resulted in alcohol contents ranging from 8.4-10.8% (alc./vol.). The mead and distilled spirit prepared in this study were subjected to sensory evaluation across four attributes: color, aroma, flavor, and overall acceptability. Results from 43 judges indicated that the Chinese tallow Honey mead showed no significant difference from the commercial control (Lychee honey mead) in terms of flavor (p = 0.274) and overall acceptability (p = 0.11). In a separate evaluation of the distilled spirits by 38 judges, the lemon Chinese tallow honey distilled spirit was found to be significantly superior to the commercial control in terms of aroma (p = 0.027), with no significant differences observed in the other attributes (p > 0.05). Furthermore, a gender-based analysis of 19 female judges revealed that the lemon Chinese tallow honey distilled spirit was significantly superior to the commercial control in both aroma(p = 0.009) and overall acceptability (p = 0.009). Analyzing the descriptive sensory terms used by the judges, both the mead and the distilled spirit samples were consistently perceived to have characteristic honey notes, fruit aromas, and a mellow mouthfeel. This demonstrates that the fermentation process developed in this study is capable of keeping the flavor characteristics of both the honey and the fruit by-products, and the results have the potential to enhance the processing value of mead products.

三、計畫目的：

提升蜂蜜加工價值與增加水果副產物再利用價值。

1140996

四、重要工作項目及實施方法：

1. 篩選適用果香蜂蜜酒蜂之菌株：

(1) 蜂蜜來源：台灣主要鮮食蜂蜜商品為龍眼蜂蜜與荔枝蜂蜜，為研究提升其他特色蜂蜜加工價值，本研究使用烏桕(*Sapium sebiferum* (L.) Roxb.）蜂蜜，蜂蜜為112年購自苗栗蜂農。

(2) 菌株：果酒酵母A菌株(*Saccharomyces bayanus*, Red star premier cuveée)；耐高溫酵母B菌株(*Saccharomyces cerevisiae*, Fermentis Lesaffre 42150)；耐酒精酵母C菌株(*Saccharomyces cerevisiae*, emulsifier ES91, Fermentis Lesaffre SafSprit HG-1)；適低溫酵母D菌株(*Saccharomyces bayanus* Y497, Maurivin lager497)。

(3) 菌株發酵效率評估：將烏桕蜂蜜兌水稀釋將糖度調配製至 23-24˚Bx，每公升發酵液接種0.5g分別接種A、B、C、D乾式酵母，菌落數為10^7 CFU/ g (Colony-forming unit)，劑量，形成成優勢菌叢在25℃進行發酵，再以釀酒三用刻度計估算出最終的酒精含量，以評估發酵產酒效率。

(4) 評估水果副產物對酵母菌發酵之影響：本計畫擬利用三種香氣濃郁的水果副產物)，分別為檸檬皮、鳳梨皮與百香果肉，本計畫前試驗檸檬皮劑量為2.5 w/v%，過量檸檬皮會影響酒品風味，鳳梨皮與百香果肉分別需要20 w/v%、10 w/v%蒸餾後酒體才能保有果香。方法(1)之條件分別以4種菌株接種在3種果皮(肉)共12個處理組，在避光密閉25℃之條件進行發酵測試，每隔96小時以釀酒三用刻度計測量酒精濃度，並在紀錄發酵前與完成發酵後之pH，以評估水果副產物對發酵的影響。

(5) 製備釀造酒：烏桕蜂蜜發酵26天後，每公升發酵液加入0.5%澎潤土與發酵液充分混和後靜置12天沉降再取上清液過濾。初過濾以6μm孔徑定性濾紙(ADVANTEC)處理，中過濾以0.45μm孔徑PVDF過濾膜處理，終過濾以0.22μm孔徑PVDF過濾處理，過濾完成酒體置於4℃備用。

(6) 製備蒸餾酒：將(2)之發酵液進行蒸餾，初餾之酒俗稱酒頭，含有少量甲醇容易有雜味，儘管本研究前試驗之酒頭，以酒管理法之「酒類衛生標準」檢驗符合國家甲醇含量標準，但本研究僅收取60%-38%(alc./vol.)之蒸餾中餾酒體，初餾高於60%%(Alc./vol.)與尾餾低於38%(alc./vol.)不收取。為避免窖藏過程有雜菌汙染，本研究製備約45-48%(Alc./vol.)之蒸餾酒，隨窖藏時間約一年下降3-5%，擬窖藏一年再進行風味評估。

2. 製備蜂蜜果香再製酒：項目(1)所製備之蒸餾製備40%(alc./vol.)酒體作為基酒，分別以浸漬檸檬皮與果肉2.5%、鳳梨皮與果肉20%與百香果肉10%，存放3個月再評估適飲性。

3. 完成果香蜂蜜風味品評調查一式：

(1) 酵母菌種風味初評：依四種酵母菌種分類，別為未添加處理組、添加檸檬皮處理、添加鳳梨皮處理添加百香果肉四種處理，完成發酵後進行蒸餾製備成蒸餾酒，再依香氣(10分)、滋味(10分)與整體(5分)項目品評，總分共25分。

(2) 釀造酒組：本組共4個樣品，分別為A：烏桕蜂蜜釀造酒(8.5% alc./vol)；B：百香果烏桕蜂蜜釀造酒(9.6% alc./vol)；C：荔枝蜂蜜商品酒(霧峰酒莊)為對照酒品(8% alc./vol)。為評估烏桕蜂蜜釀造與蒸餾製程消費者接受度，樣品D為烏桕蜂蜜蒸餾酒(38% alc./vol)。品評分為色澤、香氣、風味與整體四項，採盲測每項滿分10分。

(3) 蒸餾酒組：本組共5個樣品，分別為A：檸檬烏桕蜂蜜蒸餾酒(38% alc./vol)；B：百香果烏桕蜂蜜蒸餾酒(38% alc./vol)；C：鳳梨烏桕蜂蜜蒸餾酒(38% alc./vol)；D：

檸檬皮(2.5 w/v%)浸漬烏桕蜂蜜蒸餾酒(38% alc./vol)所製成之再製酒；E：商品蒸餾酒(金門酒廠)為對照(38% alc./vol)。評分為色澤、香氣、風味與整體四項，採盲測每項滿分10分。

(4) 統計分析：釀造組共43位受試者，蒸餾酒組共38位受試者，評分結果以IBM SPSS Statistics (Version 27) 進行分析，分析方法為Kruskal-Wallis檢定，再以Mann-Whitney U進行事後檢定，樣品之間在5 %顯著性水準下無顯著差異。

五、結果與討論：

1. 菌株篩選：

(1) 評估無添加水果副產物產酒量：烏桕蜂蜜兌水24°Bx，分別接種A果酒酵母(*Saccharomyces bayanus*, Red star premier cuveée)；B耐高溫酵母(*Saccharomyces cerevisiae*, Fermentis Lesaffre 42150)；C耐高酒精酵母(*Saccharomyces cerevisiae*, emulsifier ES91, Fermentis Lesaffre SafSprit HG-1)；D適低溫發酵酵母(*Saccharomyces bayanus* Y497, Maurivin lager497)，在25℃發酵24天，A與B酵母分別有8.0±0.6%與8.5±0.4%(alc./vol.)，高於C與D酵母分別產生5.0±0.5%與5.5±0.1%(alc./vol.)(圖一A)。天然蜂蜜含有少量過氧化氫、酸性、高糖分與酚類化合物，具有抑制微生物生長機能(Ogwu and Izah, 2025)，A與B酵母在蜂蜜發效液具有較佳活性，產酒量高於C、D酵母，更適合蜂蜜釀酒使用。

(2) 評估添加水果副產物產酒量：烏桕蜂蜜發酵液分別接種A、B、C、D四種酵母後，再分別添加檸檬皮量2.5 w/v%，鳳梨皮20 w/v%與百香果肉10 w/v%共同發酵。檸檬皮添加於四種酵母的發酵液，酒精濃度與未添加處理相近(圖一B)，添加鳳梨皮處理，A與B酵母產酒量提升至10.4-10.8%(alc./vol.)(圖一C)，C與D酵母產酒量增加至8.5%(alc./vol.)(圖一C)，而添加百香果處理，A與B酵母產酒量提升至9.4-9.6%(alc./vol.)，但C與D酵母產酒量增加至9.4-9.6%(alc./vol.)(圖一D)，而表一為發酵前後pH變化，添加檸檬皮、鳳梨皮與百香果肉三種水果副產物發酵前與發酵後pH與無添加水果副產物對照組相近，pH變動範圍2.5-2.8，顯示水果副產物對發酵液pH影響小，推測鳳梨皮與百香果肉酵母菌所需營養素維持活性進而增加酒精產量，但營養機制仍須要進一步研究。

(3) 酵母菌種風味初評：四種菌種分別添加水果副產物(未添加、檸檬、鳳梨、百香果)發酵完成後進行蒸餾製程完成蒸餾酒，再分組依序香氣(10分)、滋味(10分)與整體(5分)進行初評(表二)，受試者共6人，未添加處理四種菌種總分範圍11.0-12.3，檸檬組四種菌種總分範圍13-15，鳳梨皮組總分範圍11-13，百香果組總分範圍12-13，儘管B酵母在各處理組內分數最高，但組間酵母對風味影響沒有顯著差異。

2. 蜂蜜酒風味品評：依產酒量A與B酵母產酒量優於C、D酵母，而B酵母蒸餾風味分數初評略優於A酵母，故用B酵母繼續製備烏桕蜂蜜釀造酒與蒸餾酒並依色澤、香氣、風味與整體四項進行評分。

(1) 釀造組：本組共有四個樣品，分別為A本研究製備烏桕蜂蜜釀造酒(8.5% alc./vol)，B本研究製備百香果烏桕蜂蜜釀造酒(9.6% alc./vol)，C為荔枝蜂蜜商品酒(購自霧峰酒莊)為對照酒品(8% alc./vol)，又為研究烏桕蜂蜜釀造酒與蒸餾酒消費者接受度，本研究製備之烏桕蜂蜜蒸餾酒為樣品D(38% alc./vol)。本組受試者共43位，樣品C色澤評價中位數8為最高，顯著優於其他樣品($p<0.01$)(圖二A)，樣品C香氣與樣品B受試者評分中位數達7-8無顯著差異，並顯著優於樣品A、D($p<0.01$)(圖二B)，此外樣品C與樣品A在風味與整體項評分無差異，並顯著優於樣品B與樣品D($p<0.01$)(圖二C、D)。綜合受試者品評結果顯示，對照酒品(樣品C)在各品評項都有最佳表現，但樣品A在風味與整體項與對照酒品(樣品C)相同，顯示樣品A具有與同質商品競爭潛力，未來

如能加強樣品A香氣表現，例如加入樣品B果香，將進一步提升研究成果商品化潛力。受試者對樣品D整體項評分最低，顯示受試者偏好蜂蜜釀造酒，可能因樣品A、B、C屬於甜味酒，樣品D為蒸餾酒(38% alc./vol)，受試者依序品評更加深蒸餾酒辛辣口感的印象，然而蒸餾酒與釀造酒口感迥異，分組品評能更加表現受試者對本計畫研發之蜂蜜蒸餾酒接受度。

(2) 蒸餾組：本組樣品分別為A為檸檬烏桕蜂蜜蒸餾酒(38% alc./vol)，B為百香果烏桕蜂蜜蒸餾酒(38% alc./vol)，C為鳳梨烏桕蜂蜜蒸餾酒(38% alc./vol)，D為檸檬皮(2.5 w/v%)浸漬烏桕蜂蜜蒸餾酒(38% alc./vol)所製成之再製酒，E為蒸餾酒商品(購自金門酒廠)為對照(38% alc./vol)。本研究受試者共38位，樣品A香氣顯著優於對照商品(p=0.027)(圖三A)，但色澤、風味與整體項各樣品之間無顯著差異。此外，女姓受試者品評樣品A香氣顯著優於再製酒(樣品D)(p=0.015)與對照商品(樣品E)(p=0.009)(圖三A)，在整體項樣品A顯著優於再製酒樣品(p=0.037)與對照商品(p=0.009)(圖三B)，但色澤與風味項無顯著差異。綜合蒸餾酒受試者品評結果，樣品A香氣優於對照商品，尤其女性受試者認為樣品A的香氣與整體項優於再製酒與對照商品。風味品評結果顯示，水果副產物與蜂蜜共同發酵製程香氣與整體項更加，研究成果如能商品化，計畫成果是形成行銷策略制定參考，例如可加強對女性族群行銷。

3. 蜂蜜酒品評受試者感官描述

(1) 釀造駐：品評結果顯示本研究製備之樣品A(烏桕蜂蜜釀造酒(9.6% alc./vol))具有潛力，品評過程以提示辭彙方式請受試者對在各品評項對分數最高之樣品描述感受，統計各品評項感官描述辭彙次數並繪製成風味雷達圖。感官辭彙次數統計結果顯示，受試者對樣品A色澤項對評分最高的只有5位，描述辭彙有色澤金黃、有透亮感、 純淨等(圖五A)，香氣項評分最高的受試者僅有3位，感受有清香、蜜香與甜香(圖五B)，有15位受試者對樣品A風味項給予最高評分，描述辭彙有甜、蜜香、果香等(圖五C)，整體項有12位受試者給予最高評分，描述辭彙為爽淨、優雅、愉悅(圖五D)。

(2) 蒸餾組：品評結果顯示本研究製備之樣品A(檸檬烏桕蜂蜜蒸餾酒(38% alc./vol))具有潛力，品評過程以提示辭彙方式請受試者對在各品評項對分數最高之樣品描述感受，統計各品評項感官描述辭彙次數並繪製成風味雷達圖。辭彙次數統計結果顯示，受試者對樣品A色澤項評分最高有14位，描述感受有蜜香、果香等(圖六A)，風味項評分最高受試者共16位，描述感受有口感醇和、蜜香與果香等(圖六B)，對樣品A風味項評分最高有12位，描述感受有爽淨、多層次與愉悅等(圖六C)，整體項有11位受試者給予最高評分，描述辭彙為爽淨、優雅、愉悅(圖六D)。

(3) 風味圖譜：分析樣品酒感官辭彙，顯示本研究添加水果副產物的蜂蜜釀造製程很好地保留蜂蜜甜、香感與果香等特點，感官辭彙雷達圖可當作酒品風味圖譜。綜覽雷達圖譜，在盲測條件本研究蜂蜜釀造酒在色澤、香氣、風味與感受項覆蓋面向與對照商品接近，蜂蜜蒸餾酒在四個品評項覆蓋面大於對照商品，顯示本研究蜂蜜酒商品化潛力。未來如媒合廠商技術轉移生產，可分別擴大受試者族群，再進一步以性別、年齡習慣受試者習慣進行分析，有助於形成市場行銷策略，實質商品化後可邀請專業品酒師協助品評與風味描述，利用名人聚光燈效應將吸引消費者，進一步提升商品行銷並促進特色蜂蜜加工品產值。

六、結論：

1. 本研究從四種商用酵母選出適合製備蜂蜜酒高產與風味接受度高的耐高溫酵母(*Saccharomyces cerevisiae*, Fermentis Lesaffre 42150)，在受試者風味品評調查，樣品A(烏桕蜂蜜釀造酒)風味與整體項與荔枝蜂蜜商品酒相比無顯著差異，未來如改善製程例如添加檸檬皮共同發酵，或釀造完成後添加桂花等能加強樣品A香氣表現，將能進一步提

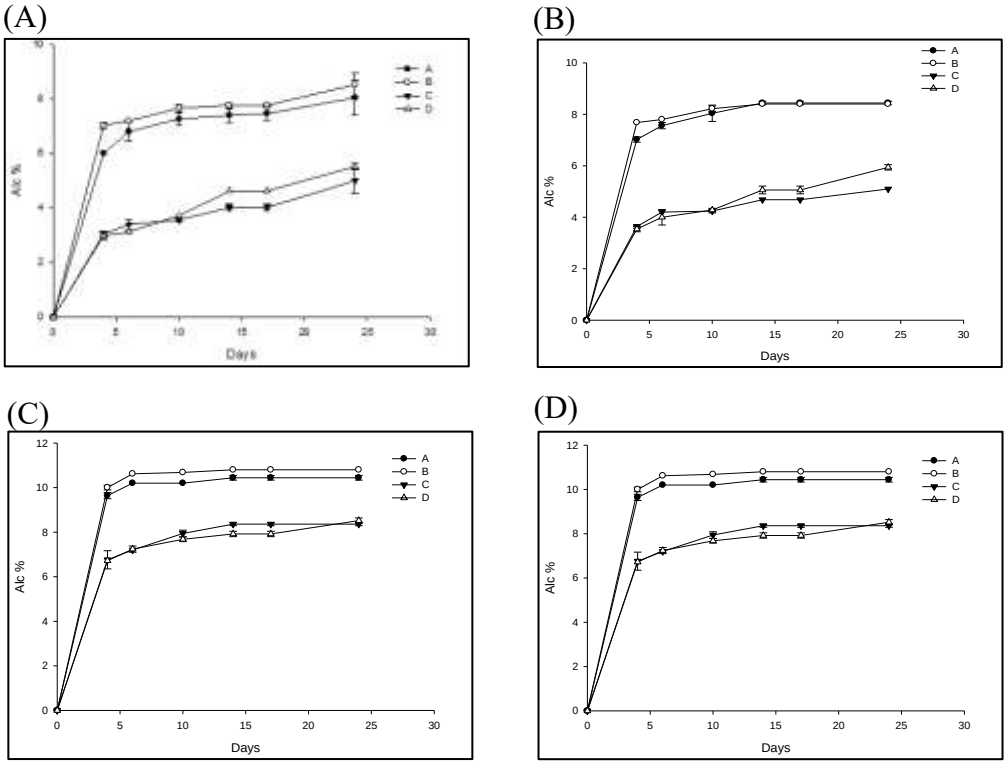
升產品競爭力。在蜂蜜釀造酒與蒸餾酒品評，受試者明顯偏好甜味釀造酒，但蒸餾酒精度38% (alc./vol)遠高於釀造酒樣品，同組比較不能凸顯蜂蜜蒸餾酒優勢，因此我們在蒸餾酒組將烏桕蜂蜜蒸餾酒與蒸餾酒商品共同品評，本研究製備檸檬烏桕蜂蜜酒(樣品A)在香氣顯著優於對照商品，尤其女性受試者對本研究製備樣品A香氣與整體項顯著有更高的評價，顯示本研究樣品能拓展女性消費，倘能媒合技轉廠商，有潛力在男性為主要的烈酒市場拓展行銷藍海。本研究受試者對蜂蜜釀造酒樣品風味感受到蜜香、協調等，對蜂蜜蒸餾酒樣品產感受到口感醇和、蜜香與果香，顯示本研究發酵製程能保有蜂蜜與水果副產物風味特色。

2. 臺灣蜂蜜主要商品為荔枝蜂蜜與龍眼蜂蜜，產地價分別為107.1-142.9元/公斤與至少214.3元/公斤，百花蜂蜜例如烏桕蜂蜜產地價約64.3-85.7元/公斤約為荔枝蜂蜜的1/2，本研究使用荔枝蜜蜂酒對照商品為680元/0.5公升，蒸餾酒對照商品為370元/0.6公升。蜂蜜比重約1.4，每公斤蜂蜜約0.71公升，本研究製備果香蜂蜜酒風味品評不遜於對照商品，如商品化粗估能創造產地5.3-9.7倍的產品價值(釀造酒：680元商品價/70元烏桕蜂蜜產地價=9.7倍，370元商品價/70烏桕蜂蜜產地價=5.3倍)。

七、參考文獻：

1. 吳添金。2008。蜂蜜酒釀造技術。苗栗區農業專訊。43：6-7。
2. 梁雯晶。2020。將廢棄果皮化為綠金再使用。工業技術與資訊月刊。337：37。
3. 黃子豪、吳姿嫻。2021。臺灣蜂蜜澱粉酶活性特性之研究。苗栗區農業改良場研究彙報。10：115-128。
4. Armentano, I., Bitinis, N., Fortunati, E., Mattioli, S., Rescignano, N., Verdejo, R., Lopez-Manchado, M. A., & Kenny, J. M. (2013). Multifunctional nanostructured PLA materials for packaging and tissue engineering. Progress in Polymer Science, 38(10-11), 1720-1747.
5. Blumenthal, P., Steger, M. C., Quintanilla Bellucci, A., Segatz, V., Rieke-Zapp, J., Sommerfeld, K., Schwarz, S., Einfalt, D., & Lachenmeier, D. W. (2022). Production of coffee cherry spirits from coffea arabica varieties. Foods, 11(12), 1672.
6. Christen, P., Meza, J. C., & Revah, S. (1997). Fruity aroma production in solid state fermentation by Ceratocystis fimbriata: Influence of the substrate type and the presence of precursors. Mycological Research, 101(8), 911-919.
7. Faruk, O., & Sain, M. (2015). Biofiber reinforcements in composite materials. Elsevier.
8. Hadj Saadoun, J., Bertani, G., Levante, A., Vezzosi, F., Ricci, A., Bernini, V., & Lazzi, C. (2021). Fermentation of agri-food waste: A promising route for the production of aroma compounds. Foods, 10(4), 707.
9. Khalil, M. I., Sulaiman, S. A., & Gan, S. H. (2010). High 5-hydroxymethylfurfural concentrations are found in Malaysian honey samples stored for more than one year. *Food and Chemical Toxicology*, *48*(8-9), 2388-2392. https://doi.org/10.1016/j.fct.2010.05.076

10. Osho, M. B., & Solomon, T. (2021). Use of composite agro-substrates for amyloglucosidase synthesis and characterization by aspergillus niger otf and aspergillus flavus clorl using solid state fermentation. Journal of microbiology, biotechnology and food sciences, 9(5), 879-883.
11. Ogwu, M. C., & Izah, S. C. (2025). Honey as a natural antimicrobial. *Antibiotics*, *14*(3), 255.
12. Pilco, C. J., Mendoza, F. V., Siza, K. C., Sisa, N. G., & Manobanda, M. P. (2024). Use of organic fruit residues to obtain bioplastics. Migration Letters, 21(S5), 1382-1400.
13. Pinelo, M., Zornoza, B., & Meyer, A. S. (2008). Selective release of phenols from apple skin: Mass transfer kinetics during solvent and enzyme-assisted extraction. Separation and Purification Technology, 63(3), 620-627.
14. Ravindran, R., & Jaiswal, A. K. (2016). Exploitation of food industry waste for high-value products. Trends in Biotechnology, 34(1), 58-69.
15. Soares, M., Christen, P., Pandey, A., & Soccol, C. R. (2000). Fruity flavour production by Ceratocystis fimbriata grown on coffee husk in solid-state fermentation. Process Biochemistry, 35(8), 857-861.
16. Vidrih, R., & Hribar, J. (2007). Studies on the sensory properties of mead and the formation of aroma compounds related to the type of honey. Acta Alimentaria, 36(2), 151-162.
17. Waiba, P. S., Sherab, J., & Hingmang, A. R. (2021). International journal of engineering applied sciences and technology, 2021 vol. 6, issue3, issn no. 2455-2143, pages 36-44published online july 2021 in ijeast (Http://www. Ijeast. Com)36an empirical study on quality of education:a case study in primary schools in wangduephodrang district,bhutan. *International Journal of Engineering Applied Sciences and Technology*, *6*(3).
18. Yaradoddi, J. S., Banapurmath, N. R., Ganachari, S. V., Soudagar, M. E. M., Sajjan, A. M., Kamat, S., Mujtaba, M. A., Shettar, A. S., Anqi, A. E., Safaei, M. R., Elfasakhany, A., Haque Siddiqui, M. I., & Ali, M. A. (2022). Bio-based material from fruit waste of orange peel for industrial applications. Journal of Materials Research and Technology, 17, 3186-3197.
19. Zhang, W., Zeng, G., Pan, Y., Chen, W., Huang, W., Chen, H., & Li, Y. (2017). Properties of soluble dietary fiber-polysaccharide from papaya peel obtained through alkaline or ultrasound-assisted alkaline extraction. Carbohydrate Polymers, 172, 102-112.



圖一、烏桕蜂蜜發酵產生酒精趨勢。(A) 烏桕蜂蜜發酵液分別接種四種酵母菌株產生酒精趨勢。(B)烏桕蜂蜜發酵液添加檸檬皮(2.5 w/v%)於分別接種四種酵母菌株產生酒精趨勢。(C)烏桕蜂蜜發酵液添加添加鳳梨皮(20 w/v%)分別接種四種酵母菌株產生酒精趨勢。(D)烏桕蜂蜜發酵液添加百香果肉(10 w/v%)分別接種四種酵母菌株產生酒精趨勢。A 菌株(*Saccharomyces bayanus*, Red star premier cuveée)；B 菌株(*Saccharomyces cerevisiae,* Fermentis Lesaffre 42150)；C 菌株(*Saccharomyces cerevisiae,* emulsifier ES91, Fermentis Lesaffre SafSprit HG-1)；D 菌株(*Saccharomyces bayanus* Y497*,* Maurivin lager497)。

Figure 1. Trend of alcohol production by Chinese Tallow (*Sapium sebiferum (L.) Roxb.*）honey fermentation. (A) Alcohol production trend of Chinese Tallow Honey fermentation broth inoculated with four different yeast strains. (B) Alcohol production trend of Chinese Tallow Honey fermentation broth with added lemon peel (2.5 w/v%) and inoculated with four different yeast strains. (C) Alcohol production trend of Chinese Tallow Honey fermentation broth with added pineapple peel (20 w/v%) and inoculated with four different yeast strains. (D) Alcohol production trend of Chinese Tallow Honey fermentation broth with added passion fruit pulp (10 w/v%) and inoculated with four different yeast strains. Strain A: Saccharomyces bayanus, Red star premier cuveée. Strain B: Saccharomyces cerevisiae, Fermentis Lesaffre 42150. Strain C: Saccharomyces cerevisiae, emulsifier ES91, Fermentis Lesaffre SafSprit HG-1. Strain D: Saccharomyces bayanus Y497, Maurivin lager497.

表一、烏桕蜂蜜添加水果副產物發酵液前後 pH。

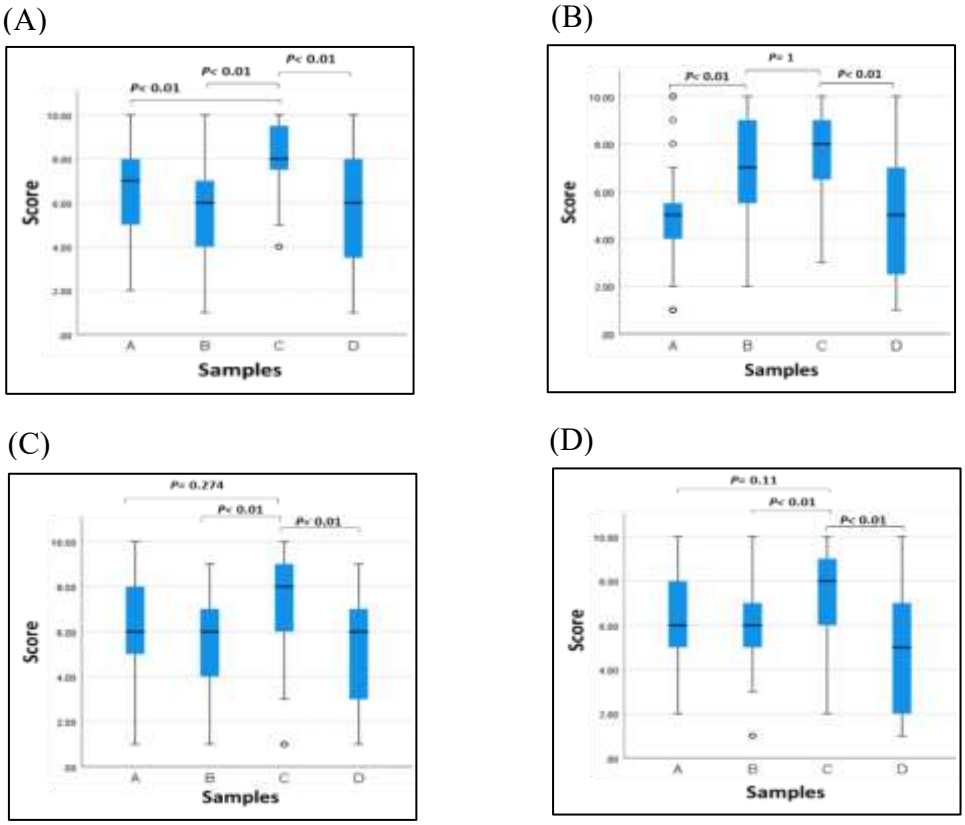
Table 1. pH of Chinese Tallow (*Sapium sebiferum (L.) Roxb.*）honey fermentation broth before and after adding fruit by-products.

Yeast Strain	None		Lemon peel (2.5 w/v %)		Pineapple peel (20 w/v %)		Passion fruit (20 w/v %)	
	Beginning	After	Beginning	After	Beginning	After	Beginning	After
A	2.81	2.68	2.72	2.72	2.56	2.69	2.78	2.81
B	2.77	2.86	2.77	2.91	2.54	2.69	2.77	2.86
C	2.6	2.7	2.54	2.7	2.62	2.65	2.76	2.82
D	2.77	2.89	2.76	2.85	2.67	2.68	2.8	2.86

表二、菌株影響蜂蜜蒸餾酒風味初評表。

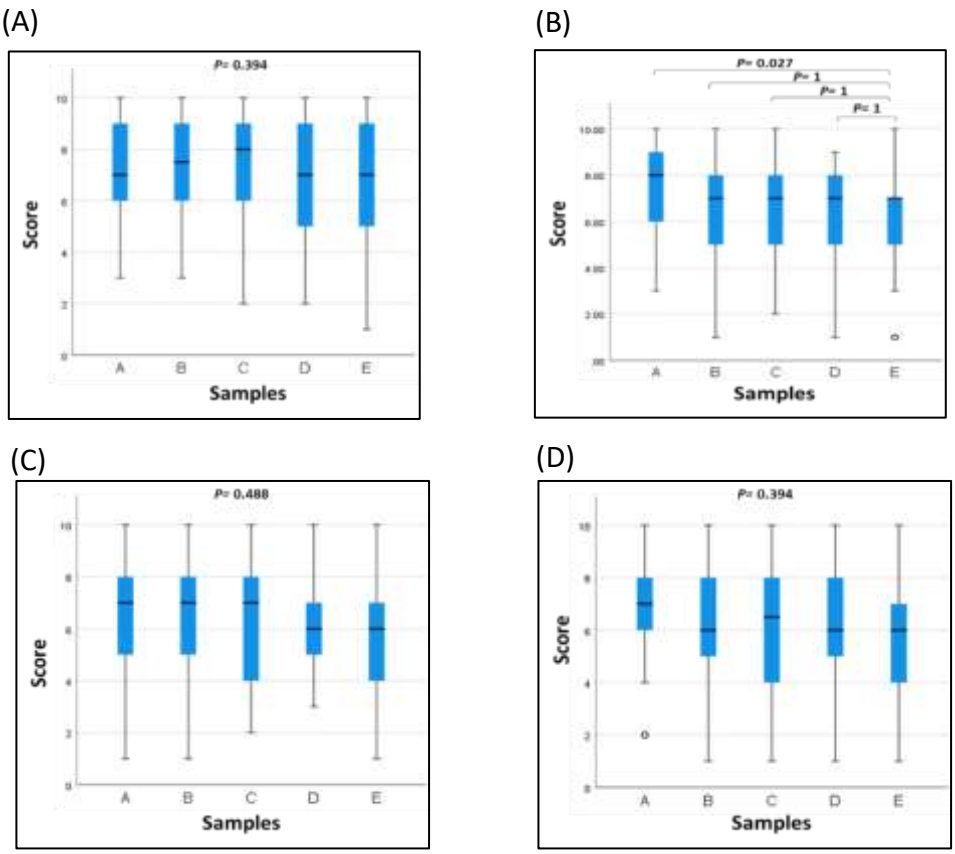
Table 2: Preliminary evaluation of yeast strains' influence on honey distilled spirits' flavor profile.

Treatments	Strains			
	A	B	C	D
None	11.0±1.0a	12.3±2.1a	11.7±3.2a	11±2.0a
Lemon Peel	13.7±5.5a	15.0±2.0a	12.7±2.5a	13.7±1.5a
Pineapple Peel	11.5±4.0a	13.2±3.1a	12.2±2.6a	11.8±4.8a
Passion fruit	13.7±5.1a	12.3±3.7a	13.8±3.1a	13.7±3.3a



圖二、烏桕蜂蜜釀造酒消費者品評。(A)烏桕蜂蜜釀造酒樣品色澤品評。(B)烏桕蜂蜜釀造酒樣品香氣品評。(C)烏桕蜂蜜釀造酒樣品風味品評。(D)烏桕蜂蜜釀造酒樣品整體評分。A 樣本：烏桕蜂蜜釀造酒(Alc 8.5%)；B 樣本：百香果烏桕蜂蜜酒(Alc 9.6%)；C 樣本：對照商品酒，荔枝蜂蜜酒商(Alc 8%)；D 烏桕蜂蜜蒸餾酒(Alc 38%)。受試者共 43 位，品評分數之盒形圖分別代表了上下四分位數，盒中線為中位數，評分結果以 Kruskal-Wallis 分析後再進行 Mann-Whitney U 檢定，樣品之間在 5 %顯著性水準下無顯著差異。

Figure 2. Consumer sensory evaluation of mead brewed with Chinese Tallow honey. (A) Color evaluation of Chinese Tallow honey mead samples. (B) Aroma evaluation of Chinese Tallow honey mead samples. (C) Flavor evaluation of Chinese Tallow honey mead samples. (D) Overall acceptability scores of Chinese Tallow honey mead samples. A total of 43 panelists participated in the evaluation. The box plots of the sensory scores represent the upper and lower quartiles, with the line inside the box representing the median. The scoring results were analyzed using the Kruskal-Wallis test followed by the Mann-Whitney U test. No significant difference was observed among the samples at a 5% significance level. Sample A: Chinese Tallow Honey mead (Alc 8.5%); Sample B: Passion Fruit Chinese Tallow Honey mead (Alc 9.6%); Sample C: Commercial control wine, Lychee Honey Wine (Alc 8%); Sample D: Chinese Tallow Honey distilled spirit (Alc 38%).

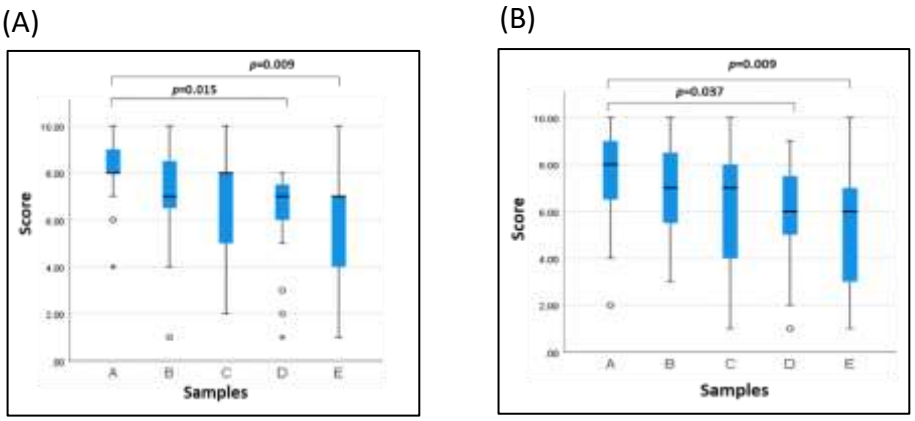


圖三、烏桕蜂蜜蒸餾酒消費者品評。(A)烏桕蜂蜜蒸餾酒色澤品評。(B)烏桕蜂蜜蒸餾酒香氣品評。(C)烏桕蜂蜜蒸餾酒香氣風味品評。(D)烏桕蜂蜜蒸餾酒整體評分。A 樣品：檸檬烏桕蜂蜜蒸餾酒(Alc 38%)；B 樣品：百香果烏桕蜂蜜蒸餾酒(Alc 38%)；C 樣品：鳳梨烏桕蜂蜜蒸餾酒(Alc 38%)；D 樣品：烏桕檸檬再製酒(Alc 38%)；E.對照酒品為蒸餾酒商品(Alc 38%)。受試者共 38 位，品評分數之盒形圖分別代表了上下四分位數，盒中線為中位數，品評結果以 Kruskal-Wallis 分析後再進行 Mann-Whitney U1 檢定，樣品之間在 5 %顯著性水準下無顯著差異。

Figure 3. Consumer sensory evaluation of Chinese Tallow honey distilled spirit. (A) Color evaluation of Chinese Tallow honey distilled spirit samples. (B) Aroma evaluation of Chinese Tallow honey distilled spirit samples. (C) Flavor evaluation of Chinese Tallow honey distilled spirit samples. (D) Overall acceptability scores of Chinese Tallow honey distilled spirit samples. A total of 38 panelists participated in the evaluation. The box plots of the sensory scores represent the upper and lower quartiles, with the line inside the box representing the median. The scoring results were analyzed using the Kruskal-Wallis test followed by the Mann-Whitney U test. No significant difference was observed among the samples at a 5% significance level.

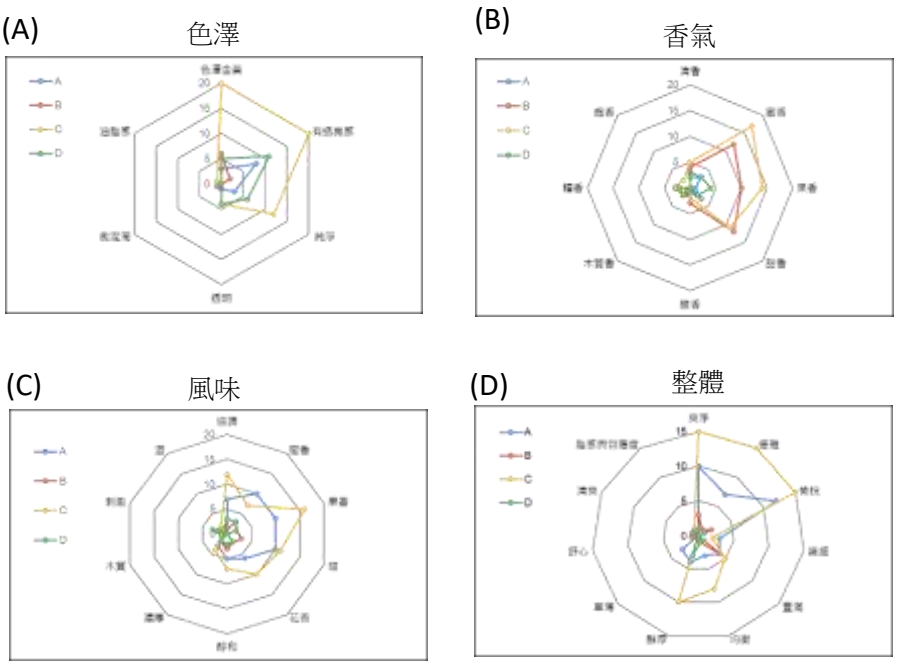
1140996

Sample A: Lemon Chinese Tallow honey distilled spirit (Alc 38%). Sample B: Passion Fruit Chinese Tallow honey distilled spirit (Alc 38%). Sample C: Pineapple Chinese Tallow honey distilled spirit (Alc 38%). Sample D: Chinese Tallow lemon reconstituted spirit (Alc 38%). Sample E: Commercial distilled spirit product (Alc 38%).



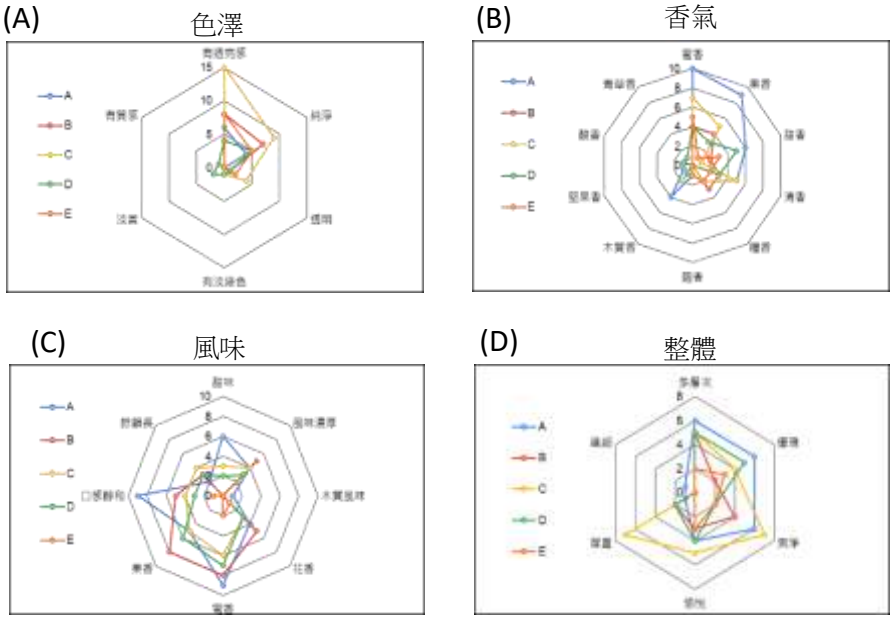
圖四、烏桕蜂蜜蒸餾酒女性受試者品評。(A)女性消費者品評烏桕蜂蜜蒸餾酒香氣。(B)女性消費者品評烏桕蜂蜜蒸餾酒整體感受。A 樣品：檸檬烏桕蜂蜜蒸餾酒(Alc 38%)；B 樣品：百香果烏桕蜂蜜蒸餾酒(Alc 38%)；C 樣品：鳳梨烏桕蜂蜜蒸餾酒(Alc 38%)；D 樣品：烏桕檸檬再製酒(Alc 38%)；E.對照酒品為蒸餾酒商品(Alc 38%)。女性受試者共 19 位，品評分數之盒形圖分別代表了上下四分位數，盒中線為中位數，品評結果以 Kruskal-Wallis 分析後再進行 Mann-Whitney U1 檢定，樣品之間在 5 %顯著性水準下無顯著差異。

Figure 4. Sensory evaluation of Chinese Tallow honey distilled spirit by female subjects. (A) Aroma evaluation of Chinese Tallow Honey distilled spirit by female consumers. (B) Overall acceptability evaluation of Chinese Tallow Honey distilled spirit by female consumers. A total of 19 female panelists participated in the evaluation. The box plots of the sensory scores represent the upper and lower quartiles, with the line inside the box representing the median. The scoring results were analyzed using the Kruskal-Wallis test followed by the Mann-Whitney U test. No significant difference was observed among the samples at a 5% significance level. Sample A: Lemon Chinese Tallow Honey distilled spirit (Alc 38%). Sample B: Passion Fruit Chinese Tallow Honey distilled spirit (Alc 38%). Sample C: Pineapple Chinese Tallow Honey distilled spirit (Alc 38%). Sample D: Chinese Tallow Lemon reconstituted spirit (Alc 38%). Sample E: Commercial control distilled spirit product (Alc 38%).



圖五、蜂蜜釀造酒風味特性。蜂蜜品評受試者對評分最高樣本進行質性描述，圖形分數為描述詞出現次數。(A)蜂蜜釀造酒樣品色澤描述。(B)蜂蜜釀造酒樣品香氣描述。(C)蜂蜜釀造酒樣品風味描述。(D) 蜂蜜釀造酒樣品整體描述。A 為烏桕蜂蜜釀造酒(Alc 8.5%)，B 為百香果烏桕蜂蜜酒(Alc 9.6%)，C 為對照商品酒，荔枝蜂蜜酒商(Alc 8%)，D 烏桕蜂蜜蒸餾酒(Alc 38%)。

Figure 5. Flavor characteristics of mead brewed with Chinese Tallow honey. Qualitative descriptions provided by panelists for the highest-scoring samples of mead; the scores in the figure represent the frequency of appearance for each descriptive term. (A) Color description of mead samples. (B) Aroma description of mead samples. (C) Flavor description of mead samples. (D) Overall description of mead samples. Sample A: Chinese Tallow honey mead (Alc 8.5%). Sample B: Passion Fruit Chinese Tallow Honey mead (Alc 9.6%). Sample C: Commercial control wine, Lychee Honey Wine (Alc 8%). Sample D: Chinese Tallow Honey distilled spirit (Alc 38%).



圖六、蜂蜜蒸餾酒風味特性。蜂蜜品評受試者對評分最高樣本進行質性描述，圖形分數為描述詞出現次數。(A)蜂蜜蒸餾酒樣品色澤描述。(B)蜂蜜蒸餾酒樣品香氣描述。(C)蜂蜜蒸餾酒樣品風味描述。(D)蜂蜜蒸餾酒樣品整體描述。A 為檸檬烏桕蜂蜜蒸餾酒(Alc 38%)，B 為百香果烏桕蜂蜜蒸餾酒(Alc 38%)，C 樣品為鳳梨烏桕蜂蜜蒸餾酒(Alc 38%)，D 樣品為烏桕檸檬再製酒(Alc 38%)，E 為對照酒品為蒸餾酒商品(Alc 38%)。

Figure 6. Flavor characteristics of Chinese Tallow honey distilled spirit. Qualitative descriptions provided by panelists for the highest-scoring samples of the distilled spirit; the scores in the figure represent the frequency of appearance for each descriptive term. (A) Color description of distilled spirit samples. (B) Aroma description of distilled spirit samples. (C) Flavor description of distilled spirit samples. (D) Overall description of distilled spirit samples.Sample A: Lemon Chinese Tallow Honey distilled spirit (Alc 38%). Sample B: Passion Fruit Chinese Tallow Honey distilled spirit (Alc 38%). Sample C: Pineapple Chinese Tallow Honey distilled spirit (Alc 38%). Sample D: Chinese Tallow Lemon reconstituted spirit (Alc 38%). Sample E: Commercial control distilled spirit product (Alc 38%).