SOLVENTEXTRACTIONOFOILANDIT'SECONOMY

[1]Nirav K. Meghpara, [2]Sanket A. Pandya, [3]ijay V. Mehta
[1, 2, 3]Assistant Professor
[1]Mechanical Engineering Department
[1]V.V.P. Engineering College, Rajkot, India

***Abstract:**Theprocessingofoilseedsandoilcontainingfruitsbecomesvitalbecausethepeopleneedmoreandmoreoilforhumannutritionandalsofortechnicalapplications.Therearethreedifferentmethodsfortheextractionsofoilareconceivable:(1)pressing(2)extractionbysolventandPressingfollowedbysolventextraction.Pressingisaveryoldmethodwhichisreplacedbytheuseofsolventwhichismoreefficient,especiallyforoilseedswithloweroilcontentssuchassoybeans.Seedswithhigheroilcontentsareprepressedbeforeextractionbysolvent.Wediscussedthedifferentaspectsofoilprocessingoftherawmaterialviaextractioneitherbypressingorsolventextraction.WediscussedFactorsInfluencingtheExtractionEfficiency,Choiceofsolvent,SeparationsofSolventandOil,RelativeYieldsandAdvantagesofsolventextraction.Oilextractionprocesswhichwearegoingtouseitincreasestheyieldofoil%.WealsostudiedEdibleOilProductionandConsumption,Indianvegetableoileconomy.*

***Keywords:** MechanicalPressing, SolventExtraction, SolventRecoverySystem,Hexane*

I. INTRODUCTION

Oilproductionfromdifferentsourcesisimportanttoprovideoilfortheuseasfoodorinseveraltechnicalapplications, suchasfuel,lubricants,orrawmaterialetc. Themainpointistheseparationoftheoilfromtheoil-bearingmaterialwithsubsequentpurification of theraw oil,butlookingattheoilproductionasawholenotonlytheoilprocessingisimportantfortheproductionofhighqualityoil,butalsothepretreatmentoftherawmaterial,andthestorageconditionsunitprocessinghavetobetakenintoconsideration.Theaimoftheextractionmethodistoincreasetheoilyieldwithsimultaneousmaintenanceoftheoilquality.Whilemechanicalextractionofseedsorfruits,aoldmethodfortheprocessingofoil.Thismethodisnowadaysusedonlyforfruitoilsorspecialtyoils,intheextensiveextractionprocessinlargefacilities,mechanicalandsolventextractionareapplied.

II. PRODUCTIONPROCESS

Edibleoiltechnologycanbegroupedintotwo:mechanicalpressingandsolventextraction.Foroilseedswithhighoilcontent suchasgroundnut,firstmechanicalpressingwillbeappliedtoextracttheoil.Theremainingoilintheexpellercakewillthenbeextractedusingsolvent.oilseedwithlowoilcontentsuchsoyabean,sunflower,rapeseedetc.solventextractionisgenerallyconsideredasthebestalter native.

A. MechanicalPressing

Theaimofthepressingprocessistoseparatetheoilyphasefromthesolidphaseoftheseedmaterial.Inlargescalefacilities,twodifferentpressingtechniquesareusedfortheseparationofoilfromtheseed.Thefirsttechniqueisamoreextensivepressingoftheoilseedwithoutfurtherextractionbysolvent.Thismechanicalpressingisusefulforoilseedswithhighoilcontent,whereitisnoproblemtogetextrareleaseofsomepercentofoilintheresidue.Thishastheadvantagesoflowerinvestmentandmaintenancecostsandhigheroilquality.Oilpressconsistofarotatingscrewshaft(Fig.A.1)withinahorizontalbarrel.Thisscrewshafttransportstheseedsthroughthescrewflight,inordertoincreasethepressureonmaterialduringthepassage,thevolumeofthescrewincreasesorthediameterofthescrewflightdecreasesinthedirectionoftheseedflowresultinginlessspacefortheseedmaterialandincreasingpressureontothematerial.Dependingontheneedsoftheseedmaterial,itispossibletovarytheslopeofthescrewwhichresultsinachangeofthepressureincreasewithinthescrewpress.Thebarrelsurroundedbyflatbars,whichformaconfinearoundthescrew(Fig.A.2).Betweenthebarsissomespace,inwhichoilcanflowoutofthebarrelwhilemostofthesolidmaterialleavesthescrewpressattheend.Byvaryingthespacebetweenthebars,itispossibletochangeandtoadjustthepressurewithinthebarrel.Anotherprobabilityistoinfluencethepressurewithinthebarrelisthesizeofthepress cake exitat theend ofthebarrel andtheslopeofthescrew.

Fig.1: Screwpresswithoutbarrelcagetoshow wormsections

Fig.2:BarrelofascrewpresssurroundedbyflatbarsduringpressingofoilseedsSolventExtraction

Extractionwithsolventsisthemosteffectivemethodfortherecoveryofoil.Whenperformedatlowtemperature,thesolventextractionhasanotheradvantageoverscrewpressing:betterqualityofoilproduced.Thisisbecauseduringexpellingasuddenheatingoftheoilcanoccur,changingsomeparametersofitsquality.Theaimofextractionbysolventistoremovelargeamountofoilfromtheoilseed.hexaneisextensivelyusedassolvent,becauseitischeap,hasgoodoilsolubilityatrelativelylowtemperature,hasanappropriateboilingtemperature,isnoncorrosivetometal,inerttotheoil.Itisstableundertheoperatingconditions,isimmisciblewithwater,whichcauseeasyseparationofwaterfromtheoil,anditiseasilyandcompletelyremovedfromthebottomproductwithlowenergy inputandwithoutharm oftheraw oil.Duringsolventextractionoftheoilseed,anintensivecontactbetweensolventandpresscakeisnecessarytoachieveancompleteremovalofoil.Thesolventisheatedto5060°C,butitisimportanttoavoidboilingwhenhotpresscakecomesintocontactwiththesolvent.Presscakecomeswithhightemperaturefromthemechanicalpressingprocess,afurthertemperatureincreaseisonlynecessarywhentheextractorstartsworking.Temperatureisimportantfortheex

tractionsinceviscosityofthesolventisreducedsoitcaneasilyflowintooilcakeandthesolubilityoftheextractincreaseswithhighertemperatures.Thecompositionoftheextractisinfluencedbytheextractiontemperature.Whilemostoilsmainlyconsistoftriacylglycerides,minorcomponentssuchasphospholipids,chlorophyll,freefattyacids, color pigments,anddegradationproductsofoxidativereactionsarecoextractedbythesolvent.Thisamountofminorcomponentsincreaseslargelywiththetemperature.Forexample,anincreaseintemperaturefrom313°Kto331°Kraisesthecontentofphospholipidsinrapeseedoilfrom0.2to0.8%.Importantfactorinfluencingtheresultofsolventextractionismoisture,whichcancomefromthesurfaceofthepresscakeorfrompoorwater/hexaneseparationafterdistillation.Thismoisturecanavoidanoptimalpenetrationofthepresscakebythesolvent,resultinginlowextractionratesandhighresidualsolventinthemeal.Theextractionratedependsontemperatureandmoistureandalsoontheadjustmentofequilibriumbetweendiffusionofsolventintocakeparticlestodissolveoilanddiffusion ofoilfromwithintheparticles outintothesolventforwhichacertaintimeisnecessary.Thehighestamountofoilisextractedatinitialconditionofprocess:75%inthefirst25min,whereasthetotaloilyielddependsonthefurthernumberofextractionstepsandthetotalextractiontime.Theextractionoftheremaining25%oilfromthepresscaketakesmoretime.Thestructureandthebehaviorofthecakeparticlesareimportantfortheresultoftheextractionprocess.Excessivelyfinepresscakeresultingfromlargenumberofhandlingofthecakebeforeprocessing,frompoorsettingsofthescrewpressduringpressingorfromimpropermoisturecontentoftherawseedmaterialnegativelyinfluencesthepercolationrateofthesolventthroughthecake.Whilesoybeanflakesarestableenoughtosurvivethemechanicalandhydraulicstrainduringtheextraction process.
Theresultissmallparticleswithaworsesurface/volumeratio,whichleadtoaremarkablelesspercolationofthesolventthroughthecakebed.Thisagainresultsinlessextractionefficiency,higherresidualoilcontentinthepresscakeandalsohighlevelsofsolventinthemeal.Thus,largenumberofextractionstepsandahighersolventrequirementareneededtoachieveasufficientoilyield.

1) ProcessSolventextractionofthepresscakeiscarriedoutbyusingacontinuouscountercurrentextractionprocessmovingthepresscakeandthesolventindifferentdirections(Fig.B).Thismethodisefficientinreducingtheoilcontentofthepresscaketoaminimum,whiletheamountofsolventrequiredremainscomparablylow.Duringtheprocess,thecakeiscomesintocontactwithsolventmanytimesandafteracertaintimeofadjustmentofequilibriumthesolvent/oilmixture,calledasmiscella,isallowedtodrainawayfromthecake.Witheachstep,theamountofoilinthecakeisminimized,butsinceitisnotpossibletoremoveallofthesolventfromthecakeasomeamountremainstogetherwithoilinthecake.Thenumberofextractionstepsdependsontheperformanceoftheextractor.Moreseventotensuccessivewashstageshavebeenused.However,anextensiveextractionwithfewerstepsispossibleifthecakeissaturatedbysolventallowingittosoakoverasufficienttimefollowedbyflushingtheenrichedmiscellafromthesurfaceoftheparticlesandreplacingitwithaleanermiscella.Insuchcase,onlytwoorthreeextractionstepsarerequiredwithareducednumberofpumps,therebyreducingcostsofenergy,capital,andmaintenance Fig.3:ExtractorFortheextractionofthepresscakeoroilcake,amixtureofnhexaneandoilisusedandtheconcentrationofoilinhexanedecreaseswithevery extractionstep.Attheendoftheprocess,beforethemealleavestheextractoritwillbewashed withpuresolvent.

III. FACTORSINFLUENCING THEEXTRACTIONEFFICIENCY

Primaryrequirementofsolventextractionforseparationorremovalpurposesisahighdistributionratioofthesoluteofinterestbetweenthetwoliquidphases.Continuousandcountercurrentdistributiontechniquescanbeusedforthecaseswherelowdistributionratiosarepresent.Itisgenerallydesirabletoattainashighavalueaspossibleforthedevelopmentofsimpleanalyticalprocedures.Thereforenumbersofdifferenttechniquesareusedforenhancingthedistributionratio.Thesedependonthenatureofthespeciesbeingextractedandextractionsystem.Theattainmentofselectivityinanextractionprocedureisveryimportant.

IV. CHOICE OFSOLVENT

Selectionofsuitablesolventforeffectiveseparationisveryimportant.Metalchelatesandmanyorganicmolecules,beingessentiallycovalentcompoundsdonotinflictmanyrestrictionsonthesolventandthegeneralrulesofsolubilityareuse.Inionassociationsystemsandparticularlyinoxoniumtypeions,theroleofsolventsisveryimportant.Thisisduetoinclusionofsolventintheformationofextractable species.Thechoiceofsolventdependsonseveralimportantpropertiessuchasthegoodsolubility,efficiencyasloworambienttemperatures,lowinflammability,boilingpointandtoxicity.Thesolventmustbeeasilyrecoverableanditisenvironmentalfriendly.Itisobviouslyimpossibletocomeupwithasolventthatfulfillstheserequirementsfully.Onesolventthathascomeveryclosetothesecriteriaishexane.Theacceptanceforthissolventhasbeensuchthatitsomewhatenjoysamonopolyinthesolventextractionofvegetableoils.Similarly,thedegreeofmiscibilityofthetwophases,therelativespecificgravities,viscosityandtendencytoformemulsionsshouldbeconsidered.Withregardtosafety,thetoxicityandinflammabilityoftheorganicsolventsmustbeconsidered.Thedesiredcharacteristicsofasolventcanbeachievedbyusingamixedsolventsystem.Anexampleofthisistheuseofmixturesofalcoholsandethersfortheextractionofthethiocyanatecomplexesofmetals.Anothermethod ofachievingdesiredcharacteristicsoftheextractingsolventistouseorganicdiluents.

V. SEPARATIONS OFSOLVENT ANDOIL

Thenextstepofsolventextractionprocessistheseparationofsolventfromoil.Afterthesolvent-extractionprocess,theresultingmiscellacontains20–30%oilinsolvent.Foraneconomicalprocedure,therecoveryandre-utilizationofthesolventisimportant.Separationofsolventneedsenergyandequipment,theaimmustbetoobtainasmuchoilaspossiblefromthemiscellawithaneconomicalneedofenergy.Afterleavingthesolventextractor,finestparticlesoftheseedmaterialresultingfromthe treatment duringsolventextraction,alsofromthetreatmentduringmechanicalpressing,haveto beseparated fromthe miscella,becausetheycaninfluencetheheattransferduringdistillation.Theamountofspeciesdependsontheequipmentusedfortheextraction.Whiledirectsolventextractionwithoutprepressingresultsincomparablyhigheramountsofparticles,theamountismuchlowerifprepressingisused before solvent extraction. The separationofsolventandoilisachievedbydistillationmethodsbyusingaseriesof sills,strippingcolumns,andcondensers.Ingeneral,atwoorthreestageprocessiscarriedout.Inafirststage,hexaneandsteamvaporsfromthedesolventizertoasterusedfortheremovalofhexanefromthemealareappliedasheatsource.Inthisstage,themixturereachestemperaturesofabout50°C.Afterthat,theresultingoilenrichedliquidistreatedinasteamheatedexchangerwheretheconcentrationofhexanedecreasestoabout5%ofthemiscellamassatatemperatureofabout80°C.Thehexaneisagainsendtotheextractorforfurtheruse.Finally,theconcentrationofhexanehastobereducedtolessthan800ppmtoreachaflashpointoftheoilhigherthan250°C.Residuesofhexaneintheoilarefinallyremovedduringdeodorization.Toreachtherequiredamountofhexaneintheoil,themiscellaispassedthroughanoilstrippertowerunderpressureof0.13126atmandtemperatureofabout373°K.Astemperaturehigherthan378°Kbadlyaffectsthequalityofthecrudeoil,steamdistillationisused.Forthispurpose,theoilisheatedto363373°Kinapreheaterandthensteamisinjectedfromthebottomtoincreasetheeffectivenessoftheprocess.

VI. RELATIVEYIELDS

Theadvantageofthesolventextractionprocessistherelativelyhighefficiencyattainedintheextractionofoilfromoil-bearingmaterials.TheusualoilcontentoftheexpelleroilcakesinIndiaisbetween68percentbyweight;whilethedeoiledmealhasoilcontentlessthanonepercent.Table(a)givestherelativeyieldsoftheproductsbydifferentmethodsemployed,fortherecoveryofoilfromgroundnutkernels.

	Yieldpercentoftotaloil		
Component	Ghani	Screwpressing	Solventextraction
Oil	42.5	45.5	49.5
Meal	57.5	51.5	50.5
Percentefficiency	85.0	91.0	99.0

Table1:ComparativeYieldofProductsbyDifferentMethods:ProcessingGroundnutKernels(50percentoilbyweight)

VII. ADVANTAGES

Theadvantagesofthesolventextractionindustrymaybesummarizedasfollows:
1) Therecoveryofoilfromoilseedsisveryhigh.
2) Itcanprofitablysavetheoilfromdamageotherwisegoingaswasteintheoilcakes
3) Nodamageisdonetothenutritionalvalueoftheenteringmaterialsintheprocess.
4) Nitrogenofthedeoiledmealissuppliedinsuchaformthatitiseasilymadeavailabletothesoil,whenusedasmanure.
5) Itisquitepossibletorevivevillageghanis,drivenbybullocksinamostefficientmannerwhenworkedinconjunctionwithasolventextractionplant.
6) Deoiledmealproducedunderhygienicconditionsoftheplantfromtheedibleoilseeds,mayverywellbeutilizedashumanfood.
7) Theproductionofsyntheticvegetableproteinfibreismadepossible.

VIII. EDIBLEOILPRODUCTIONAND CONSUMPTION

Increasingpopulation,risingincomelevelsandimprovedsupplyconditionsareexpectedtocontinuetodriveedibleoilconsumptionto17.4milliontonsin2012/13,up1.08milliontonsoverthepreviousyear.Palmoilislargestconsumededibleoil.Becauseofitsversatilityinblendingwithotheredibleoils,competitiveprices,andincreasedusageacross,sweetfoodandbutterindustries,itsfooduseconsumptionwillriseto8.4milliontonsin2013/14.Softoilssuchas soybeanandrapeseedarethelargestedibleoilwhichis3.2milliontonsand2.6milliontons,respectively.Peanut,cottonseedandsunflowertogetherconstitutethe5.8milliontons.ThepercapitaedibleoilconsumptioninIndiaisincreasing(currentlyestimatedat14.04Kgfor2012/13)remainsfarbelowtheestimatedworldaveragepercapitaconsumptionof22.4Kg.

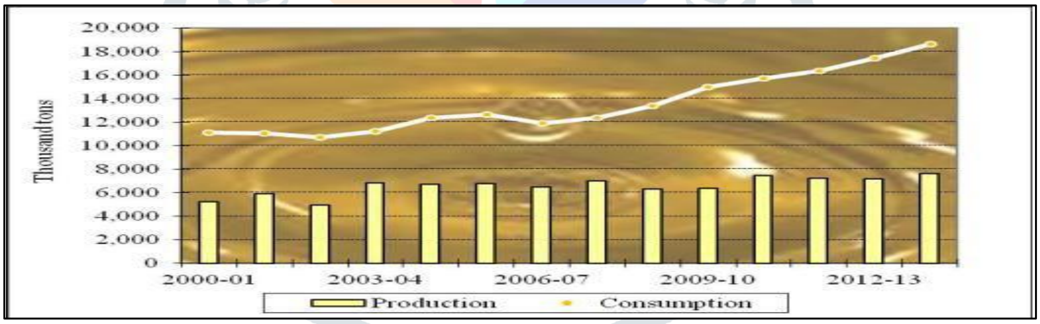

Fig.1:India:EdibleOilProductionandConsumption

IX. ECONOMY

Indianvegetableoileconomyisthefourthlargestintheworld.Thecountryaccountsfor12-15%ofglobaloilseedsarea, 6-7% of vegetableoilsproduction(nexttoU.S.A,ChinaandBrazil)and910%ofthetotaledibleoilsconsumption(FAO,2011).Currently,Indiaaccountsfor6.8% oftheoilmealproduction,5.9%oftheoilmealexport,6.1%ofthevegetableoilexport,9.00%ofthevegetableoilimportand9.3%oftheedibleoilconsumptionoftheworld(Sonna*detal*.,2011).Indiaranksfirstintheproductionofmostoftheminoroilseeds(castor,sunflowerandsesame).Inthecaseofmajoroilseeds,Indiaranksfirstintheproductionofgroundnut,thirdinrapeseed-mustardandfifthinsoyabean.AllIndiaCrop/SeasonwiseArea,productionandyieldofoilseedcropsduringXIthplanperiodreleasedbyDirectorateofEconomics&Statistics,GOI,NewDelhiisgivenintable1.Table2:AllIndiaCrop/SeasonwiseArea,productionandyieldofoilseedcropsduringXIthplanperiodreleasedbyDirectorateofEconomics&Statistics,GOI,NewDelhi

X. CONCLUSION

Asweknow,morethan98%oftheoilproductionworldwideiscarriedoutbysolventextraction,butforspecialtyoils,suchasextravirginoliveoilorvirginrapeseedoil,oilsproducedin rural areas,orfor pre-pressingbeforesolventextraction.Theadvantageofpre-pressingisthatapresscakeisformedfromthesmallflakeswhichallowagoodsolventcontactandpercolationintheextractor.Extractionbycombiningscrewpressandsolventextractionhastheeconomicaladvantageslowcostsusingascrewpressandhigheroilyieldusingsolventextraction.Theadvantageofsolventextractionovermechanicalpressingcanbeclearlyshowninthecaseofsoyabeanbythefactthatoilrecoveryisover97%whensolventextractionisusedasagainstabout80%whenmechanicalpressingisused.Theyieldpercentoftotaloilbyusingghaniis42.5withscrewpressingis45.5andfinallywithsolventextractionis49.5(onthebasisof50percentoilbyweight)whichevidentthattheoilyieldishigherbyusingsolventextraction.Thepercentefficiencyis85, 91and99percentforghani,screwpressingandsolventextractionrespectively.TheproductionandconsumptionofoilinIndiaiscontinuouslyincreasingfromyear2000-01to2012-

13.Theconsumptionofoilin201213ismoreascomparetotheproductionofoil.Indianvegetableoileconomyisthefourthlargestintheworld.Thecountry accountsfor12-15%ofglobaloilseedsarea,6-7%ofvegetableoilsproduction(nexttoU.S.A,ChinaandBrazil)and9-10%ofthetotaledibleoilsconsumption.Soweconcludethatsolventextractionismostpreferableandeconomicalprocessfortheproductionofedibleoil.

REFERENCES

[1] EconomicResearchServiceofUnitedStatesDepartmentofAgriculture.(October,2002).OilCropSituationandOutlookYearbook.Available:http://usda.mannlib.cornell.edu/reports/erssor/field/ocs-bby/ocs2002.pdf.

[2] 2004Soya&OilseedBluebook,Soyatech,Inc.,BarHarbor,Maine,2003.

[3] T.J.BrummandC.R.Hurburgh,Jr.,Qualityofthe2002SoybeanCropfromtheUnitedStates,ReporttotheAmericanSoybeanAssociation.

[4] AalrustE,BeyerW,OttofrickensteinH(1992)Enzymaticmethodforreducingtheamountofphosphorous-containingcomponentsinvegetableandanimaloils.EuropePatent0,513,709.

[5] AdemosunOC(1982)MechanisedproductionsystemoofoilpalmproduceinNigeria:apreliminarystudyontheestablishmentoflocation–allocationmodels.AgrSyst8:193–207

[6] Anonymous(2000)Monographsontheevaluationofcarcinogenicriskstohumans.Someindustrialchemicals.IARC–WorldHealthOrganizationInternationalAgencyforResearchonCancer,vol.77,Lyon,France.

[7] Anonymous(2001)ScientificCommitteeonfood(2001).Opinionon3-monochloro-propane-1,2-diol(3-MCPD).UpdatingtheSCFopinionof1994adoptedon30May2001.

[8] Anonymous(2003)ErgänzendetoxikologischeBewertungvon3-MCPDunterbesondererBerücksichtigungderGefährdungvonKindern.StellungnahmedesBfRvom,9Juli2003

[9] H.G.Kirschenbauer,FatsandOils,ReinholdPublishing,NewYork,1944,pp.122–123.

[10] Anonymous,inTheExtractionofOilfromSeedsandNuts,June1997.

[11] Anonymous,inChronology,May(2000).

[12] V.D.AndersonU.S.Patent637,354,1900.

[13] Anonynous.(2002,March18).AndersonInternationalCorp. Available:http://www.andersonintl.com/history.html.

[14] Abete,P.,G.Testa,etal.(2009)."PUFAforhuman health: Diet or supplementation?" CurrentPharmaceuticalDesign15(36):4186-4190.

[15] AOCS(2005).OfficialmethodsandrecommendedpracticesoftheAOCS.Gaithersburg,M.D.,AmericanOilChemists'Society.

[16] Aryee,A.N.A.andB.K.Simpson(2009)."Comparativstudiesontheyieldandqualityofsolvent-extractedoilfromsalmonskin."JournalofFoodEngineering92(3):353-358.

[17] BermúdezAguirre,D.,T.Mobbs,etal.(2011).UltrasoundApplicationsinFoodProcessing.UltrasoundTechnologiesforFoodandBioprocessing.H.Feng,G.Barbosa-CanovasandJ.Weiss.New York,Springer:65-105.

[18] Bligh,E.G.andW.J.Dyer(1959)."Arapidmethodoftotallipidextractionandpurification."CanadianJournalofPhysiologyandPharmacology37(8):911-917.